European Committee
of the Regions

Territorial foresight study in addressing the digital divide and promoting digital cohesion

Table of contents

List of acronyms

3D/4D	Three-dimensional / Four-dimensional
4G/5G/6G	Fourth Generation / Fifth Generation / Sixth Generation
AGI	Artificial General Intelligence
AI	Artificial Intelligence
AI HLEG	High-Level Expert Group on Artificial Intelligence
AR	Augmented Reality
BEREC	Body of European Regulators for Electronic Communications
CIS	Commonwealth of Independent States
CoR	European Committee of the Regions
Covid-19	Coronavirus Disease 2019
DC	Digital Compass
DD	Digital Divide
DESI	Digital Economy and Society Index
DG	Directorate-General
DII	Digital Intensity Index
DLT	Distributed Ledger Technology
DPR	Digital Preparedness in Regions
EC	European Commission
ENISA	European Union Agency for Cybersecurity
ESPON	European Observation Network for Territorial Development and Cohesion
EST	Environmentally Sustainable Transport
ETNO	European Telecommunications Network Operators' Association
EU	European Union
GDP	Gross Domestic Product
HS	Horizon Scanning
I&C	Information and Communication
IAB	Integrated Access and Backhaul
ICTs	Information and Communication Technologies
IoT	Internet of Things
IT	Information Technologies
ITU	Intermodal Transport Unit
JRC	Joint Research Centre
LAU	Local Administrative Unit
LORDI	Local and Regional Digital Indicator
LRA	Local and Regional Authority
LTE	Long Term Evolution
MFF	Multiannual Financial Framework

MOOC	Massive Open Online Course
MS	Member State
NACE	Statistical Classification of Economic Activities in the European Community
NGA	Next Generation Access
NUTS	Nomenclature of Territorial Units for Statistics
OECD	Organization for Economic Cooperation and Development
P4	Predictive, Preventive, Personalized and Participatory
PA	Public Administration
PESTLE	Political, Economic, Social, Technological, Legal and Environmental
R&D	Research and Development
R&I	Research and Innovation
SARS-CoV-2	Severe Acute Respiratory Syndrome Coronavirus 2
SME	Small and Medium-sized Enterprise
SPOC	Small Private Online Course
STEM	Science, Technology, Engineering and/or Mathematics
TIM	Technology Innovation Monitoring
TSMC	Taiwan Semiconductor Manufacturing Company
UAV	Unmanned Aerial Vehicle
US	United States
UX	User Experience
V2X	Vehicle-to-everything
VHCN	Very High Capacity Networks
VR	Virtual Reality
WC	Wild Card
WS	Weak Signal

Executive Summary

In acknowledging the importance of the digital domain for an equal growth in Europe, since 2019 the European Committee of the Regions (CoR) has been advocating for including digital cohesion as part of the traditional concept of cohesion, which currently encompasses the economic, social and territorial dimensions. Digital cohesion can be described as the state achieved through the closing of the digital divide and the attainment of even participation of all European citizens in the benefits of digital transformation. Against this backdrop, the present study aims to investigate the potential evolution of digital cohesion in the future with a combination of approaches used in the foresight studies: horizon scanning, megatrends analysis, scenarios building, visioning and backcasting.

The study is structured in four parts preceded by an introduction. In the introduction the definitions of digital cohesion and digital divide are provided, illustrating how to measure digital cohesion at the regional level. Also, the main EU policy developments against the digital divide are presented.

In Part 1, the approach includes horizon scanning for weak signals and wild cards, which are, respectively, early signs of change and unlikely events with severe impact. This is done in order to better understand the potential convergence of the relevant future context towards digital cohesion. The approach consists of exploring, filtering and assessing weak signals and wild cards, employing both desk research and stakeholders' consultation. After the initial scanning conducted by the study team, two stakeholders' consultations were held. These consultations involved experts in the digital fields and CoR members, and were conducted in order to detect relevant weak signals and wild cards and also to deepen their linkage to the digital divide in Europe. Starting from 51 weak signals retrieved through desk research and literature review, 19 are identified (among them metaverse workforce, Unmanned Aerial Vehicles and digital constitutionalism). With the same approach, from 20 wild cards, eight are identified (among them disruptive digital pandemic, out of control Artificial Intelligence and a massive immigration within Europe).

Part 2 follows and broadens the scope of the investigation conducted in the previous part through megatrends analysis and scenarios building. Concerning the megatrends analysis, the 14 global megatrends identified by the Competence Centre on Foresight of the European Commission are reviewed based on the exploration of each megatrend's linkages with digital skills, digital infrastructures, digital transformation of businesses and digital public services (i.e., the four cardinal points of the Digital Compass). Then their impact on digital cohesion as long-term driving forces is analysed. In the proposed approach, the

occurrence of weak signals is associated with each megatrend, thus exploring the positive implications of weak signals in reducing the digital divide in Europe. This assessment is derived from the insights gathered through the CoR members' consultation.

Four scenarios are then built in order to provide different perspectives on how digital cohesion can be achieved and to learn possible implications for the present by evaluating each scenario according to the dimensions described in the Digital Compass: digital skills, digital infrastructures, digital transformation of businesses and digital public services. The results of the experts' consultation concerning the relevance of weak signals and wild cards drives the creation of the scenarios with a quantitative method. These scenarios vary in terms of achievement of digital cohesion and the level of security of the environment generated by the weak signals. For example, in one scenario each weak signal has the maximum impact on digital cohesion, resulting in an even uptake of the technologies by the private sector, by the public administration and by the citizens, with digital skills and digital infrastructures as the main enablers for the transformation of the private sector and of the public administration. In another scenario, some technologies are less relevant than others, due to barriers for the general public's uptake such as the lack of the appropriate digital skills or digital infrastructures. Malicious online threats are better managed by public governance.

In [Part 3](), the forecasting model developed previously is complemented by a visioning and backcasting approach. The visioning, through the implementation of the megatrends considered, describes a future ideal vision for digital cohesion in Europe by highlighting how megatrends can accelerate or decelerate the Digital Compass dimensions. The vision is composed of eight sub-visions, each of them focusing on the reduction or the disappearance of a specific digital divide, e.g., between European regions, between genders or between vulnerable and non-vulnerable groups. These sub-visions create the image of an ideal future where digital cohesion in Europe approaches becoming a reality. Visioning builds upon the targets of the Digital Compass set for 2030 and looks further to 2050. Since it considers more specific divides than those addressed in the Digital Compass, the vision also widens the scope of the targets, providing evidence of the existing digital divides, proposing indicators to measure and monitor the progress towards the divides' closing and highlighting data gaps and opportunities driven by new types of data and indicators.

Afterwards, a backcasting exercise is applied as a strategic approach to retrospectively identify the steps needed towards the desirable futures described in the visioning. Based on existing backcasting models, three phases are applied to each of the eight sub-visions. First, components and enabling factors for achieving each sub-vision are outlined. Then a mapping of the current state and

the identification of the gap towards each sub-vision are performed. Finally, the path towards each sub-vision is identified by working backwards. This last phase identifies barriers and possible policy and strategy actions whose implementation would result in the attainment of digital cohesion.

Finally, in Part 4 the conclusions elaborated to expand the concept of digital cohesion are complemented by action-oriented recommendations to European institutions, Member States and local and regional authorities (LRAs). The recommendations address the horizontal and vertical aspects which emerged and are divided into three groups. The first one focuses on the weak signals and megatrends analysis that has the objective of foreseeing where the future is directed based on the existing context. Therefore, the recommendations are formulated to address foreseeable risks and shortfalls of the current policies and to provide strategies. The second group of recommendations aims at providing more topic-specific directions to prepare for the unforeseeable future and for correcting the course towards achieving digital cohesion. In fact, those recommendations take into consideration the impact of the identified wild cards and the backcasting exercise towards the vision illustrated in Part 3. Finally, in the third group, specific recommendations for improving the monitoring and the measuring of the progress towards digital cohesion are proposed.

Introduction

Why digital cohesion? The narrative.

At the institutional level, the principle of digital cohesion was introduced in 2019 by the European Committee of the Regions (CoR). In its Opinion on 'Digital Europe for all: delivering smart and inclusive solutions on the ground', the CoR refers to digital cohesion as '*an important additional dimension of the traditional concept of economic, social and territorial cohesion defined in the EU Treaty*' (CoR, 2019). Although institutionally supported, the inclusion of a principle on digital cohesion to ensure that no region or person is left behind in terms of connectivity and accessibility was not part of the European Commission (EC) proposal for a 'European Declaration on Digital Rights and Principles for the Digital Decade' (EC, 2022a). Still, the Declaration, published in late January 2022 to guide the digital transformation in the EU, emphasises solidarity and inclusion under its Chapter 2, stating that '*Everyone should have access to technology that aims at uniting, and not dividing, people*' (EC, 2022b). This antithesis between uniting and dividing people that is at the core of the proposed Declaration exactly mirrors the antithesis between digital cohesion and digital divide.

Since 2001, digital divide has been defined by the Organization for Economic Cooperation and Development (OECD) as '*the gap between individuals, households, businesses and geographic areas at different socio-economic levels with regard to both their opportunities to access information and communication technologies (ICTs) and to their use of the Internet for a wide variety of activities*' (OECD Glossary of Statistical Terms). Although technologies have evolved since the early 2000s, this definition is still meaningful from the point of view of cohesion. In fact, it identifies *accessibility* and *use* as the key determinants of the 'digital' *differences* between individuals, businesses, and territories (regions and countries). These differences jeopardise equality and justify the **definition of 'digital cohesion' as the dimension achieved by removing the divide in accessibility and use of ICT, i.e., the digital divide.**

Digital cohesion, with its reference to digital differences, goes beyond concepts like 'digital inclusion', defined as '*the effort to ensure that everybody can contribute to and benefit from the digital world*' (EC-DG CONNECT webpage), or like 'e-cohesion', defined as the simplification and reduction of administrative burden for the EU Member States while implementing the Cohesion Policy (EC-DG REGIO webpage).

How to measure digital cohesion at the regional level?

In this study we adopt the above definition of digital cohesion and investigate digital divides in Europe according to the four cardinal points of the Digital Compass (DC) (Figure 1). The analysis of this introduction is a preliminary attempt to assess the divide at the territorial level based on the identification of key indicators for each of the four cardinal points. When focusing on the territorial dimension, the divide is reflected by the difference between the values taken by these indicators across regions.

Figure 1. Digital Compass' cardinal points and targets
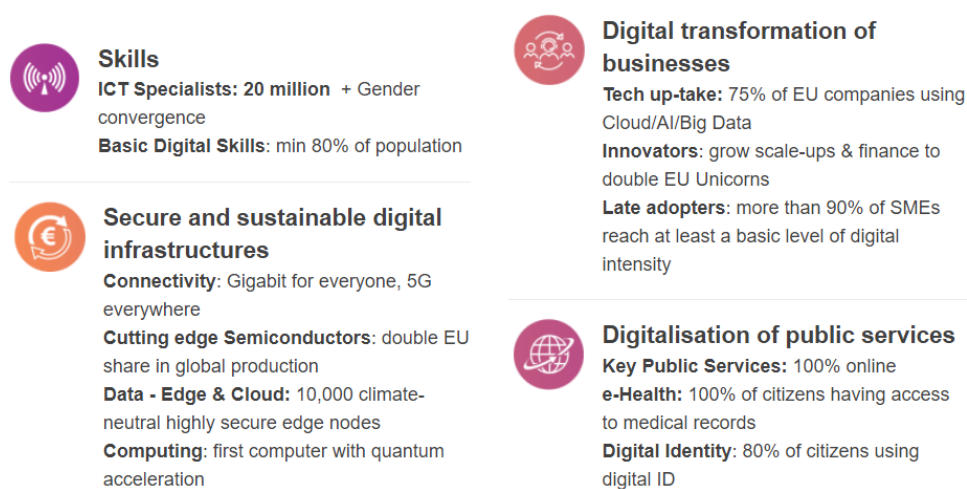
Source: European Commission webpage on digital targets for 2030.

The Digital Economy and Society Index (DESI) is the index entrusted by the EC to measure country-level progress against the targets set in the Digital Compass. DESI 2021 has been adapted to reflect the Digital Compass' cardinal points, but it measures the performance of Member States and is currently unable to provide the same information at the regional level.[1] So, even if the priority for a territorial analysis would be to use the same indicators and instruments (i.e., DESI) identified by the European Commission, in practice this is not possible because of the lack of regional data for such indicators.

We thus identify alternative indicators to measure digital cohesion at the regional level against the four cardinal points, which are shortened for ease of reference to 'skills', 'infrastructure', 'businesses' and 'public services' (Table 1). These

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[1] DESI shortcomings in informing digital policymaking at the regional level are pointed out in Cavallini and Soldi (2021). While analysing the Digital Preparedness in Regions (DPR) to facilitate the digital transformation of business, the authors implemented a thorough data gaps analysis which is also considered in this study to identify suitable indicators.

indicators are analysed in the following sections. As disparities may vary according to the type of individuals/groups, businesses, families and territories (OECD, 2021), variables such as gender, age, skill level, firm size or geographical features (e.g., urban and rural) are considered as far as data allow to verify if some types are more affected by digital divides than others.

Table 1. Country level indicators to measure progress of the Digital Decade and tentative set of proxies for use at the regional level

	SKILLS	INFRASTRUCTURE	BUSINESSES	PUBLIC SERVICES
National level (targets in brackets) (DESI)	•Individuals aged 16-74 have basic digital skills (80%). •Employed ICT specialists (20 million) – gender convergence.	•Gigabit coverage, 5G coverage (100%). •EU production of cutting-edge & sustainable semiconductors (20% of global production). •Climate-neutral highly secure edge nodes are deployed in the Union (10,000). •The Union has its first computer with quantum acceleration (by 2025).	•Union enterprises have taken up cloud computing services, big data, AI (75%). •Over 90% of Union SMEs reach at least a basic level of digital intensity. •Grow scale-ups & finance to double the number of unicorns.	•Online accessible provision of key public services for Union citizens and businesses (100%). •Union citizens have access to their medical records (100%). •Union citizens use a digital identification solution (80%).
Regional level	•Individuals who used the internet (daily, never). •Employment in the I&C sector, by gender.	•NGA coverage, total and in rural areas (mapped info). •Rural/urban divide for fixed broadband, Very High-Capacity Networks, 4G mobile, 5G mobile.	•High growth enterprises by urbanisation level.	•Individuals who used the internet for interaction with public authorities.

In addition, based upon the evidence that in some cases the Covid-19 pandemic has increased the digital divide (Cavallini and Soldi, 2021), when available, pre- and post-Covid-19 data are represented to highlight this aspect.

Data on different types of divides are presented in the following paragraphs according to the order of the cardinal points and targets from the Digital Compass.

Digital divide for skills

Digital competencies are proxied by the **individuals' ability to use the internet** daily. Cavallini and Soldi (2021) already evidenced the digital divide across regions against this indicator (p.9). In 2021, this divide still exists but several regions have improved their situation compared to a pre-Covid-19 level (2019). The 2021-2019 change is represented in Map 1. In some countries, the pandemic boosted the daily use of the internet with positive changes of over 10 percentage points (e.g., Romania, Slovenia and several regions of Greece, Portugal and Spain). In other countries such as Germany, France and Sweden, the decrease of daily internet use in 2021 compared to 2019 is evident (red colour). In 2019, the highest gap across European regions was 47 percentage points; in 2021, it decreased to 36 percentage points.

Map 1. 2019-2021 change of individuals using the internet daily (percentage points)
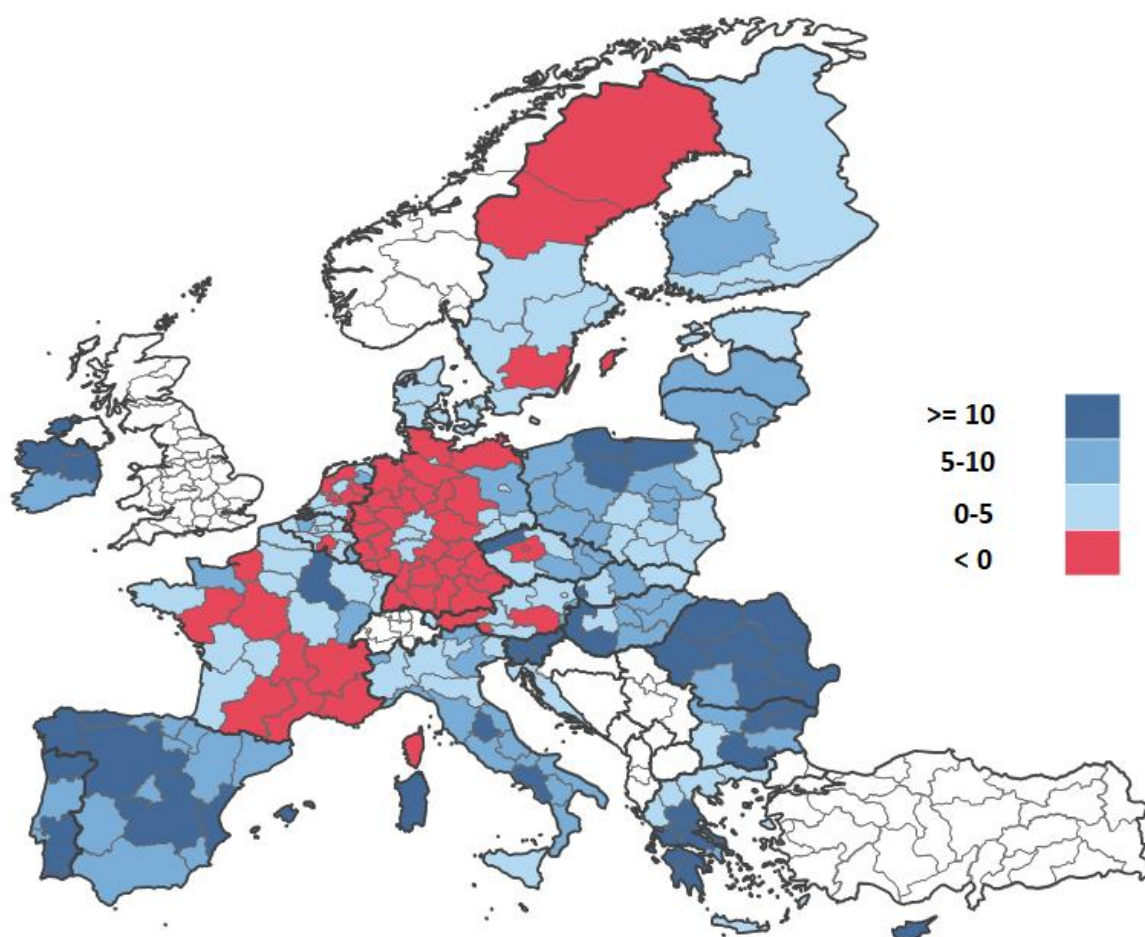
Notes: No data for Åland, Kontinentalna Hrvatska and Mayotte. Data for Greece, Poland and Germany are at the NUTS1 level. Map created by Progress Consulting S.r.l. on the basis of Eurostat data [isoc_r_iuse_i] accessed in May 2022.

By considering a similar indicator (i.e., the 'Frequency of internet access: once a week (including every day)') which is made available by Eurostat by degree of

urbanisation, in 2021 the digital divide between rural and urban areas has almost closed in Belgium, Ireland, Luxembourg and Denmark (Figure 2). Peaks of the divide are found in Bulgaria, Greece, Portugal, Malta and Croatia, i.e., in those countries where the percentage of individuals accessing the internet at least once a week is at the lowest levels across the EU.

Figure 2. Percentage of individuals accessing the internet at least once a week (including daily access), by degree of urbanisation

	2021		
	urban areas	towns and suburbs	rural areas
Ireland	99	96	98
Denmark	98	97	96
Luxembourg	97	98	96
Netherlands	93	94	96
Sweden	96	95	93
Finland	97	95	92
Belgium	91	92	90
Spain	93	91	89
Estonia	93	87	88
Latvia	92	90	87
Austria	92	90	87
Cyprus	91	95	86
Germany	91	88	87
France	91	88	87
Slovenia	90	88	86
Slovakia	92	88	84
Czechia	92	88	83
Hungary	92	87	82
Lithuania	89	87	82
Poland	89	84	79
Romania	87	84	76
Italy	83	80	76
Croatia	88	82	75
Malta	88	86	73
Portugal	85	80	70
Greece	83	81	64
Bulgaria	82	73	64

Eurostat data [isoc_bdek_di] accessed in May 2022. In 2021, break in time series for Ireland and Germany.

In terms of progress, since 2019, data show that in the post-Covid-19 era the situation slightly worsened in Germany, the Netherlands and Sweden while it improved substantially in several other countries (Figure 3).

Notably, improvement is observed in many rural areas. In some of these areas the increase reached 10 or more percentage points (e.g., Ireland, Romania, Bulgaria and Slovenia).

Figure 3. Percentage of individuals accessing the internet at least once a week (including daily access) in 2019 and 2021, selected countries, by degree of urbanisation

Examples of countries increasing the digital divide (2019-2021)				
		urban areas	towns and suburbs	rural areas
Germany	2019	93	91	90
	2021	91	88	87
Netherlands	2019	96	95	96
	2021	93	94	96
Sweden	2019	95	96	94
	2021	96	95	93

Examples of countries reducing the digital divide (2019-2021)				
		urban areas	towns and suburbs	rural areas
Ireland	2019	91	88	85
	2021	99	96	98
Slovenia	2019	86	84	76
	2021	90	88	86
Romania	2019	80	72	64
	2021	87	84	76
Bulgaria	2019	75	68	54
	2021	82	73	64

Eurostat data [isoc_bdek_di] accessed in May 2022. In 2021, break in time series for Ireland and Germany.

Another detail of particular significance is the indication of the share of individuals who never use the internet. Since broadband connectivity is guaranteed across the EU (see next chapter), the 'no use' condition is considered to imply the lack of digital skills and points to an audience that may need to be addressed by tailored digital inclusion policies. Figure 4 highlights the existence of a rural-urban divide for this indicator in the majority of the EU countries.

Figure 4. Individuals who never use the internet, by degree of urbanisation, (%), 2021, by country
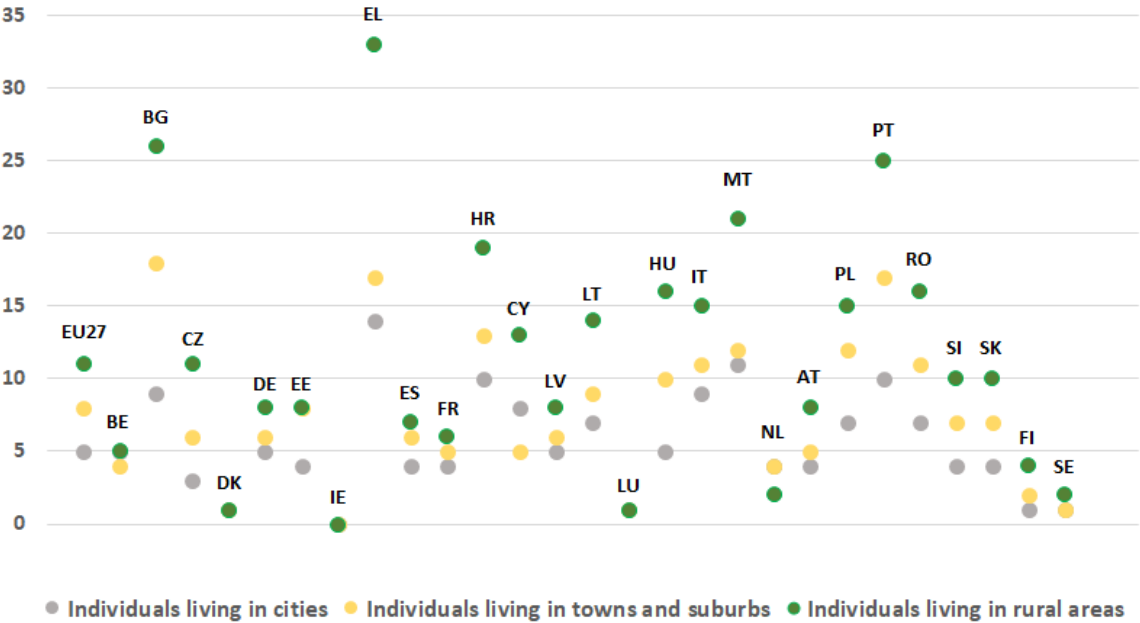
Source: Eurostat data [isoc_bdek_di] accessed in May 2022.

The highest divide is found in Bulgaria, Greece and Portugal. Denmark, Ireland and Luxembourg show no rural-urban divide and also have a negligible share of individuals who never use the internet.

By using **employment in the information and communication sector** as a proxy of the gender convergence in the digital skills domain, the divide is evident. The indicator has very diverse values across regions and lacks a clear country-based pattern. Map 2 shows the ratio of female employment versus male employment. According to latest data (2021), the only region where the number of employed females aged 15-64 years is higher than the number of males is Észak-Alföld, in Hungary. Észak-Magyarország also has a high ratio (78%). Other regions where the ratio of employed females versus males is over 70% are Comunidad Foral de Navarra (86%), Spain; Alsace (77%), France; and Friuli-Venezia Giulia (72%), Italy. Still in Italy, the divide has almost closed in Umbria (94%).

In summary, evidence shows that the digital skills area is characterised by digital divides across regions according to different variables, e.g., geographical and by gender. In addition, it is noted that the Covid-19 pandemic has impacted differently across Europe. In some cases, it has accelerated processes; in others it has stopped or reversed previous trends.

Map 2. Ratio of female vs. male employed in the I&C sector, %, 2021
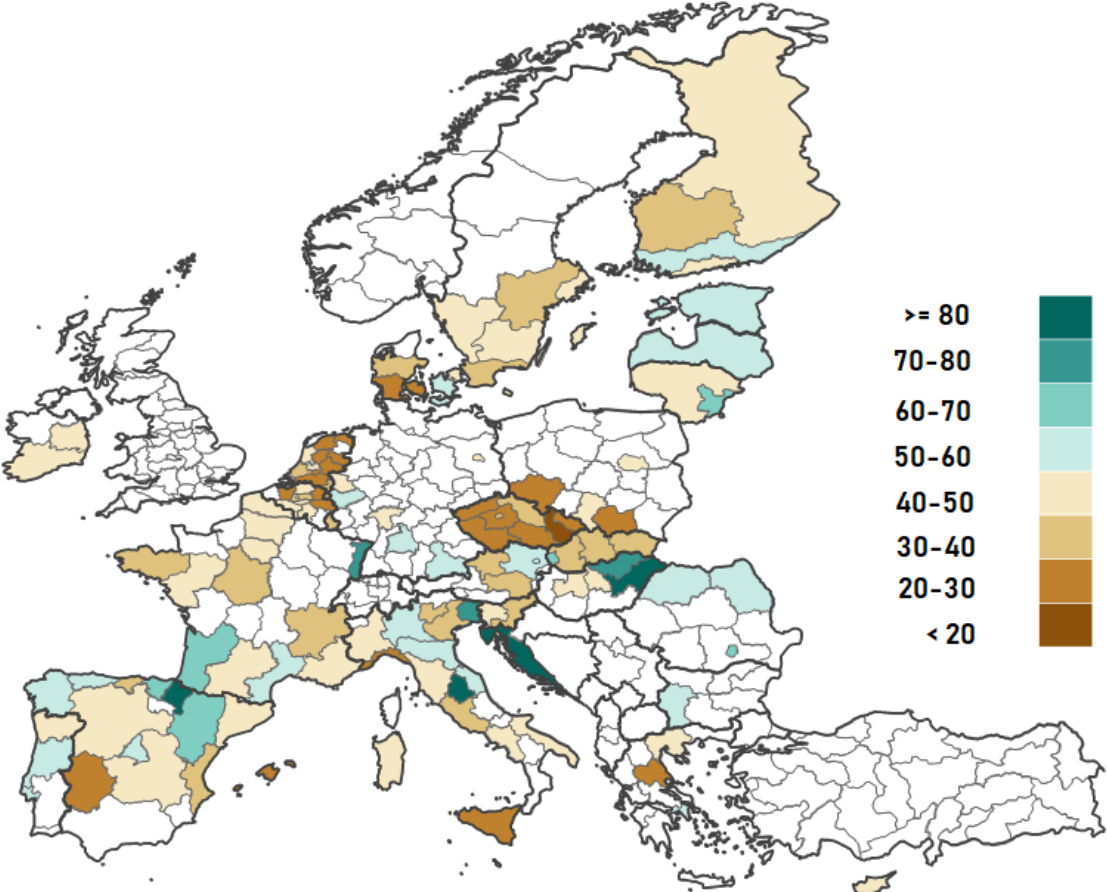
Source: Eurostat data [lfst_r_lfe2en2] accessed in May 2022. Map created by Progress Consulting S.r.l. Notes: several data gaps (white colour).

Digital divide in digital infrastructure endowments

Latest available data on infrastructure endowments refer to 2020 and are provided in the 2021 'digital infrastructures' update of DESI distinguishing between 'total' and 'rural' coverage.[2] A summary of these data is presented in Table 2. Only data on NGA are made available at the territorial level in the latest study commissioned by DG CONNECT.[3]

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[2] In the digital infrastructure studies of the EC, rural areas are defined as having fewer than 100 people per km^2.
[3] See also Cavallini and Soldi (2021), p.8.

Table 2. Digital infrastructures coverage, total and rural, 2020, % of households

	Fixed broadband	NGA broadband	VHCN	4G (LTE) mobile	5G Mobile
Total	97.4%	87%	59%	99.7%	See Figure 5[4]
Rural	89.7%	60%	28%	98.6%	

Source: EC-DG CONNECT (2021).

Figure 5. 5G mobile coverage, % of populated areas, 2020
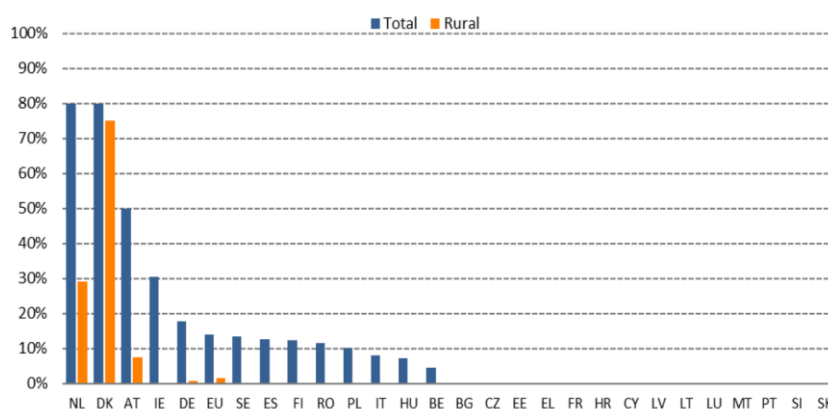
Source: see footnote 4.

In summary, the rural-urban digital gap has almost closed for 4G mobile, but the deployment of all the other digital infrastructures lags behind in rural areas. Since 2018, the growth rate of NGA coverage increased more in rural areas than in urban areas (Figure 6). In terms of VHCN coverage, the opposite occurred (Figure 7).

Figure 6. NGA broadband coverage, % of households, 2013-2020, EU27
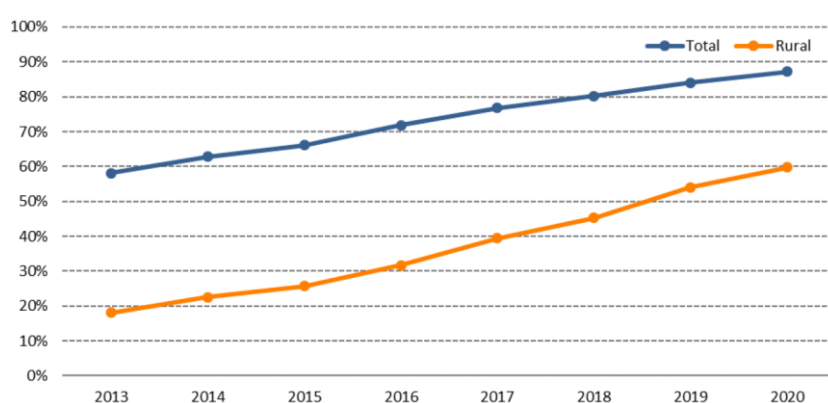
Source: see footnote 4.

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[4] Figures 5, 6 and 7 are from EC-DG CONNECT (2021), p.11, p.7 and p.8, respectively.

Figure 7. Fixed VHCN coverage, % of households, 2013-2020, EU27
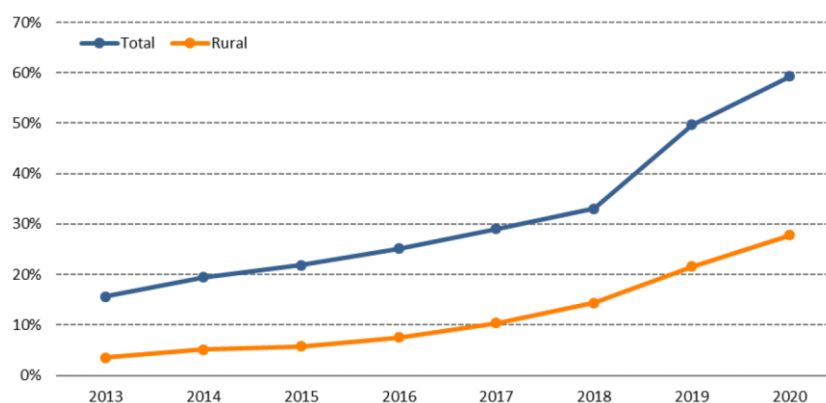
Source: see footnote 4.

Digital infrastructure endowments only refer to coverage indicators. No digital targets are set under this cardinal point with regard to the take-up of available types of connectivity by users. In addition, it is noted that the categorisation of data based only on a rural/urban criterion (as provided in the studies commissioned by DG CONNECT) does not allow analysing coverage versus other variables such as GDP/capita.

Digital divide in digital transformation of businesses

There are no data on the take-up of digital tools and services by businesses and there is no equivalent of the digital intensity index at the regional level. The only proxy we propose relates to scale-ups and is expressed as **the share of high growth enterprises by urbanisation level**. This proxy provides an indication of the geographical distribution within a country of high-growth enterprises where the growth is measured in employment terms.[5] For the scope of this study, this proxy is preferred to the number of unicorns used by the Commission in the Digital Decade because it is expressed by degree of urbanisation, thus it allows assessing the existence of a rural-urban divide depending on the way enterprises are geographically distributed. In Figure 8, data refer to all NACE activities (industry, construction and services except insurance activities of holding companies) as the high-growth capability of the economic sector is what is being assessed and digital transformation crosscuts all sectors.

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[5] Eurostat defines a high-growth enterprise as an enterprise with average annualised growth in number of employees greater than 10 % per year over a three-year period (t – 3 to t) and having at least 10 employees in the beginning of the growth (t – 3).

Figure 8. High-growth enterprises, by urbanization level, by country, 2018

= predominantly rural   = intermediate   = predominantly urban

Countries with a relatively balanced distribution of high growth enterprises

Romania — 437; 30% | 505; 34% | 528; 36%

Croatia — 565; 32% | 600; 33% | 622; 35%

Austria — 1.338; 36% | 1.099; 29% | 1.329; 35%

Finland — 1.076; 40% | 723; 27% | 906; 33%

Denmark — 892; 32% | 1.013; 36% | 919; 32%

France — 9.658; 46% | 6.609; 32% | 4.527; 22%

Portugal — 3.372; 50% | 1.844; 27% | 1.580; 23%

Slovakia — 619; 27% | 960; 43% | 670; 30%
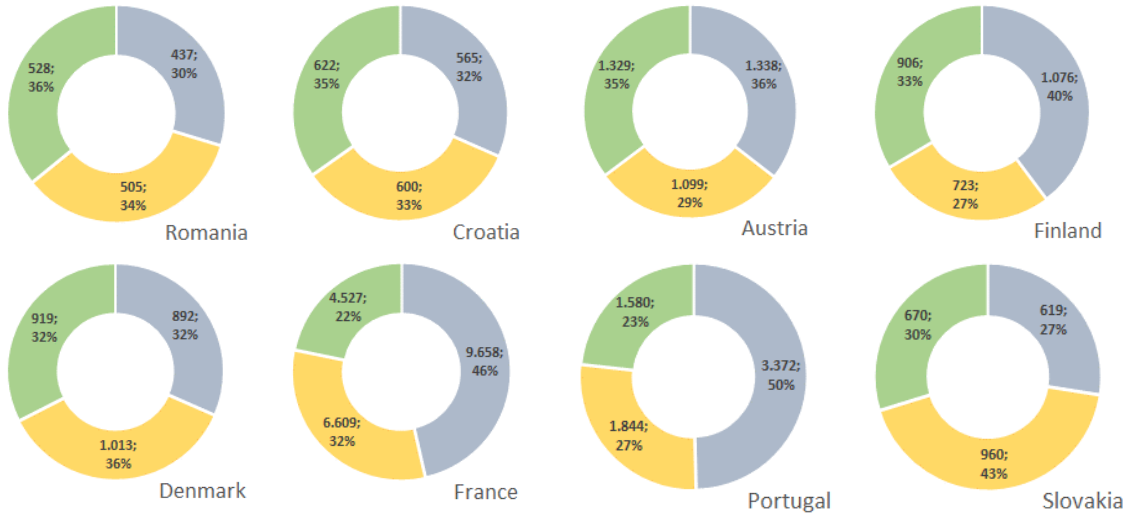
Countries with a prevailing distribution of high growth enterprises in urban areas

Spain — 15.676; 70% | 6.230; 28% | 522; 2%

Netherlands — 7.817; 75% | 2.488; 24% | 54; 1%

Latvia — 646; 58% | 332; 30% | 128; 12%

Estonia — 503; 63% | 41; 5% | 253; 32%
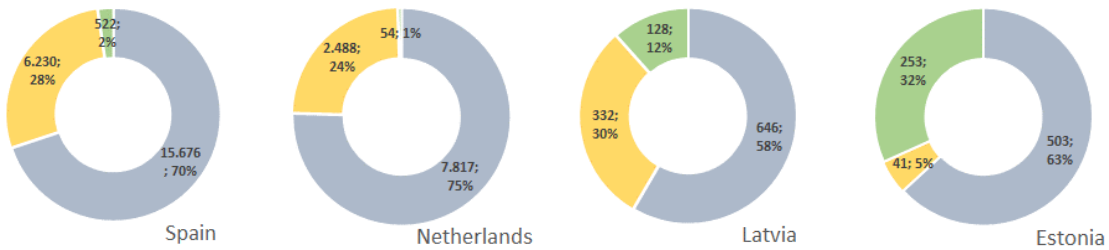
Countries with a prevailing distribution of high growth enterprises in intermediate and urban areas

Bulgaria — 1.257; 36% | 1.929; 56% | 291; 8%

Italy — 10.632; 49% | 9.303; 43% | 1.853; 8%

Sweden — 2.849; 51% | 2.390; 42% | 393; 7%

Lithuania — 624; 41% | 823; 54% | 68; 5%

Czechia — 1.938; 41% | 2.090; 44% | 729; 15%

Hungary — 1.570; 36% | 2.315; 53% | 467; 11%
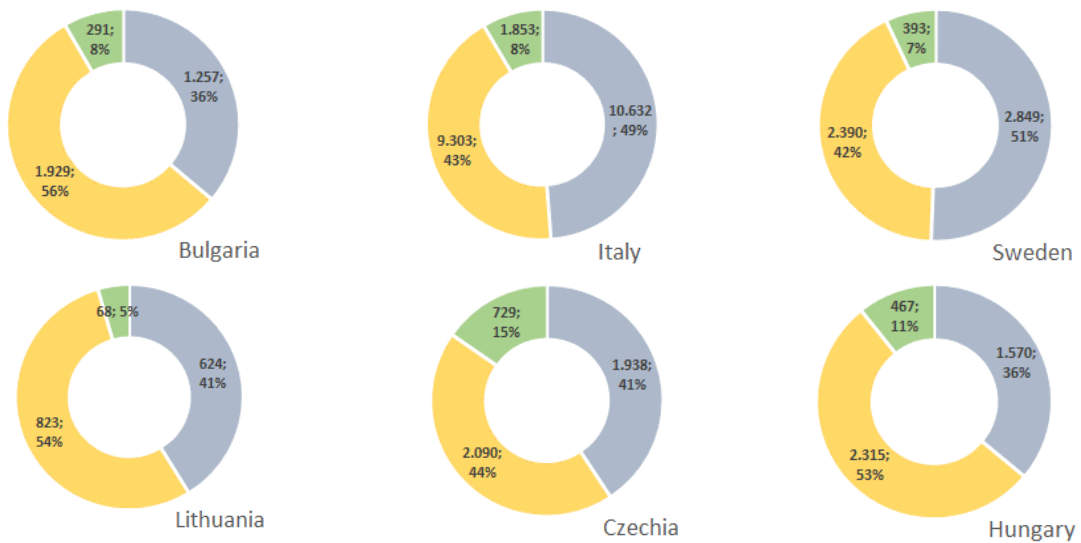
Data source: Eurostat, table [urt_bd_hgn2], accessed in May 2022.
Notes: no data for BE, CY, DE, EL, IE, LU, PL, SI. Malta has only enterprises in predominantly urban areas.

According to this proxy, there is a comparable number of high-growth businesses across rural, intermediate and urban areas of Romania, Croatia, Austria, Finland, Denmark, France, Portugal and Slovakia (Figure 8). In contrast, there is a marked rural-urban divide in terms of distribution of high-growth enterprises in Bulgaria, Italy, Sweden, Lithuania, Czechia and Hungary. Spain, the Netherlands, Latvia and Estonia have their high-growth businesses concentrated in urban areas. Still, Estonia has also a third of its high-growth enterprises located in rural areas.

Overall, it is necessary to highlight that it is not possible to link the high growth of a business to its digital transformation, but whatever the reasons for high growth, this growth implies higher employment levels and benefits for the community.

Digital divide in digitalisation of public services

In this area of the Digital Compass, the digitalisation of public services can be proxied with the demand of digital public services by considering **the share of individuals who use the internet for interaction with public authorities**. Since data are available up to 2021 (included), we have created two maps, one showing the state of play of the indicator in 2021 (Map 3), the other one comparing the pre-Covid-19 situation (2019) with the post-Covid-19 one (2021) (Map 4).
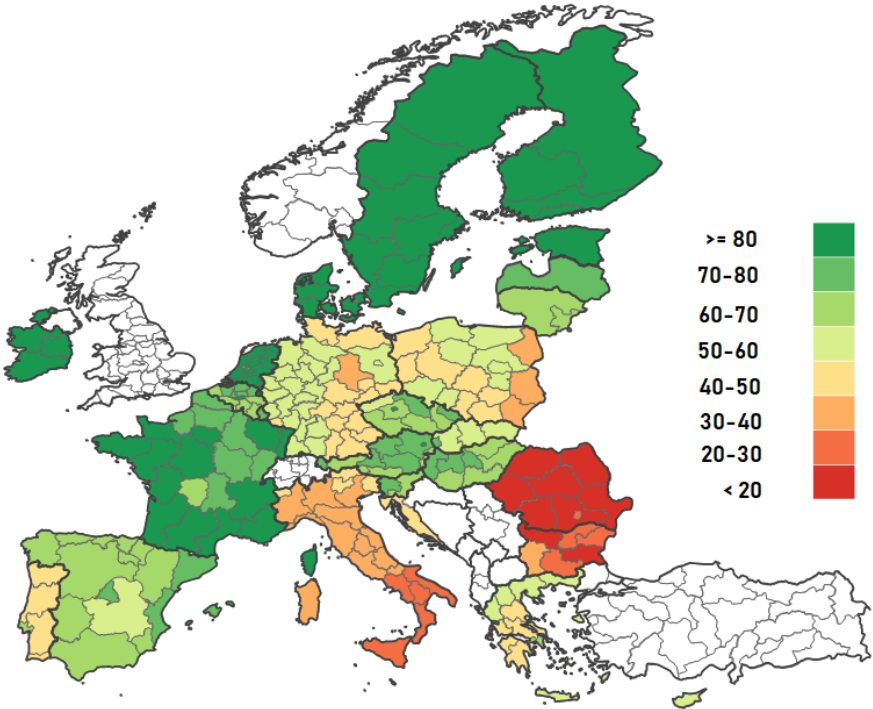
Map 3. Interacting with public authorities through the internet, % of individuals, 2021

Legend:
>= 80
70-80
60-70
50-60
40-50
30-40
20-30
< 20

Data source: Eurostat, table [isoc_r_gov_i], accessed in May 2022. Map created by Progress Consulting S.r.l.

Notes: no data for Åland, Mayotte and Kontinentalna Hrvatska; data for DE, EL and PL are at the NUTS1 level.
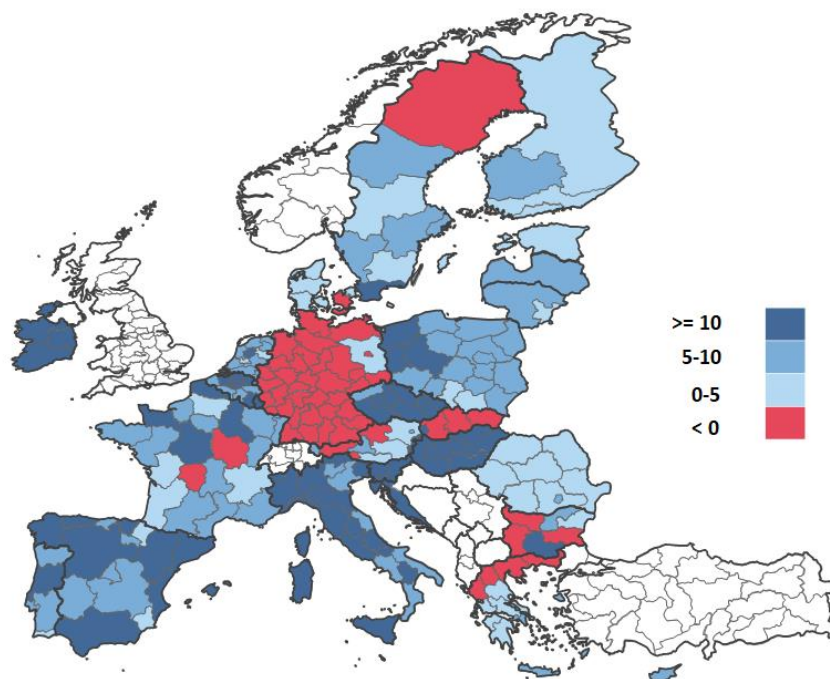
Map 4. 2021-2019 change, individuals interacting with public authorities through the internet, p.p.

Data source: Eurostat, table [isoc_r_gov_i], accessed in May 2022. Map created by Progress Consulting S.r.l.

Notes: no data for Åland, Mayotte and Kontinentalna Hrvatska; data for DE, EL and PL are at the NUTS1 level.

Map 3 highlights how the divide is evident across countries. This possibly points to structural barriers to the take-up of e-government services. However, it is also evident that there is a divide across regions of the same country, for example in Italy, Germany and Poland. Map 4 confirms the information reported in Map 1 on the daily use of the internet by individuals, showing that in some EU countries the share of people interacting with public authorities through the internet has decreased in 2021 compared to pre-Covid-19 levels. Examples include almost all German regions, Slovakian regions and several regions of Bulgaria.

From the supply side point of view, the main source of information is the e-government benchmark report that is carried out yearly. Unfortunately, the 2021 report does not add value to the information at the local and regional level presented in the previous report.

Main EU policy developments against the digital divide

There are several European policies in place which are aimed at increasing the uptake of digital technologies by citizens, businesses and public administrations and at fighting the digital divide in all its components in the medium to long term. Just to mention a few, there are the new Digital Education Action Plan 2021-2027 for digital skills, the deployment and take-up of very high-capacity networks further to the implementation of an internal market in electronic communications networks and services (European Electronic Communication Code), the SME strategy for a sustainable and digital Europe to support the digitalisation of

businesses and the new European data strategy for data interoperability and quality. This last policy is especially needed at the level of public services' delivery, as well as for data use in the adoption of innovations. There are also sectorial policies which are highly relevant to fight the digital divide. A main example of this is the 2021 EU long-term vision for rural areas that tackles stronger, connected, resilient and prosperous rural areas by 2040, and its Rural Action Plan which is instrumental in filling the gap between rural and urban areas, including in terms of connectivity and digital services.

This study aims at considering the issue of the digital divide in a forward-looking perspective with the aim of understanding what is needed in order to achieve digital cohesion across the Union.

An initial reflection is that digital cohesion is achieved by simultaneously reducing the divide in all four cardinal points of the Digital Compass. As a simple example, it is not enough to provide very high-capacity network coverage if individuals do not connect (take-up), or if businesses are unable (because of low skills) to benefit from the services that may be derived from ultra-fast connectivity.

A second reflection concerns the long-term effort already made by the EU to achieve cohesion in the territorial, social and economic domains. There is a cause-effect relationship between cohesion in these domains and cohesion in the digital domain that indeed deserves further investigation. It is interesting to analyse if and how progress in the achievement of the former has positive side-effects on the achievement of the latter and vice-versa.

A third reflection is that several of the existing EU visions and strategies are already forward-looking, but in most of the cases they serve multiple scopes while in this study we are called to assess how they may serve one specific scope, i.e., digital cohesion. This is done by scanning the horizon for the identification of weak signals and wild cards that may affect the digital transition path commenced in the EU. It is also accomplished by exploring key long-term driving forces, or megatrends, capable of leading to large-scale transformations that may, or may not, be favourable to digital cohesion. In parallel, this analysis is complemented by the development of scenarios where options related to the achievement of digital cohesion are assessed so as to derive reflections on actions needed by European policymakers.

Relevant policies will thus be looked at in more detail in Parts II and III of this study (i.e., when performing backcasting).

Part 1 Methodology and Horizon Scanning

1.1 Horizon scanning and its scope

'Horizon scanning is the systematic outlook to detect early signs of potentially important developments in the future' (EC, 2016). It aims at looking at one or more time horizons in the future to understand the impact in a certain domain of what today is more or less likely to occur. Policymakers (at any administrative level) targeting a more cohesive Europe from the digital point of view should take into account 'signals of change' that may affect the expected impacts of their decisions and actions. The occurrence of these 'changes' can favour convergence of existing policies towards the achievement of more favourable impacts or towards speeding up the achievement process. But it can also determine a partial or total failure of policymakers' actions for a gradual or sudden change of the framing conditions that was not considered when designing policies.

Identification of the early signals of changes that can affect future dynamics and effectiveness of policies is a key part of foresight exercises. Signals of changes are grouped into weak signals and wild cards. Following, for ease of reference, are the definitions of weak signals and wild cards (they will be discussed in more detail in section 1.2 and 1.3, respectively). Weak signals are *'unclear observables warning us about the possibility of future 'game changing' events'* and *'their 'weakness' is directly proportional to levels of uncertainty about their interpretations, importance and implications in the short-medium to long-term.'* (iKnow project). A wild card *'...is a future development or event with a relatively low probability of occurrence but a likely high impact on the conduct of business'* (Steinmüller, 2003).

Foresight in general, and horizon scanning in particular, has an anticipatory function. The identification of early signals of changes as well as their effects in the short, medium and long term has become crucial for proper agenda-setting in the EU regulatory and policy process, in any domain. As indicated in the Better Regulation Toolbox of the European Commission, horizon scanning *'... is useful whenever there is a high degree of uncertainty surrounding changes to the relevant future context and to ensure that short term actions are grounded in the long-term objectives'* (EC, 2021a).

1.2 The approach adopted in this study for horizon scanning

Horizon scanning (HS) methodology can be structured differently according to its objective and to the time available. It may range from a tailored and participative process when the scope is broad, to a fast, automated and vertical approach when the scope is tight.

For the purpose of this study, we adopt a broad, comprehensive and participative approach, mainly because we do not rely on automated tools and HS is not a stand-alone method but is part of a wider approach.

The HS method is modelled according to four main phases derived from relevant literature:

1) **Exploring**: building an overview of the current situation through the collection of data from different sources, taking into account that the sources for weak signals are to be found among specialist and innovative publications (Schultz, 2006). Instead, weak signals are data points indicating that significant change could be underway.

2) **Filtration**: Since HS is a data-driven approach (Neugarten, 2006), it is crucial to scope according to the methodology and the themes to be investigated. In this phase, weak signals and wild cards are selected by confirmation, i.e., by cumulating evidence from different sources (Schultz, 2006).

3) **Assessment**: experts' consultation validated the weak signals and wild cards collected and the weak signals' potential temporal horizon of impact. Here, the assessment of the data collected has been achieved by convergence of the scientific dialogue (Schultz, 2006). The engagement of key stakeholders has been particularly important in gathering relevant contributions and in fostering ownership of the results.

4) **Application**: the results of the previous phases are structured and consolidated to serve as input to further foresight exercises. In general, it is of utmost importance to disseminate the outcomes to the relevant stakeholders, but in the present study results are used to validate the main identified upcoming trends from weak signals and wild cards (reference is to Part 2 'Megatrends analysis and Scenarios building' and Part 3 'Visioning and backcasting').

Statistical analysis, initially foreseen in the methodology, has been deemed not relevant for supporting the desk research for phase 1 and 2. This is mostly due to

the very specific nature of weak signals and wild cards that makes finding suitable statistics very difficult.

HS requires continuous updating to remain relevant in time, thus it needs to be regular and integrated in order to reflect the current context (Cunha *et al.*, 2006). However, this phase of continuous exploring is beyond the scope of this study. Figure 9 represents the HS method applied in this study. As mentioned, the method relies on desk/literature research (phase 1 and 2) and stakeholders' consultations (phase 3).

Figure 9. HS method for this study
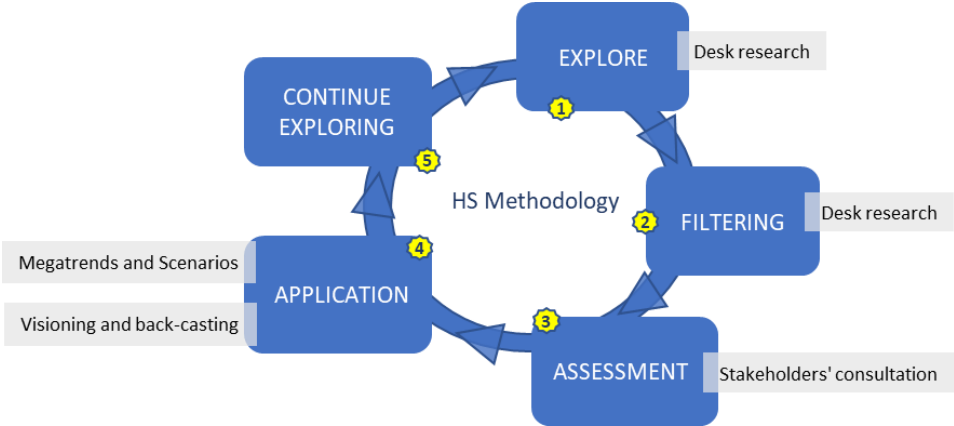
1.2.1 Desk Research

Desk research started with the collection of qualitative data from reputable scientific studies and technical reports, EU research/sectorial studies, projects and policy documents. Moreover, when considered of sufficient quality, data have also been derived from social media scanning, conference findings, initiatives, studies and projects carried out by private and other public actors and sectoral networks.

1.2.2 Stakeholders' consultations

In order to gather feedback and relevant information on the weak signals and wild cards collected through desk research we planned two consultations (phase 3 of the HS model). The first one was directed towards experts in the digital fields with the aim of selecting a list of relevant weak signals and wild cards. The second consultation was addressed to CoR members with the purpose of collecting more data on the perception of digital cohesion and of the digital divide in Europe.

Experts' consultation

The experts' consultation was launched on 26 January 2022 and concluded on 7 February 2022. Thus, it ran for 13 days. In inviting experts to take part in the consultation, and considering the types of stakeholders identified in the Inception Report, we selected officers from European and international organisations and private sector experts in the field of digital policies and foresight studies. The final list of invitees includes experts from the above-mentioned entities, distributed as follows:

Figure 10. Experts' consultation – Affiliation of invited experts
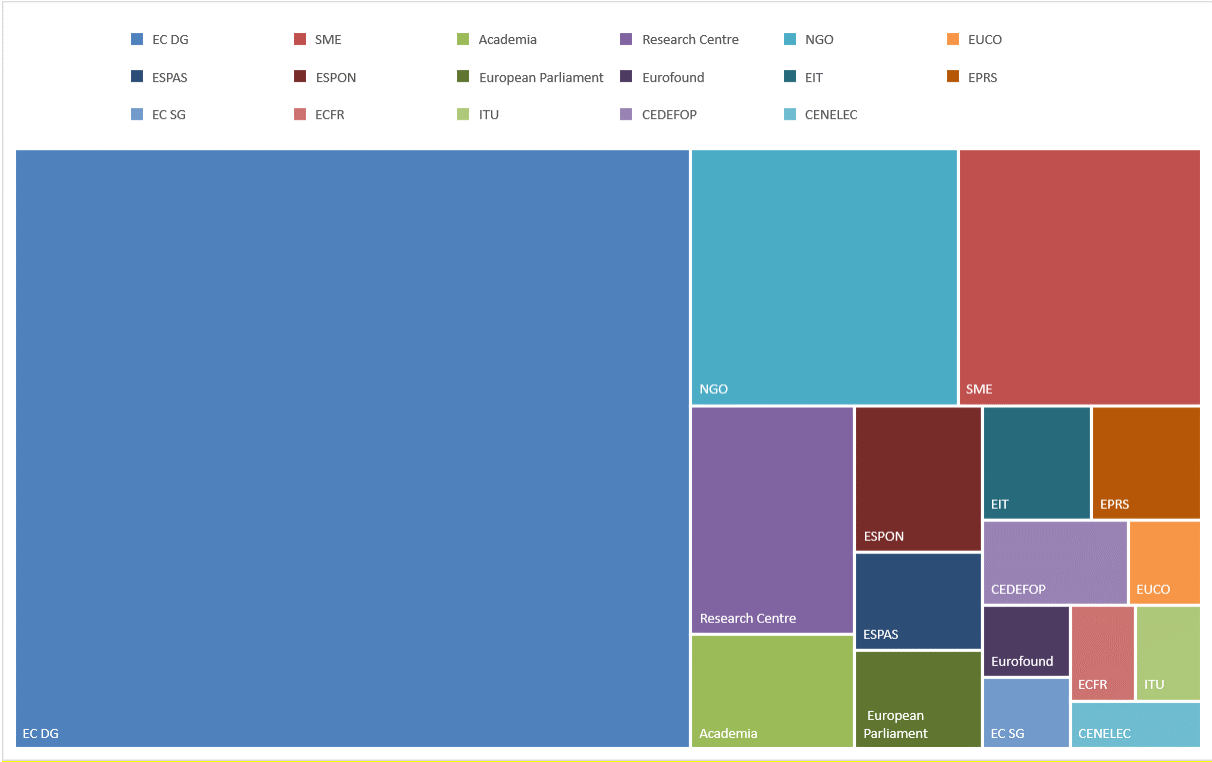
In total, the experts invited were 117. The consultation was structured into three parts: weak signals, wild cards and open contribution, and was aimed at getting feedback on the preliminary lists of 51 weak signals and 20 wild cards which were obtained with the horizon scanning. A total of 14 replies were received. The rate of response (12%) reflects the complexity of the survey and the time and dedication needed to complete it. The contributions gathered show a prevalence of respondents working at the European Commission, followed by ESPON officials.

Figure 11. Experts' consultation – Affiliation of respondents
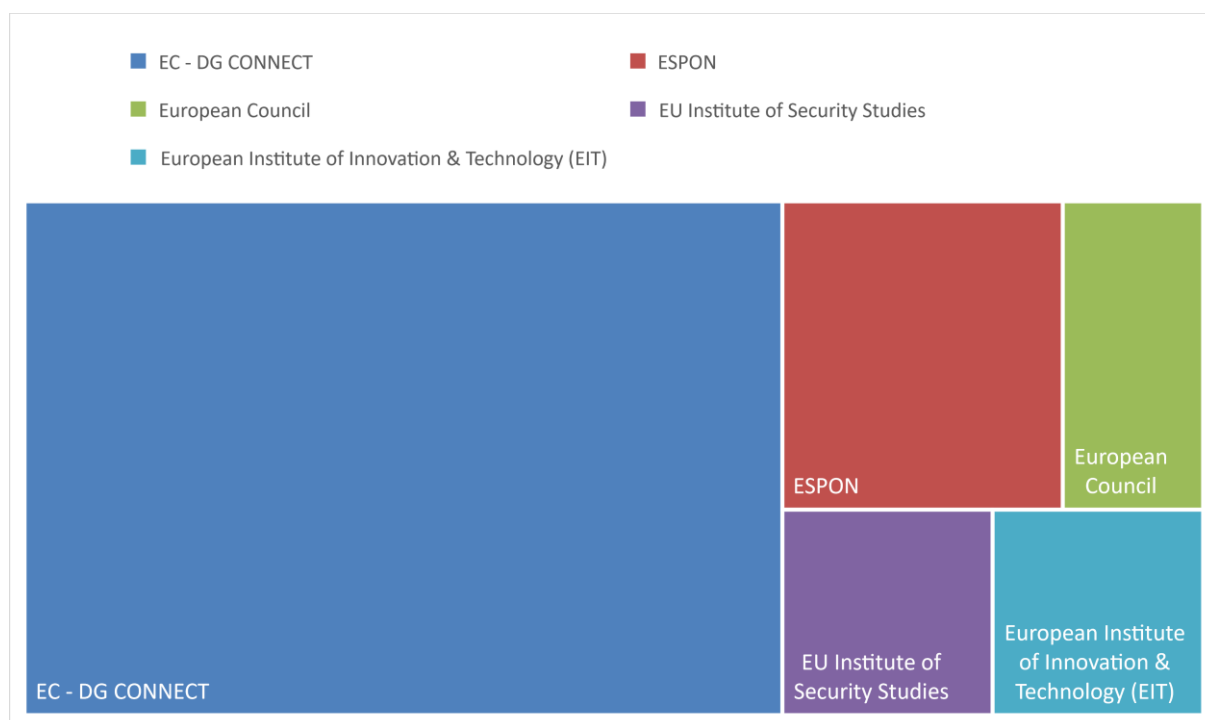
In the weak signals section, experts were asked to rate the relevance of each weak signal from not relevant (value 0) to very relevant (value 5). If the weak signal was considered relevant by the experts, another question followed, asking for the possible timespan for the weak signal to produce a significant impact. The choice was between short term - up to 5 years (value 1); medium term - from 6 to 15 years (value 2); and long term - from 16 to 30 years (value 3).

Each above-mentioned timespan was chosen with regard to the EC timeline, namely:

- Short span covers the timeline of the current Multiannual Financial Framework (MFF): 2021-2027.
- Medium span covers a period up to 2035 (i.e., the next MFF).
- Long span covers a period up to 2050, i.e., for a long perspective vision.

In the wild cards section, experts were asked to rate the relevance of each wild card from not relevant (value 0) to very relevant (value 5). Finally, the open contribution section aimed at gathering any suggestions on additional weak signals and wild cards.

CoR members' consultation

The CoR members' consultation was launched on 10 February 2022 and concluded on 11 March 2022. Thus, it ran for 30 days. The consultation was open

to all the CoR members, i.e., 329 members, and structured into three parts: weak signals, wild cards and open contribution.

This consultation aimed at gathering data on the regional dimension of digital cohesion and of the digital divide. CoR members were therefore proposed a list of 19 weak signals and eight wild cards. A total of 11 replies were received, equalling a low response rate of 3%. Despite six invitations and subsequent reminders to the members and political group secretariats in total, the response rate remained low. Figure 12 shows the nationalities of the CoR members who participated in the consultation.

In the weak signals section, CoR members were asked to rate the relevance of each weak signal from not relevant (value 0) to very relevant (value 5). If the weak signal was considered relevant by the respondents, another question followed, asking whether the impact of the rated weak signal on digital cohesion was positive or negative.

Figure 12. CoR consultation – Respondents' nationality
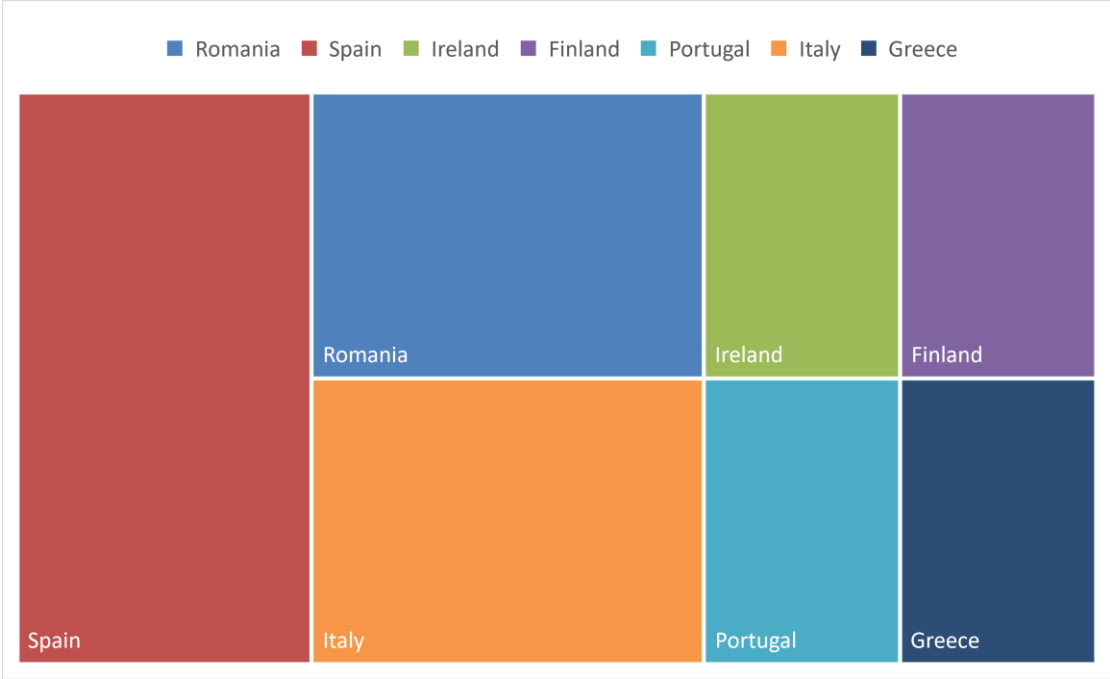
In the case of positive impact on digital cohesion, the respondents were asked which digital divide would be reduced the most. A maximum of three selections was possible among the following replies: between European regions / between urban and rural areas / between genders / between vulnerable and non-vulnerable groups / between younger and older people / between skilled and unskilled people / between SMEs and large enterprises / between rich and poor people. The respondents were also able to indicate other types of digital divides that could have been reduced in the case of the weak signal's occurrence.

In the wild cards section, CoR members were asked to rate the relevance of each wild card from not relevant (value 0) to very relevant (value 5). Finally, the open contribution section aimed at gathering any suggestions on weak signals and wild cards.

## 1.3 Weak signals potentially affecting the reduction of the digital divide in Europe

1.3.1 What is a weak signal?

The weak signal theory was developed to address corporate governance issues. In particular, it was used to investigate signals in the external environment which have the potential to influence business and would likely lead to threats or opportunities. Some of these signals were considered 'weak' due to their uncertainty and difficulty to be understood and observed (Ansoff, 1975). Weak signals are also referred to as 'seeds of change', providing, in a particular time and context, 'hints' about potentially important futures, including wild cards and emerging trends. Weak signals are *'unclear observables warning us about the possibility of future 'game changing' events'* and *'their 'weakness' is directly proportional to levels of uncertainty about their interpretations, importance and implications in the short-medium to long-term.'* (iKnow project).

A key aspect related to the weaknesses of these signals is the distance to the perceiver's reference frame (van Veen and Ortt, 2021). For example, before 2020, weak signals warning about a plausible worldwide pandemic can be found in scientific studies related to the risk of zoonotic disease outbreaks and propagation as well as in structural strategic foresight documents (Guntzburger, 2020; The Oracle Partnership, 2020). The US National Intelligence Council report 'Global Trends – Paradox of Progress' published in 2017, foresaw a potential pandemic in 2023 originating in East and Southeast Asia as *'several countries in the region are considered hotspots for the emergence of influenza virus of pandemic potential. The highly pathogenic avian virus H5N1 is endemic in poultry in China, Indonesia, and Vietnam, and has a high mortality rate in humans. The highly pathogenic virus H7N9 is also circulating in Chinese poultry, and an increased number of human cases have been seen since 2013.'* (National Intelligence Council, 2017).

1.3.2 The process for the identification of weak signals in this study

Since the detection of weak signals of potentially important developments (i.e., threats and opportunities) may suffer from the distance with the specific field of

expertise, the identification process within this study was carried out through the desk research of as many 'informed sources' as possible. Namely, these sources were a) sources related to foresight and future studies (horizontal approach) and b) sources related to frontier research in scientific and technological domains (vertical approach). The identification of weak signals in frontier research related to scientific and technological domains was based on the screening and selection of the outcomes of the work carried out in 2019 and in 2020 by the Joint Research Centre (JRC) of the European Commission. The JRC exercise was to detect very early signs of emerging technologies in specific scientific fields according to a quantitative methodology which combined text mining, scientometrics and domain knowledge applied to a corpus of peer-reviewed scientific articles of the Scopus database[6] published in the last two decades, patents and research projects funded through the EU framework programmes. Each signal identified by JRC is made available in the TIM Trends system (i.e., a monitoring system developed by JRC) with information about countries in which the identified weak signal is more frequent, the main industrial and academic actors involved, their level of maturity or the current trends and the potential future applications.

For the purpose of this study, weak signals identified by the JRC were screened and selected (filtering - phase 2) according to the confirmation principle (see section 1.1) (Schultz, 2006) and to their relevance to digitalisation/digital transformation and their societal implications. In particular, a link between the selected weak signals and the four components of the Digital Compass was investigated.

The screening of the seven JRC categories including 75 weak signals and four clusters of weak signals identified for 2020 (Eulaerts *et al.*, 2021) led to the selection of weak signals related to energy production, storage and distribution in the *Chemistry&Materials* category*;* weak signals related to computation and connectivity and their societal implication in the *ICT* category*;* and weak signals related to societal implication in the *Health* category and in the *Environment* category. In addition, we considered all the weak signals in the *Engineering&Physics* category and in the *Social Sciences* category as well as the three clusters of weak signals related to blockchain, neural networks and SARS-coV-2.
In addition, the analogous JRC work concerning weak signals in science and technology of the year before (i.e., 2019) (Eulaerts *et al.*, 2020) was used to integrate the previously selected set of weak signals. It adopted a slightly different

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[6] Scopus is a source-neutral abstract and citation database of 84+ million records with 58.5+ million post-1995 records, 18.0+ million open access items, including gold, hybrid gold, green & bronze, 10.9+ million conference papers, 47.4 million patent links, 27.1+ thousand active serial titles with 25.8+ thousand active peer-reviewed journals, 825+ book series and 249.0+ thousand books.

methodology and led to the identification of 256 weak signals classified into nine categories. Those included in the *Social Sciences* category and related to digital aspects were included.

Weak signals resulting from the screening and selection phases of the vertical approach were added to those identified through the horizontal approach. Starting from this set of weak signals, an aggregation and tailoring exercise combined similar/connected weak signals (in some cases, into clusters) and provided a user-friendly description of the weak signal, which is easily understandable also by non-experts in the domain. For example, *'6G Network', 'Disaggregated optical networks',* and *'Integrated Access and Backhaul (IAB) for 5G'* led to the weak signal '*Innovative wireless connectivity applications that extend the performance of the current 5G network (also favouring edge computing). Among them, the 5G network slicing in disaggregated optical networks, the Integrated Access and Backhaul (IAB) for 5G, the adoption of the 6G networks'.*

The aggregation and tailoring exercise conducted by the authors of this study led to a total of 51 weak signals potentially affecting digital cohesion in Europe that were further linked to the four pillars of the Digital Compass and/or classified as weak signals with societal relevance in the digital domain (Table 3). These 51 weak signals were proposed for validation to the first group of stakeholders: experts in the domain.

Table 3. List of the 51 weak signals potentially affecting digital cohesion in Europe proposed for the validation phase

	Weak Signal (WS) description	**WS's link with the four pillars of the Digital Compass and/or with societal relevance**
1	**New generation of batteries or ways to convert/store energy** that allow high energy density and long life cycle/high power density and are able to meet one of the shortcomings of today's batteries e.g., <u>aqueous zinc batteries</u>, <u>flexible zinc-air batteries</u>, <u>fluoride shuttle batteries</u>, batteries based on <u>lithium argyrodites</u> or on <u>lithium niobite</u>.	**Secure and sustainable digital infrastructure** (Data - Edge & Cloud)
2	**Innovative wireless connectivity applications that extend the performance of the current 5G network** (also favouring edge computing). Among them, the 5G network slicing in <u>disaggregated optical networks</u>, the <u>Integrated Access and Backhaul (IAB) for 5G</u>, the adoption of the <u>6G networks</u>.	**Secure and sustainable digital infrastructure** (Connectivity)

	Weak Signal (WS) description	WS's link with the four pillars of the Digital Compass and/or with societal relevance
3	**Enabling technologies** (based on 5G architecture and useful for IoT) **allowing efficient data collection and high-speed cloud computing capabilities at the edge of the network** with a reduction of network latency and traffic (e.g., <u>multi-access edge computing</u>, <u>over-the-air computation</u>).	**Secure and sustainable digital infrastructure** (Data - Edge & Cloud). **Digital transformation of businesses** (Tech up-take, Late adopters) **Digitalisation of public services** (Key Public Services)
4	**Emerging applications of <u>blockchain</u>** allowing data transactions between two parties and avoiding data alteration.	**Secure and sustainable digital infrastructure** (Data - Edge & Cloud) **Digital transformation of businesses** (Tech up-take, Late adopters) **Digitalisation of public services** (Key Public Services, Digital Identity)
5	**Emerging applications of <u>neural networks</u> to improve speed and save energy in computational tasks and to perform effective machine learning.** Examples are photonic neural networks inspired by the structure of the human brain (<u>neuromorphic photonics</u>) or <u>Siamese networks for object tracking</u>**.**	**Secure and sustainable digital infrastructure** (Data - Edge & Cloud) **Digital transformation of businesses** (Tech up-take, Late adopters) **Digitalisation of public services (Key Public Services)**
6	Although the SARS-coV-2 is not something unpredictable and unexpected, there is a **significant number of weak signals related to some social and technological implications of the current SARS-coV-2 pandemic** (e.g., <u>community quarantine</u>, <u>health crises</u>, <u>social lockdown</u>, <u>digital contact tracking</u>, <u>emergency remote teaching</u>).	**Secure and sustainable digital infrastructure** (Connectivity) **Digital transformation of businesses** (Tech up-take, Late adopters) **Digitalisation of public services** (Key Public Services, health). **Societal**
7	**Integration of energy and ICT networks** leading to an <u>Enernet</u> concept. This is the convergence of electricity smart grids with the Internet of Things (IoT), making the emerging network of distributed and interactive energy network the largest IoT.	**Secure and sustainable digital infrastructure** (Connectivity)
8	<u>**Indoor photovoltaics**</u> **as one of the promising technologies to power connected devices (IoT) in indoor environments** (characterised by artificial light sources).	**Secure and sustainable digital infrastructure** (Connectivity)

	Weak Signal (WS) description	WS's link with the four pillars of the Digital Compass and/or with societal relevance
9	Optical wireless power transmission as one of the **emerging options for electricity distribution**. It is a way to charge aerial drones as well as implanted medical devices.	**Secure and sustainable digital infrastructure** (Connectivity) **Digitalisation of public services** (e-health)
10	**Multiplying of IoT malware** as malicious software which is threatening the functioning of the IoT.	**Secure and sustainable digital infrastructure** (Data - Edge & Cloud) **Digital transformation of businesses** (Tech up-take, Late adopters) **Digitalisation of public services** (Key Public Services)
11	The global drive for greener energy production is spurring towards **innovative electrochemical energy devices with an optimized ratio energy density/emissions**. Urea oxidation reaction in fuel cells is promising due to a number of factors such as the abundance of urea in wastewaters and low-cost catalysts.	**Secure and sustainable digital infrastructure** (Data - Edge & Cloud)
12	**New classes of quantum systems and technologies** are currently being explored by mixing photonics, electronics, and spintronics. Optomagnonic has a key role in these applications.	**Secure and sustainable digital infrastructure** (Computing)
13	**Free public access to prototype quantum processors** such as the IBM Quantum processors used for the experiments of the online platform 'IBM Quantum Experience'.	**Secure and sustainable digital infrastructure** (Computing)
14	Federated learning as one of the **emerging machine learning techniques for training computing models** with data collected by devices at the edge (e.g., mobile devices) also guaranteeing privacy for data owners.	**Digitalisation of public services** (Key Public Services, Digital Identity)
15	**Evolutions of cloud computing offloading the management and server configuration from the user to the provider** (e.g., serverless computing).	**Secure and sustainable digital infrastructure** (Data - Edge & Cloud) **Digital transformation of businesses** (Tech up-take, Late adopters) **Digitalisation of public services** (Key Public Services)
16	**New AI techniques developed for geospatial data management, processing, analysis, modelling, and visualization**. Geospatial AI results from a combination of geospatial	**Secure and sustainable digital infrastructure** (Data - Edge & Cloud) **Digital transformation of businesses**

	Weak Signal (WS) description	WS's link with the four pillars of the Digital Compass and/or with societal relevance
	computing, big data and Artificial Intelligence (AI).	(Tech up-take. Last adopters) **Digitalisation of public services** (Key Public Services, Digital Identity)
17	**Standardised Vehicle-to-everything communication** (Cellular V2X) as an enabling technology allowing vehicles to share information with other vehicles, pedestrians, road-side equipment and the vast amount of data available on the internet. Advantages are improved safety, a decrease in traffic congestion and lower environmental impacts.	**Secure and sustainable digital infrastructure** (Connectivity) **Digitalisation of public services** (Key Public Services)
18	**Unmanned Aerial Vehicles (UAVs)** have the potential to revolutionise business models of various sectors (e.g., energy, healthcare) by operating as wireless relays to improve connectivity, providing **communication** within and between networks of connected devices on the ground.	**Secure and sustainable digital infrastructure** (Connectivity) **Digital transformation of businesses** (Tech up-take, Innovators, Late adopters)
19	AI Based Healthcare: aside from data management, **AI can also improve the accuracy of diagnoses and monitor a patient's condition and treatment**.	**Secure and sustainable digital infrastructure** (Data - Edge & Cloud) **Digitalisation of public services** (e-health)
20	Neuralnanorobotics as devices injected into the vascular system to monitor electrical information that passes between synapses and neurons. The result is an **interface between the brain and the cloud**.	**Digitalisation of public services** (e-health)
21	Wearable biosensors as tools for **remote monitoring of human health by on-the-skin detection** (e.g., sweat, tears, saliva) in a non-invasive manner.	**Secure and sustainable digital infrastructure** (Data - Edge & Cloud) **Digitalisation of public services** (e-health)
22	**Large-scale group decision-making** processes needed for the increasing complexity of society and favoured by new technologies and communication means.	**Secure and sustainable digital infrastructure** (Connectivity) **Digitalisation of public services** (Key Public Services, Digital Identities) **Societal**
23	Nature's Contribution to People as one of the **new approaches in decision-making** that aims at including the evaluation of nature's contribution to people and society when designing new policies.	**Societal**

	Weak Signal (WS) description	WS's link with the four pillars of the Digital Compass and/or with societal relevance
24	Infodemic as a **disinformation pandemic leading to the dissemination of fake news, hoaxes, misleading content and conspiracy theories** related to the Covid-19 pandemic.	**Societal**
25	Digital constitutionalism as **a way to identify how values of good governance and public good can be protected in the digital age.** This implies a rethinking and a redefinition of the limits of the exercise of power in a networked society.	**Digitalisation of public services** (Key Public Services) **Societal**
26	Civic technologies (based on IoT and AI) as **tools to inform, engage and connect citizens with their government and to improve public governance.**	**Secure and sustainable digital infrastructure** (Connectivity) **Digitalisation of public services** (Key Public Services, Digital Identity) **Societal**
27	Behavioural public administration approach as **a psychological method which investigates the political administrative settings** and focuses on cognitive and decision biases and discriminations by bureaucrats, interactions between citizens and bureaucrats, and psychological effects of public service failure.	**Digitalisation of public services** (Key Public Services, Digital Identity) **Societal**
28	Digital vigilantism as an **emerging practice for societal vigilantism carried out by citizens using IT technologies** (i.e., a parallel criminal justice with no moral or legal legitimacy).	**Societal** **Digitalisation of public services** (Key Public Services, Digital Identity)
29	Deepfake as an **emerging practice to make realistic fake videos or images** based on various face-swapping technologies.	**Societal**
30	Algorithmic fairness as a **response to the fairness bias of AI and the so-called 'black box' algorithms.** More fairness, accountability and transparency in AI is needed as algorithms can be sexist, racist and perpetuate other inequalities found in society.	**Secure and sustainable digital infrastructure** (Data - Edge & Cloud) **Societal**
31	Algorithmic journalism (also called 'robot journalism') as **the automated production of news in journalism by algorithms that edit, aggregate, publish, and distribute content.**	**Societal**
32	Immersive journalism (also called virtual reality journalism) as **a new form of journalism that uses Virtual Reality (VR) and similar technologies to bring news to people through virtually reconstructed scenarios of real events**.	**Societal**

	Weak Signal (WS) description	WS's link with the four pillars of the Digital Compass and/or with societal relevance
33	Digital humanitarianism as **a new approach based on digital and mobile technologies as well as social media for humanitarian crisis management**. It is also a source of complementary information on a crisis outside of the official channels.	**Societal**
34	Drug cryptomarkets as a **growing channel for drug diffusion, both in terms of volume and of variety where buyers remain anonymous using cryptocurrencies as payment means.**	**Societal**
35	**Cryptocurrencies price predictions as a way to reduce price volatility** by allowing decisions makers (e.g., investors, policymakers) to properly act and regulate these markets.	**Societal**
36	Small private online courses (SPOCs) complementing traditional teaching and massive open online courses (MOOCs) as a **recent approach adopted in digital learning which favours students-teachers interaction.**	**Societal**
37	**Automated driving of vehicles** as an evolution of the human-led vehicles with a smart take-over request in self-driving to the driver to take back control of the vehicle in specific traffic situations.	**Societal**
38	**Fluid and mixed identity as a concept that can challenge the institutional framework**. Many people no longer identify themselves within specific categories (e.g., gender).	**Societal**
39	Automated decision-making conducted by machines leading to high-stakes outcomes through **a data-driven decision-making process that is not influenced by humans.**	**Secure and sustainable digital infrastructure** (Data - Edge & Cloud) **Digital transformation of businesses** (Tech up-take) **Digitalisation of public services** (Key Public Services)
40	European legislation for the 'Right to Repair': as a result of the new laws, **manufacturers of electric and electronic goods** (such as televisions and refrigerators) **in Europe will be legally obligated to ensure repair for up to 10 years,**	**Secure and sustainable digital infrastructures** (Connectivity)
41	**Direct-to-avatar (D2A) business model** and virtual possessions: virtual products are emerging along with their corresponding digital brands, bypassing material reality.	**Digital transformation of businesses** (Tech up-take; Innovators; Late adopters)

	Weak Signal (WS) description	WS's link with the four pillars of the Digital Compass and/or with societal relevance
42	**Gaming** as new market for Cultural and Creative Industries: since gaming is replacing television and entertainment, brands and marketers are taking advantage of the gaming industry to reach a worldwide audience.	**Digital transformation of businesses** (Tech up-take; Innovators; Late adopters)
43	**The metaverse workforce**: the desire for location-defying technology that provides true social presence appears to be a priority for many companies.	**Digital transformation of businesses** (Tech up-take; Innovators; Late adopters) **Societal**
44	**The environmental impact of cryptocurrencies mining**. Currently it generates about 96 million tons of carbon dioxide emissions each year.	**Societal**
45	**Legal rights for robots** which are more and more designed to emulate humans, some are also being created using biomaterials.	**Societal**
46	**Digital afterlife industry and digital reincarnation** is possible through the data collected by industries which manage profiles of the deceased individuals.	**Societal**
47	**Death-predicting technologies** as scientific approaches to estimate how much time an individual has left to live.	**Societal**
48	IoT impacting the device's design and interaction by distributing the user experience across multiple devices, with many no longer including a digital interface.	**Societal**
49	Space debris resulting from the increasing **use of satellites** by the private sector to provide new digital services. The Earth's orbit is full of inactive satellites, putting other satellites and the population at the global level in danger.	**Secure and sustainable digital infrastructure** (Connectivity)
50	Universal Basic Income can enable all citizens to **financially afford the opportunities provided by the digital transformation.**	**Societal**
51	**Anti-tourism movements organised, vocal, and active at a political level generated by the pressure of tourism on local populations**. Tourism phobia leads tensions due to social, economic or environmental changes in territories of touristic destinations.	**Societal**

Source: authors' aggregation and tailoring exercise.

Within this study, validation (phase 3 – assessment) aims at selecting the most relevant weak signals and, at the same time, at collecting indications about the temporal horizon over which their occurrence is expected.
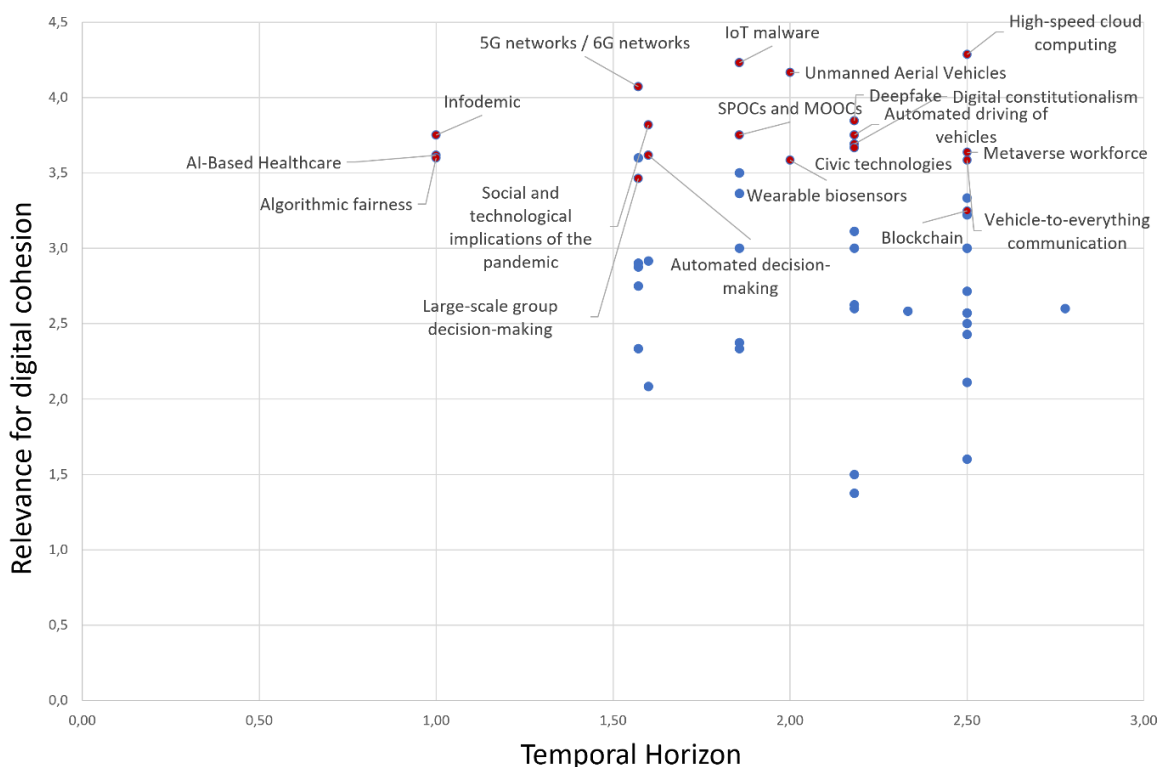
1.3.3 The validation of weak signals

Validation has gone through two stages. In the first stage weak signals were validated by domain experts. This validation exercise resulted in a list of the most relevant weak signals according to the experts' opinion. This selection was then submitted to the CoR members for further validation, taking into account a political perspective and gathering additional information on the weak signal impact on digital cohesion (positive or negative) and on the digital divide reduced the most by the weak signal (i.e., between European regions; between urban and rural areas; between genders; between vulnerable and non-vulnerable groups; between younger and older people; between skilled and unskilled people; between SMEs and large enterprises; between rich and poor people).

Only weak signals receiving a relevance higher than 3 (the relevance range was 0-5) were considered in the computation of replies. For validation purposes, the number of replies over 3 out of the total number of replies had to be over 50%. The outcome was a short list of 19 weak signals selected by the experts' consultation.

In Figure 13, the average value of each weak signal rated during the first consultation is presented. The X-axis reports the temporal horizon of occurrence, while the Y-axis shows the rate of each weak signal's relevance for digital cohesion.

Figure 13. List of the 19 weak signals selected by the experts' consultation

All of these 19 weak signals were then submitted for the validation of the CoR members. Table 4 reports the WSs validated by the consultations. In the first column of the table, the numbering of the weak signals tailored by the authors is followed in square brackets by the new numbering of the 19 weak signals selected through the consultations. In the second column, the complete name of the weak signal is followed in square brackets by the short name used in this study.

**Table 4. List of the 19 weak signals validated by the consultations**

#	Weak Signal	Responses' relevance >3			
		Experts		**CoR members**	
		Number	**%**	**Number**	**%**
2 [WS#1]	Innovative wireless connectivity applications that extend the performance of the current 5G network (also favouring edge computing). Among them, the 5G network slicing in disaggregated optical networks, the Integrated Access and Backhaul (IAB) for 5G, the adoption of the 6G networks. [5G network / 6G networks]	11	79%	9	82%
3 [WS#2]	**Enabling technologies** (based on 5G architecture and useful for IoT) **allowing efficient data collection and high-speed cloud computing capabilities at the edge of the network** with a reduction of network latency and traffic (e.g., multi-access edge computing, over-the-air computation). [High-speed cloud computing]	11	79%	9	82%
10 [WS#5]	**Multiplying of IoT malware** as malicious software which is threatening the functioning of the IoT. [IoT malware]	11	79%	6	55%
18 [WS#7]	**Unmanned Aerial Vehicles (UAVs)** have the potential to revolutionise business models of various sectors (e.g., energy, healthcare) by operating as wireless relays to improve connectivity, providing communication within and between networks of connected devices on the ground. [Unmanned Aerial Vehicles]	11	79%	10	91%
22 [WS#10]	Large-scale group decision-making processes needed for the increasing complexity of society and favoured by new technologies and communication means. [Large-scale group decision-making]	9	64%	7	64%

24 [WS#11]	Infodemic as a disinformation pandemic leading to the dissemination of fake news, hoaxes, misleading content and conspiracy theories related to the Covid-19 pandemic. [Infodemic]	9	64%	8	73%
25 [WS#12]	Digital constitutionalism as a way to identify how values of good governance and public good can be protected in the digital age. This implies a rethinking and a redefinition of the limits of the exercise of power in a networked society. [Digital constitutionalism]	9	64%	5	45%
29 [WS#14]	Deepfake as an emerging practice to make realistic fake videos or images based on various face-swapping technologies. [Deepfake]	9	64%	9	82%
36 [WS#16]	Small private online courses (SPOCs) complementing traditional teaching and massive open online courses (MOOCs) as a recent approach adopted in digital learning which favours students-teachers interaction. [SPOCs and MOOCs]	9	64%	9	82%
37 [WS#17]	Automated driving of vehicles as an evolution of the human-led vehicles with a smart take-over request in self-driving to the driver to take back control of the vehicle in specific traffic situations. [Automated driving of vehicles]	9	64%	10	91%
39 [WS#18]	Automated decision-making conducted by machines leading to high-stakes outcomes through a data-driven decision-making process that is not influenced by humans. [Automated decision-making]	9	64%	7	64%
6 [WS#4]	Although the SARS-coV-2 is not something unpredictable and unexpected, there is a significant number of weak signals related to some social and technological implications of the current SARS-coV-2 pandemic (e.g., community quarantine, health crises, social lockdown, digital contact tracking, emergency remote teaching). [Social and technological implications of the pandemic]	8	57%	7	64%

17 [WS#6]	Standardised Vehicle-to-everything communication (Cellular V2X) as an enabling technology allowing vehicles to share information with other vehicles, pedestrians, road-side equipment and the vast amount of data available on the internet. Advantages are improved safety, a decrease in traffic congestion and lower environmental impacts. [Vehicle-to-everything communication]	8	57%	9	82%
19 [WS#8]	AI Based Healthcare: aside from data management, AI can also improve the accuracy of diagnoses and monitor a patient's condition and treatment. [AI-Based Healthcare]	8	57%	9	82%
21 [WS#9]	Wearable biosensors as tools for remote monitoring of human health by on-the-skin detection (e.g., sweat, tears, saliva) in a non-invasive manner. [Wearable biosensors]	8	57%	9	82%
26 [WS#13]	Civic technologies (based on IoT and AI) as tools to inform, engage and connect citizens with their government and to improve public governance. [Civic technologies]	8	57%	10	91%
30 [WS#15]	Algorithmic fairness as a response to the fairness bias of AI and the so-called 'black box' algorithms. More fairness, accountability and transparency in AI is needed as algorithms can be sexist, racist and perpetuate other inequalities found in society. [Algorithmic fairness]	8	57%	8	73%
43 [WS#16]	The metaverse workforce: the desire for location-defying technology that provides true social presence appears to be a priority for many companies. [Metaverse workforce]	8	57%	7	64%
4 [WS#3]	Emerging applications of blockchain allowing data transactions between two parties and avoiding data alteration. [Blockchain]	7	50%	7	64%

These weak signals have then been rated by the experts involved in the first consultation and by CoR members in the second consultation. Both consultations' results have been consolidated by selecting the ones with the highest relevance (rate >3) out of the number of total responses. The selection considered only the weak signals having a >50 percentage derived from consolidation. The main variations between the two consultations are shown in Figure 14.

Figure 14. Comparison between the two consultations' results
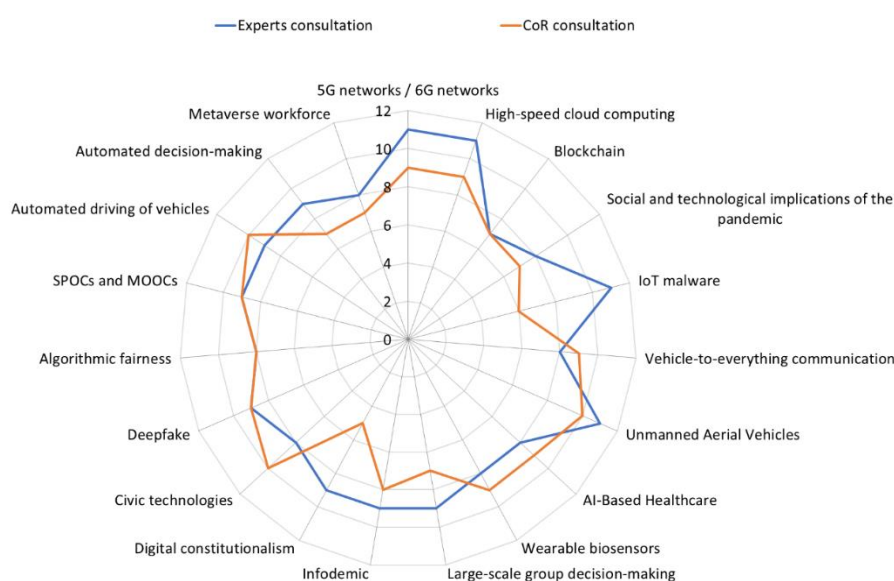
It is interesting to note that according to this criterion the second consultation addressing CoR members found WS#5 'IoT malware' and WS#12 'Digital constitutionalism' less relevant (-24% and -19%, respectively) for digital cohesion. Another important difference can be reported for WS#13 'Civic technologies' whose impact increased significantly (+34%).

1.4 Wild cards potentially affecting the reduction of the digital divide in Europe

The identification of wild cards impacting on the reduction of the digital divide in Europe does not pretend to predict which shocks are more likely to occur. Instead, the intent is to provide policymakers who are working towards digital cohesion with a knowledge base about what may possibly affect their actions in the future. The final aim is to strengthen the capacity of European institutions at any administrative level to cope with negative effects when disruptive events occur and to exploit the positive effects of other unexpected developments.

1.4.1 What is a wild card?

The first definition of 'wild card' in literature is attributed to a publication 30 years ago by BIPE Conseil, the Copenhagen Institute for Futures Studies and the Institute for the Future. As is true for the weak signals, it again concerned the 'business context' (Steinmüller, 2003): *A wild card is a future development or event with a relatively low probability of occurrence but a likely high impact on the conduct of business'*. Low probability of occurrence and high impact are key

features of wild cards as well as of the so-called *'black swans'*. Sometimes these concepts are defined and used interchangeably, but towards the scope of this study we highlight the clear distinction between the two. Black swans are extraordinary events, unexpected from the point of view of today's condition of knowledge (Aven, 2013). Wild cards are consequences of past weak signals which were ignored or not taken properly into account. *'...an imminent wild card occurrence can only be detected by deciphering weak signals, which will successively strengthen. However, these are rarely given sufficient attention.'* (Grünwald *et al.*, 2021). This distinction implies that the proper monitoring of weak signals over time can allow policymakers to be prepared for the wild cards' occurrence. Nevertheless, most of the wild cards considered in a certain period of time will never happen, others are considered threats or opportunities for years, and only a very small number of wild cards occur.

The occurrence of a wild card usually has a 'new normal' as a consequence that is characterised by different structural framing conditions in which past weak signals lose relevance and others deserve more attention (Box 1). Before 2020, a global pandemic was considered a wild card and very few political leaders in the world promptly reacted to weak signals related to Covid-19 (The Oracle Partnership, 2020). The occurrence of a new pandemic in the near future will no longer be considered a wild card since weak signals of pandemics are likely to be less neglected and the occurrence of analogous events have entered into the collective expectations in short-, medium- and long-term horizons. In the future, when the Covid-19 outbreak is labelled as a historical event (disappearing from the societal collective memory as it was for the Spanish Flu affecting most of the world in 1918-1920), global pandemics will once again be considered wild cards.

Box 1. Examples of wild cards that have occurred in the past

There is a common habit of considering wild cards as negative events. Examples in the recent past are the 2001 terrorist attacks in the United States and the 2011 Fukushima nuclear disaster ([iKnow project](#)). However, wild cards also include disruptive positive developments that in a certain historical moment radically affected societies from the political, economic, social, technological, legal and/or environmental viewpoint. The discovery of penicillin by Fleming is an example of a positive wild card ([iKnow project](#)).

1.4.2 The process for the identification of wild cards in this study

The identification of potential wild cards requires both an analytical and creative effort (Grünwald *et al.*, 2021). The analytical work carried out for this study relied on a mix of widely adopted methodologies for exploring and filtering already identified wild cards (phase 2 and 3 of the HS model). The exploration phase was essentially based on desk research. Screening covered different types of secondary sources (e.g., news in journals, scientific papers, project reports) published over

the last 15 years. In most of the cases, these sources were collecting wild cards from other sources. The screening exercise produced a set of 76 potential wild cards related to political (P), economic (Ec), social (S), technological (T), legal (L) and environmental (En) domains. Wild cards range from climate change effects due to the disruption of the Gulf Stream (En) to the rise of artificial intelligence against humans' interests (T), from the revival of monarchies (P) to the crash of global financial markets (Ec). Only some of the wild cards identified in the exploration phase were explicitly related/connected to one or more weak signals anticipating their potential occurrence.

The approach based on desk research has the advantage of leading to an important number of wild cards. Still, these wild cards may have limited relevance towards the policy target of digital cohesion in Europe. Thus, it was necessary to filter the identified wild cards in order to define a more significant subset. The filtering process foresaw three steps that were applied to every potential wild card in the set. Each of the steps aimed at answering a specific question.

1. *Is it a true wild card?* Answers were provided by strictly applying five properties of wild cards identified starting from Steinmüller and Steinmüller (2004). Wild cards: 1. are serious events and/or developments with exponential acceleration that make it impossible to 'carry on with business as usual'; 2. are considered unlikely in public discourse and assessment of their likelihood makes no sense; 3. are surprises for most of the stakeholders of the community that they affect; 4. have far-reaching effects impacting wide territories and/or entire economic systems with consequences that persist far beyond the immediate shock and entail higher-order knock-on effect. 5. are *'future quakes'* disrupting the reference frameworks and systems and forcing a change of the current paradigm and, in turn, of the future framing conditions.

2. *Is it only a potential wild card of the past?* Answers strongly depend on when a specific wild card was identified and if it occurred. Sources from 10 years ago may report events or developments as wild cards that today are no longer associated with any weak signal.

3. *Do policies for achieving digital cohesion in Europe make sense after the occurrence of this wild card?* In this filtering step, two types of wild cards were excluded: a) apocalyptic wild cards (e.g., an asteroid impacting the earth and initiating a new glacial era) and b) highly improbable wild cards (e.g., contact with an extra-terrestrial civilisation).

Potential wild cards resulting from the filtering phase were subject to an aggregation exercise and to a tailoring experiment. Aggregation led to a combination of similar/connected potential wild cards. For example, *'Extreme*

spatial concentration' and *'Agriculture on much less space'* led to the wild card *'Soil as a key resource - due to climate change effects occurring suddenly (in a few months), territories in Europe where people can live and/or where agriculture/livestock are possible are very limited'.*

The tailoring experiment requested a creative effort to design wild cards that have to maintain *'a higher degree of plausibility and a stronger reference to the present'* (Grünwald *et al.*, 2021). In the context of this study, this experiment aimed at guaranteeing that any wild card a) was relevant for the European context (e.g., having a direct and concrete impact in Europe or its territories when occurring); b) was self-explanatory also for stakeholders not considered experts in the field. This experiment, carried out within the study team through brainstorming, is the part of the approach that mostly requested imagination although it was supported by practices already adopted in analogous works and/or in other domains.

The aggregation exercise and the tailoring phases conducted by the authors of this study led to a set of 20 wild cards that were, at the same time, classified according to the PESTLE (political, economic, social, technological, legal and environmental) domains to which they belong (see Table 5). It was not possible to assign only one domain to each wild card, but this multi-domain classification carried out through the study team's brainstorming was instrumental in understanding the main fields requiring actions to cope with negative effects or to exploit the positive effects of each wild card. Similarly to the weak signals, these 20 wild cards were proposed for validation.

Table 5. List of the 20 wild cards potentially affecting digital cohesion in Europe proposed for the validation phase

#	Wild Card name	Wild Card type
1	**A disruptive digital pandemic** - a super virus collapses the internet.	PES**T**LE
2	**Failure of Europe** - the majority of the EU citizens wants to return to the monarchies, favours nationalist regimes or is in favour of the independence of their territories.	**PES**TLE
3	**AI out of control** - public and private services almost unavailable for weeks.	PE**S**TLE
4	**Extreme automation in the public sector** - crisis of confidence on justice and rule of law.	PE**STL**E
5	A **geomagnetic storm causes** an electronic apocalypse.	PESTL**E**
6	**Massive and sudden immigration** within Europe as a consequence of a war conflict in the eastern borders.	**PE**S**T**E
7	**Energy becomes a luxury good** - prices have increased preventing daily energy use by a large part of the European population.	**PE**S**T**E
8	**European Union beyond the European borders** - EU enlargement goes east (CIS countries) and south (Mediterranean countries).	**P**ES**T**E

9	**End of Moore's Law** - physical constraints prevent additional developments of digital technologies.	PESTLE
10	**Homo Deus** - a new transhumanist religion is gaining massive importance in Europe.	PESTLE
11	**Europe becomes Africa** - all territories suffer a drought which lasts years.	PESTLE
12	**China unilaterally takes world power** - trades and commerce of key resources for Europe are strongly affected.	PESTLE
13	**A nuclear disaster in the heart of Europe** - almost half of the EU citizens forced to isolation.	PESTLE
14	**Cities become an old-style concept** - urban demographic concentration is no longer a reality in Europe.	PESTLE
15	**Emergence of EU identity** - nationalities are no longer relevant.	PESTLE
16	**Soil as a key resource** - due to climate change effects occurring suddenly (in a few months), territories in Europe where people can live and/or where agriculture/livestock are possible are very limited.	PESTLE
17	**Real economy is back** - crash of global financial markets making them no longer reliable.	PESTLE
18	**A fast-growing European population** - a new baby-boom occurs suddenly.	PESTLE
19	**Virtual immortality** - individuals survive in the digital world through their digital alter-egos.	PESTLE
20	**European Union beyond the earth** - Europe as a coloniser of space.	PESTLE

Source: authors' brainstorming outcome.

The validation phase of these wild cards aimed to propose a very focused list of wild cards whose occurrence should be properly taken into account by European policymakers when considering threats and opportunities for increasing digital cohesion in the future.

1.4.3 The validation of wild cards

For the assessment (phase 3) of the wild cards, the results have been weighted by selecting the ones with the relevance >2 out of the number of total responses. The choice to adopt a different weighting from the weak signals is motivated by the particular nature of the wild cards, having a perceived less relevance because of the unpredictability of their occurrence. Moreover, the selection considered only those wild cards which have a >50 percentage derived from this weighting. The outcome is a shortlist of eight wild cards.

These wild cards have then been rated by the CoR members in the second consultation. As was the case for the first consultation, the results of the CoR members' consultation have been weighted by selecting the ones with the relevance rate >2 out of the number of total responses. A comparison between the two consultations is reported in Table 6. In the first column of the table, the numbering of the wild cards tailored by the authors is followed in square brackets by the new numbering of the eight wild cards selected through the consultations.

In the second column, only the short name of the wild card used in this study is reported.

Table 6. The list of the 8 wild cards validated by the consultations

#	Wild Card	Responses' relevance >2			
		Experts		CoR members	
		Number	%	Number	%
1 [WC#1]	A disruptive digital pandemic	11	79%	11	100%
3 [WC#2]	AI out of control	10	71%	9	82%
4 [WC#3]	Extreme automation in PA	8	57%	10	91%
6 [WC#4]	Massive immigration within Europe	8	57%	10	91%
9 [WC#5]	End of Moore's Law	8	57%	9	82%
2 [WC#6]	Failure of Europe	7	50%	8	73%
7 [WC#7]	Energy as a luxury good	7	50%	11	100%
8 [WC#8]	EU enlargement	7	50%	11	100%

It is important to take into consideration the disruptive nature of wild cards and to understand as much as possible what the consequences of each wild card could be. Hereinafter are reported some considerations stemming from the scientific literature that can provide an overview of their impact on digital cohesion.

WC#1 'A disruptive digital pandemic'

Digital pandemic or cyberpandemic is a serious threat for digital cohesion. The occurrence of such an event has been explored by the scientific community and by the relevant European bodies (Bocayuva, 2021). Scientific literature claims that a digital pandemic would trigger second- and third-order failures of computing and non-computing systems worldwide with consequences of widespread failure or malfunctioning of critical infrastructure systems and associated major societal damage (Voas and Laplante, 2020), even greater than the one caused by Covid-19: a single day without the internet would cost the world more than $50 billion (Davis and Pipikaite, 2020). Currently, also due to the pandemic and the Ukraine conflict, the trend of cyberattacks is increasing: EU's cybersecurity agency ENISA reports the detection of 230,000 new strains of malware every day (ENISA, 2020). The threat is so real that many experts from the private sector and from institutions have already recently raised warnings,

asking for better preparedness (Reich, 2020; Caulier, 2021; Yager, 2013). Risks for the public administrations mainly regards the personal data collected and the management of the digital identity, while for the private sector besides the interception and exposure of data, there are growing concerns on possible intrusions and consequences related to the AR/VR environments (Sindelar and Ferguson, 2021). In any case, it is very likely that a potential cyberpandemic will occur in multiple-hazard scenarios that can also include one or more non-cyber components in the attack.

WC#2 'AI out of control'

Before even becoming an actual science domain, for a long time AI has been one of the most exploited themes in science fiction. Nevertheless, it is clear that AI going uncontrolled can have a significative impact on digital cohesion. Many experts have expressed concerns and warnings on the negative consequences of AI, in particular referring to AGI (Artificial General Intelligence, a hypothetical AI able to match human capabilities) (Baum, 2017) or to Singularity (a hypothetical point in time at which technological growth becomes uncontrollable and irreversible) (Kluge Corrêa and De Oliveira, 2021). There is not a consensus within the scientific community on if and when AGI/Singularity can be achieved, yet its occurrence had scared many eminent personalities over the years, including Alan Touring, Bill Gates, Tim Berners-Lee - founder of the World Wide Web, Elon Musk, Steve Wozniak, Stephen Hawking and many others (Wired, 2015). However, many scientists reject the singularity concept on account that it is not grounded in any scientific or technological fact (Galeon, 2018). Furthermore, other scientists are confident that the temporal horizon is still far off (Dilmegani, 2022) and that scientists developing AI are following and will continue to follow a set of shared rules which prevent possible threats (EP, 2018), including all the ethical and social implications (EP, 2020).

WC#3 'Extreme automation in PA'

In the years to come, the automation of decision-making procedures and services in public administrations is likely to increase exponentially. Citizens demand user-friendly services that are simple, easily accessible and always available. Administrations regard automation as a chance to accelerate efficiency, facilitate processes and expedite mass and routine services (Smith *et al.*, 2010). Even though an extreme automation in the public sector is still unlikely, the occurrence of an extreme automation of public administration would clearly have important implications for digital cohesion. Major concerns (Zeynep, 2019) relate to the security of the data used, the privacy issues in the collection and integration of the data and the lack of transparency in the AI processes, posing legal (Bundin *et al.*, 2018) and ethical problems.

WC#4 'Massive immigration within Europe'

The war in Ukraine is causing a large-scale migration in Europe, concerning, according to an estimation of the United Nations Refugees Agency retrieved in May 2022, over 4 million refugees who are fleeing to neighbouring countries (UNHCR Operational Data Portal, 2022). Such a massive movement of people, not seen in Europe since World War II, will probably impact European politics more than the migration crisis of 2015 (Culbertson, 2022*)* when 1.3 million migrants (Connor, 2016) applied for asylum, seeking to escape wars in the Middle East and hardship in Africa. In addition, the EU can expect serious consequences from the sanctions the European Commission is imposing on Russia. The event, which is no longer a wild card, will have consequences in all the dimensions, including digital cohesion. One of the most foreseeable consequences is that, as a result of the ongoing cyberwar, European digital infrastructures will surely need to be reinforced to be prepared for possible attacks (Rettman and Sánchez, 2022; ETNO, 2022). Cyberattacks are to be expected, particularly ones targeting the public and the private sector (Meyer, 2022).

WC#5 'End of Moore's Law'

It is considered as a certainty among the scientific community that Moore's Law is ending and will be obsolete within years. Nevertheless, the end of Moore's Law should not be seen as the end of progress (Williams, 2017). In general, the uncertainty is whether the end of Moore's Law means the end of the Information Society era or is just the beginning of a new one. In fact, the end of Moore's law is giving impetus to the exploration of new architectures and technologies for the first time in decades (Theis and Wong, 2017; Track *et al.*, 2017). The new technologies that are already being studied will impact every industry. The end of Moore's Law will have many implications. First, the tech companies are already testing new materials, architectures and chips specialisation. Among the best-known solutions are quantum computing, memristors, graphene processors and brain networks (Peper, 2017), 3D integration through vertical transistors and cognitive architectures. Moreover, the competitive cost of producing these new technologies will generate inexpensive processing capabilities powering an explosion of machine intelligence applications. These applications that need very fast computing locally on a device will continue their transition to the cloud which will cause a rise in the cost of networks and storage needed to support this AI growth.

WC#6 'Failure of Europe'

In the current geopolitical situation (post-pandemic effects and Russian-Ukrainian conflict), characterised by extreme instability and unforeseeable consequences,

the failure of the European Union has ceased to be a completely implausible scenario. Already after the rise of populist movements and Brexit, the Union has been experiencing times of extreme uncertainty (Marjomaa, 2020). Risks are mainly connected with the possible withdrawal of one or more leading Member States and the emergence of two or more rates of development and integration within the Union (EC, 2011). Also, there is a widespread lack of confidence flowing from hesitant reactions, widespread doubts and the political will of Member States to build a reliable and sustainable architecture of economic governance of the eurozone (Van Iersel, 2011). In this context, Europe would not be able to implement sound research policies, hence causing a reduction in the pace of innovation which would widely impact digital cohesion.

WC#7 'Energy as a luxury good'

It is not the first time in history that the energy sector has undergone times of contraction. The crisis appeared evident in 2021 when prices for oil, gas and electricity surged as countries reopened after the shutdowns imposed in response to the Covid-19 outbreak. In 2022, the crisis is still ongoing and is currently exacerbated by deteriorating relations with Europe's main gas supplier, Russia (Meredith, 2022). Unfortunately, the current crisis differs from the others because, besides a series of exogenous factors such as the pandemic and the Ukraine conflict, there are some political and technological trends, such as the green and digital transition and the technology evolution, that are making the crisis a structural problem. The digital transformation is already posing problems for the energy it requires: Ethereum and Bitcoin mining operations alone are responsible for emitting more than 78 million tons of CO_2 into the atmosphere, equal to the annual tailpipe emissions of more than 15.5 million cars (Knutson, 2022). According to the Commission (EC, 2021b), the best solution to decrease dependence on imported gas and lower prices in the long run is to accelerate the implementation of the European Green Deal, including the rollout of renewable and low-carbon gases. However, the Commission warns that in the absence of a massive acceleration of the green transition, EU electricity prices will depend significantly on gas prices at least up until 2030.

WC#8 'EU enlargement'

Since the last admission of Croatia in the EU in 2013, the Union has been facing urgent domestic issues such as the crisis in Greece and the eurozone, Brexit, the refugee crisis and the rise of Euroscepticism and populist extremism in Europe. Finally, the Covid-19 pandemic has accelerated and reinforced these geopolitical faults and the EU's internal disparities and tensions. These events caused delays in the accession process of the Western Balkans and the subsequent

disillusionment of these countries concerning their European prospects (Panagiotou, 2021).

2020 was supposed to be the year of the opening of accession negotiations with North Macedonia and Albania. But the process suffered a setback after France's refusal in 2019 to entertain any further enlargement until a new negotiation methodology was agreed upon (Fouéré, 2021). The EC Communication on 'Enhancing the accession process – A credible EU perspective for the Western Balkans' (EC-DG NEAR, 2020) aimed at responding to French demands and at '*reinvigorating the accession process*'. However, this standstill in the accession negotiations, exacerbated by the pandemic and the Bulgarian veto on North Macedonia accession without certain requirements, weakened the debate over any future EU enlargement (Fouéré, 2021). It took eight years for Croatia to complete its accession negotiations and become a Member State (in 2013), while Montenegro, whose case has been underway since 2012, in the same amount of time has closed only three chapters out of the 35 required.

Finally, not even the Ukraine conflict and the request for a special procedure to grant EU candidate status, or speed up the membership process, could affect the current accession procedure, whose decision must be unanimously agreed upon by the 27 Member States, which – particularly in recent years – have found themselves in vehement disagreement on a range of issues, including enlargement (Grey and Momtaz, 2019).

Box 2. Focus on possible implications of the realisation of Wild Cards #4 and #7

Wild Card #4 'Massive immigration within Europe' as a consequence of a war conflict in the eastern borders and Wild Card #7 'Energy as a luxury good' with increased prices preventing daily energy use by a large part of the European population were analysed in December 2021 when a Russian military invasion of Ukraine was deemed highly improbable[7,8,9]. At this date, they are considered as realised. In the context of the present study, only the relevant implications for digital cohesion are examined and possible mitigation measures considered.

For WC#4, acknowledging that the conflict will have repercussions for years to come in Europe, highly important factors for digital cohesion will be the digital skills of the migrants and the protection of European digital infrastructures. For the latter, reference is to the considerations made for WC#1 'A disruptive digital pandemic' in Recommendation 4.

Concerning the Ukrainian refugees, after several internationally poorly managed migration flows over the last decades – which caused major political problems, including the rise and flourishing of populist movements – the EU seems to be addressing Ukraine's case differently, adopting an optimal international refugee protection approach (Reilly and Flynn,

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[7] France24 news dated 26/12/21.
[8] Wion news dated 23/12/21.
[9] Sky news dated 19/12/21.

2022). There will be also the need to foresee measures for the social – and thus also digital – inclusion, in order to prevent a possible increase of the digital divide in Europe.

For WC#7, only much stronger investment in low-carbon energy technologies, including renewables, energy efficiency and nuclear power can represent a way out of this impasse. This would be in addition to the current strategy for making natural gas storage part of Member States security of supply risk assessments and for ensuring that storage levels are adequate to cover end-user needs. Moreover, sector experts often recall that European institutions are addressing only the supply side of the problem, while neglecting the root causes which determine the energy savings and that require prioritising the reduction of energy use through the acceleration of energy efficiency measures (Vitali Roscini, 2021). Still, the 36% energy efficiency target proposed by the Commission is at the low end of what is achievable by 2030, with a cost-effective economic potential that stands at beyond 40% (Scheuer, 2021). A recent study by Heflich and Saulnier (2021) also finds that a 2030 energy efficiency target of 40% would deliver around €88 billion in economic benefits in 2030.

In the following chapters of the study the results of the Horizon Scanning will be used to present possible megatrends and scenarios linked with the weak signals and wild cards, also investigating possible implications for digital cohesion at the European level.

Part 2 Megatrends analysis and scenarios building

2.1 Megatrends potentially linked to the digital divide in Europe

2.1.1 What is a megatrend?

The [European Foresight Platform](#) highlights some key elements that set a clear difference between the concepts of 'trend' and of 'megatrend': *'Trend is a general tendency or direction of a development or change over time. It can be called a megatrend if it occurs at global or large scale.'* Over time, both can accelerate, remain stable and decelerate until disappearing; can be anticipated by/resulting from weak signals; and are the results of complex interactions between such a high number of stakeholders of different types that they can only be modified by means of structural and coordinated interventions (e.g., legislative acts, policy actions) or by shocks (e.g., wild cards, black swans). In general, magnitude is the key differentiating element between trends and megatrends. Furthermore, megatrends are likely to affect the future broadly (i.e., across a large number of policy areas), to have long-term effects (i.e., over a range of 10-15 years) and to largely impact societies and governments.

For what concerns Europe, the Competence Centre on Foresight of the EC has identified 14 global megatrends within its [Megatrends Hub](#) as *'long-term driving forces that are observable now and will most likely have significant influence on the future.'* These megatrends (Table 7), included in the Commission's 2020 Strategic Foresight Report (EC, 2020), are investigated according to their 'digital elements' and then analysed according to a digital cohesion perspective.

Table 7. List of the 14 megatrends affecting Europe

	Megatrend name
1	Accelerating technological change and hyperconnectivity (see footnote 11)
2	Aggravating resource scarcity
3	Changing nature of work
4	Changing security paradigm
5	Climate change and environmental degradation
6	Continuing urbanisation
7	Diversification of education and learning
8	Widening inequalities
9	Expanding influence of East and South
10	Growing consumption

11	**Increasing demographic imbalances**
12	Increasing influence of new governing systems
13	Increasing significance of migration
14	Shifting health challenges

Source: webpage of the [Megatrends Hub](#) (accessed on 28 February 2022).

2.1.2 Exploring and reviewing key megatrends with respect to the digital divide

The 14 key megatrends identified by the Competence Centre on Foresight are explored in this section according to their digital potential with respect to 'relevant weak signals'. These relevant weak signals are selected amongst the 19 weak signals derived from the experts' consultation (see [Table 4](#)). By assuming the occurrence of the weak signals associated with each megatrend, their effects in reducing the digital divide in Europe are highlighted.

First, each megatrend[10,11] is reviewed against its full description available in the Megatrend Hub. The review is based on the exploration of each megatrend's linkages with digital skills, digital infrastructures, digital transformation of businesses and digital public services (i.e., the four cardinal points of the Digital Compass). The outcome is a digital-focused description of the megatrend where the elements of the Digital Compass (DC) are highlighted (literally, in light blue in the text). Second, based on the same analysis of each megatrend's description, relevant weak signals are associated with each megatrend. Relevant weak signals are reported together with their links with the DC cardinal points and their societal relevance as mapped in [Table 3](#) in Part 1. Finally, assuming the occurrence of associated weak signals within each megatrend, the positive implications against different types of digital divides (DDs) (i.e., affecting territories, citizens, businesses and public administrations) are represented in radar graphs. The assessment in terms of types of divides is derived from the insights gathered through the consultation with the CoR members (see section [1.2.2](#)). Box 3 explains the information provided with radar graphs.

[10] Each megatrend is presented using the short description provided in the [Megatrends Hub.](#)
[11] The core of Megatrend 1 'Accelerating technological change and hyperconnectivity' is digitalisation. As it horizontally touches upon all the others, in order to avoid repetitions, this megatrend is treated at the end of the section.

Box 3. An example of radar graph

The *radar graph below reports the indications* on weak signals provided by CoR members during the consultation. In particular, the example refers to the indications received for WS*#1*. CoR members were asked whether they deemed the effects of a weak signal on digital cohesion positive, negative or null, in case of its occurrence. The possible types of digital divides proposed to the CoR members are reported on the eight axes of the graphs (e.g., *between European regions*, *between urban and rural areas*).

In the graph, the green line represents the number of respondents who have assigned a potential positive role to the weak signal in increasing digital cohesion in Europe. In the example, eight respondents, out of a total of 11, expect that the occurrence of WS#1 will have a positive effect.

#1. 5G network / 6G networks
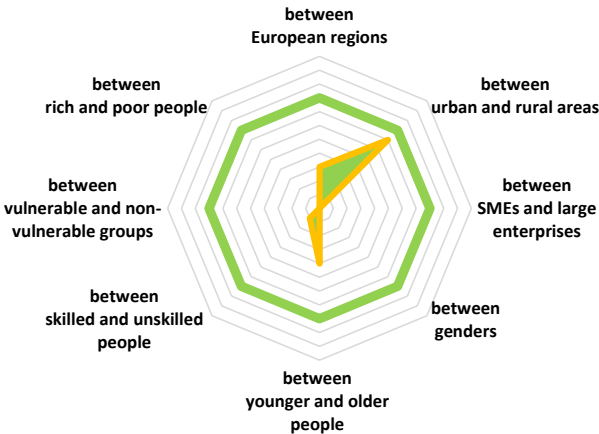
Those respondents assigning a positive effect to a weak signal were asked which divide was expected to be reduced the most. Respondents had the opportunity of selecting additional types of the digital divide. In the example, seven respondents selected the digital divide between *urban and rural areas* and none selected the digital divide *between genders*.

The resulting green area delimited by the orange line can be interpreted as a quantification of the perception of the digital divide reduction by the occurrence of the weak signal. Furthermore, peaks indicate where there is consensus about the potential effectiveness of the weak signal in reducing a specific digital divide. In the example, the occurrence of WS #1 is, in the opinion of most of the respondents, expected to reduce the digital divide between urban and rural areas, followed by the digital divide between younger and older people.

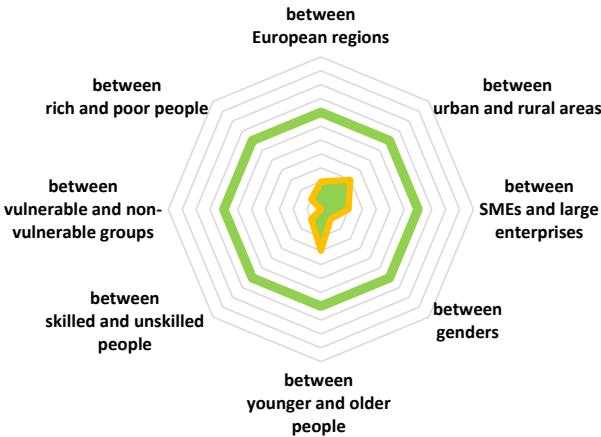| Megatrend 2	**Aggravating resource scarcity**	*'Demand for water, food, energy, land and minerals is rising substantially, making natural resources increasingly scarce and more expensive.'*

DC cardinal points in the megatrend. This megatrend is linked to Megatrend 10 '*Growing consumption* worldwide' according to which the increasing demand for resources aggravates their scarcity. A change in behaviours and attitudes towards

the protection and conservation of a healthy environment as well as a modification of consumption patterns require new business models and innovative methods for resource management. Digital transformation of businesses is seen as instrumental in creating new solutions for addressing these challenges. For example, blockchain applications may favour decentralised productions and short supply chains in some industries, or process automation may lead to more effective and environmental-friendly mining activities. A negative side-effect on resource scarcity is the increased need for raw materials to power (e.g., semiconductors, batteries) the increasingly demanded digital technologies.

One relevant weak signal is associated with *aggravating resource scarcity.*	Secure and sustainable digital infrastructure	Digital transformation of businesses	Digitalisation of public services	Digital skills	Societal
Weak Signal short name					
Blockchain	O	O	O		

#3. Blockchain

between European regions

between rich and poor people

between urban and rural areas

between vulnerable and non-vulnerable groups

between SMEs and large enterprises

between skilled and unskilled people

between genders

between younger and older people

The occurrence of WS*#3 Blockchain* is expected to have a positive impact in reducing the digital divide for 64% of the respondents. However, only a few respondents indicate positive effects in reducing the divide between *SMEs and large enterprises*.

This megatrend has **recently been accelerated by the occurrence of Wild Card #7 'Energy as a luxury good'** following the Russian military invasion of Ukrainian territories on 24 February 2022 (see Box 2). The occurrence of such a wild card was assessed to have economic and social effects in Europe.

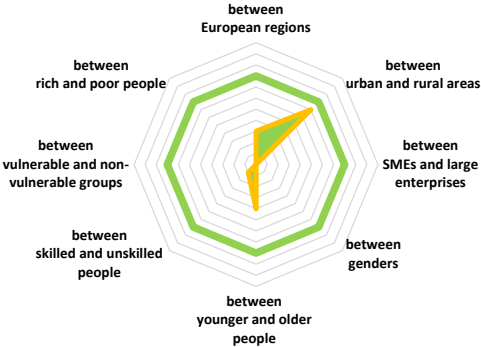| **Megatrend 3**	**Changing nature of work**	*'New generations entering the workforce and older generations working longer are changing employment, career models, and organisational structures.'*

DC cardinal points in the megatrend. Especially after the Covid-19 outbreak, digitalisation has been considered disruptive for the European labour market

because of changes both in the nature of work and in the type of employment. New patterns in which *'work is increasingly flexible, decentralised, and knowledge-based, driven by self-fulfilment and increasing entrepreneurial spirit'* (webpage of the megatrend) emerged. Basic digital skills of workers are increasingly becoming an essential requirement and knowledge investments in advanced digital skills are a 'must' for businesses. Digitalisation and digital transformation of business (i.e., business model changes) occur through the use of emerging advanced technologies such as those related to automation and AI applications. Connectivity provided by sustainable and secure digital infrastructures is the necessary condition for this ongoing *changing nature of work*. The metaverse will provide opportunities for new types of work.

Three relevant weak signals are associated with ***changing nature of work.***	Secure and sustainable digital infrastructure	Digital transformation of businesses	Digitalisation of public services	Digital skills	Societal
Weak Signal short name					
5G networks / 6G networks	O				
Social and technological implications of the pandemic	O	O	O		O
Metaverse workforce	O				O

#1. 5G network / 6G networks

#4. Social and technological implications of pandemic

#16. Metaverse workforce
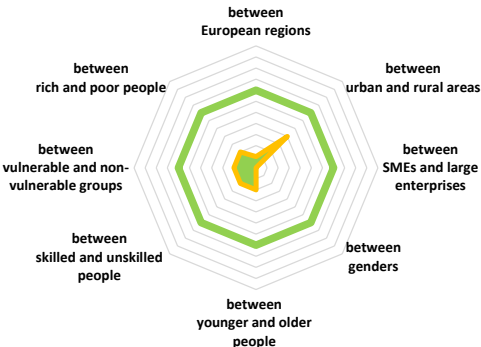
WS#1 *5G networks / 6G networks* has a positive impact in reducing the DD for most of the respondents (8/11). Its occurrence is expected to mainly reduce the divide *between urban and rural areas* and *between younger and older people*. Connectivity becomes a way to overcome labour market frictions such as the mismatching of demand and supply in a territory. In addition, the occurrence of WS#4 *Social and technological implications of the pandemic* may reduce the divide *between European regions*. Instead, only 45% of the respondents believe that the occurrence of WS *#16*

Metaverse workforce has a positive impact on digital cohesion. If this occurs, it will be mostly in terms of reducing the digital divide between urban and rural areas.
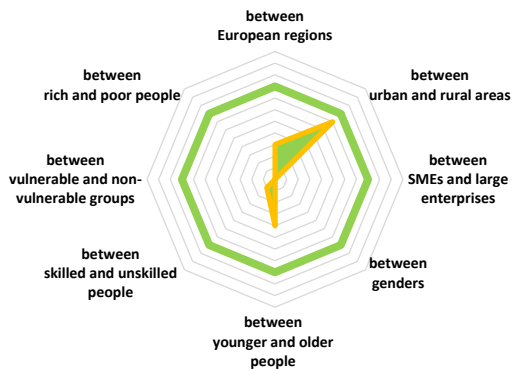
Megatrend 4	**Changing security paradigm**	*'The diversification of threats, and the people behind them, are generating new challenges for the defence and security communities, as well as to society as a whole.'*

DC cardinal points in the megatrend. Methods of confrontation among global players are evolving also by means of digital technologies. Advanced digital technologies taking a more prominent role in the creation of new weapons (e.g., armed robots, drones on battlefields, wearable sensors) have led to a digital transformation of business in industries related to security and defence. At the global level, the adoption of new strategies for the geopolitical competition in the digital domain (e.g., control of cyberspace, dissemination of fake information) has raised the attention on the relevance of information and data and on the creation/control of global infrastructures for communications (e.g., satellite systems). A side-effect is the empowerment of secure and sustainable digital infrastructures.

Five relevant weak signals are associated with *changing security paradigm.*

| Weak Signal short name	Secure and sustainable digital infrastructure	Digital transformation of businesses	Digitalisation of public services	Digital skills	Societal
5G networks / 6G networks	O				
IoT malware	O	O	O		
Unmanned Aerial Vehicles	O	O			
Infodemic					O
Deepfake					O

#1. 5G network / 6G networks


#5. IoT malware
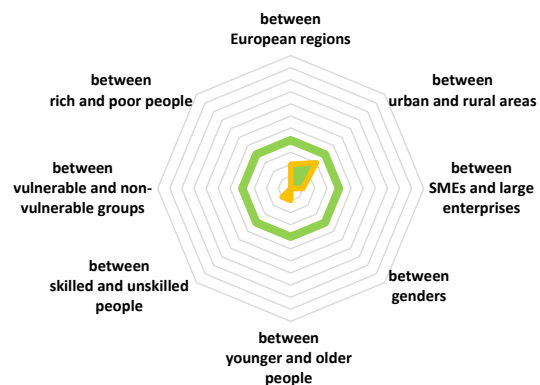
Among the five WSs associated with this megatrend, it is evident that the occurrence of those related to connectivity (i.e., WS#1 *5G networks /6G networks* and WS*#7 Unmanned Aerial Vehicles*) is considered positive in reducing DD by most of the respondents. The DD that is reduced the most is the one *between urban and rural areas*. The other WSs (i.e., those expected to negatively affect the security paradigm) have to be considered negligible in reducing the DD.
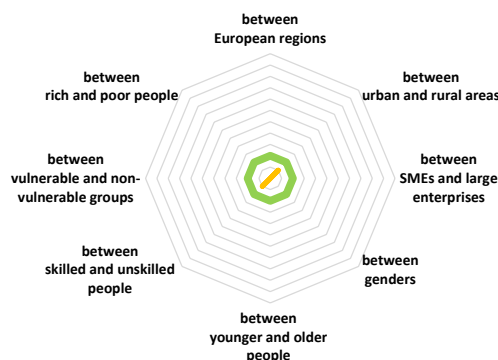
#7. Unmanned Aerial Vehicles
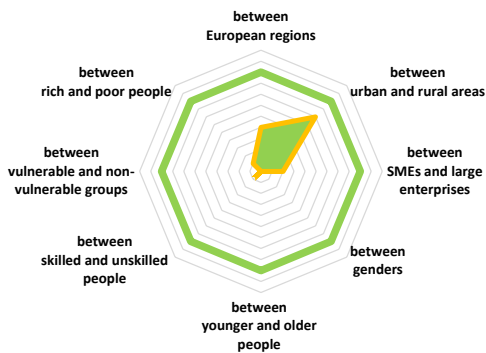
#11. Infodemic
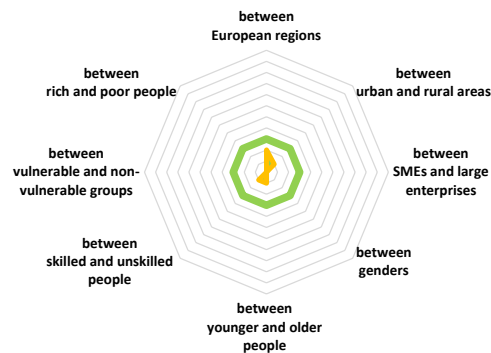
#14. Deepfake

Megatrend 5	**Climate change and environmental degradation**	*'Continued unabated, anthropogenic pollution and greenhouse gas emissions will further increase changing climate patterns.'*

DC cardinal points in the megatrend. Digital technologies can play a role in monitoring, assessing and providing solutions for improving the ecological footprint of a wide range of services. In order to contain climate change and environmental degradation, the application of advanced technologies to shorten supply chains and increase efficiency in logistics is crucial. This requires digital transformation of business across a number of sectors (e.g., blockchain in the food industry).

One relevant weak signal is associated with *climate change and environmental degradation.*

Weak Signal short name	Secure and sustainable digital infrastructure	Digital transformation of businesses	Digitalisation of public services	Digital skills	Societal
Blockchain	O	O	O		

#3. Blockchain

between
European regions

between
rich and poor people

between
urban and rural areas

between
vulnerable and non-vulnerable groups

between
SMEs and large enterprises

between
skilled and unskilled people

between
genders

between
younger and older people
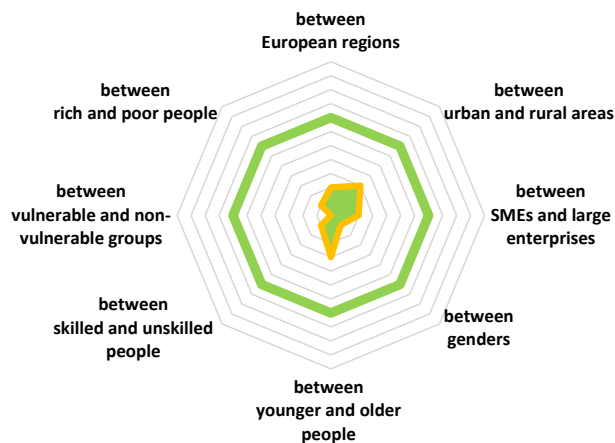
The occurrence of WS#3 *Blockchain* is expected to have a positive impact in reducing DD in Europe by 64% of the respondents. Its positive effect is perceived especially in addressing the DD *between urban and rural areas* and *between younger and older people*.

Megatrend 6 | **Continuing urbanisation** | *'By 2050, the urban population could reach 9 billion. Cities are increasingly functioning autonomously, setting new social and economic standards.'*

DC cardinal points in the megatrend. Continuing urbanisation is reinforcing the demand for digital connectivity-based services in urban settings (i.e., smart cities). Secure and sustainable digital infrastructures are needed for proper management and use of data generated by the IoT applications (e.g., big data from mobility services), for effective digital interaction with a large number of citizens and for better public governance of the entire urban system (e.g., digital twins). A data-driven decision-making approach is occurring with implications for ownership, privacy and security of data.

Seven relevant weak signals are associated with *continuing urbanization.*	Secure and sustainable digital infrastructure	Digital transformation of businesses	Digitalisation of public services	Digital skills	Societal
Weak Signal short name					
5G networks / 6G networks	O				
High-speed cloud computing	O	O	O		
IoT malware	O	O	O		
Vehicle-to-everything communication	O		O		
Algorithmic fairness	O				O
Automated driving of vehicles					O
Automated decision-making	O	O	O		

#1. 5G network / 6G networks

#2. High-speed cloud computing
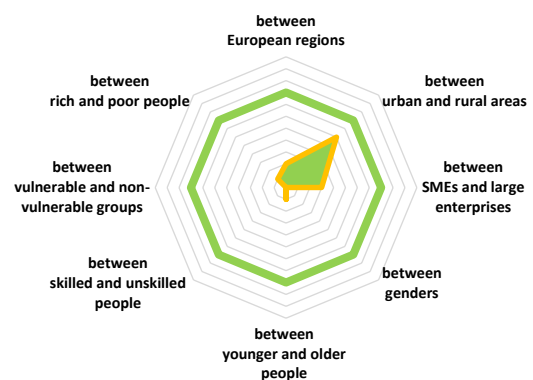
#5. IoT malware
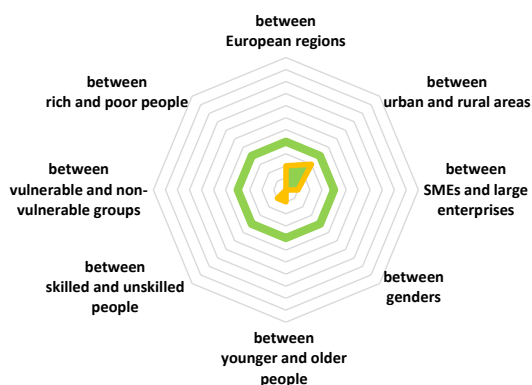
### #6. Vehicle-to-everything communication
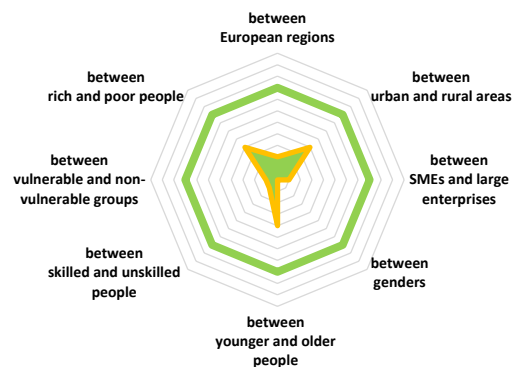
The occurrence of WSs related to improvements in connectivity (WS#1) and in data management/processing (WS#2) is expected to have a positive impact in reducing DD by most of the respondents. For both these WSs the most affected type of divide is the one *between urban and rural areas*. This divide, together with the one *between vulnerable and non-vulnerable groups,* are those considered to be reduced the most by respondents considering the effect on digital cohesion of *Algorithmic fairness* (WS#15) to be positive. WSs related to standardisation (WS#6) and automation (WS#17) in mobility are expected to have an impact in terms of the reduction of social divides.
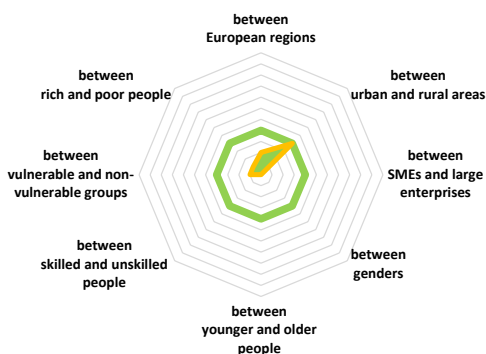
#15. *Algorithmic fairness*
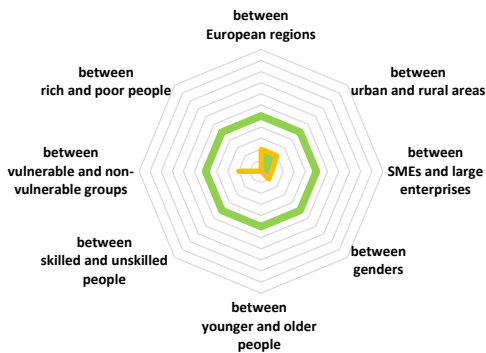
#17. *Automated driving of vehicles*
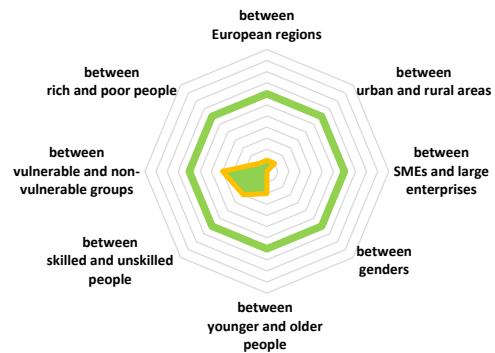
#18. *Automated decision-making*

In particular, the divide *between vulnerable and non-vulnerable groups* is expected to be reduced by automation in driving vehicles (WS#17) and the divide *between younger and older people* is expected to be reduced by WS#6 *Vehicle-to-everything communication*. The number of respondents assigning a positive impact on digital cohesion to WS#18 *Automated decision-making* is limited (4/11), but all of them agree that the divide *between urban and rural areas* is the one reduced the most.

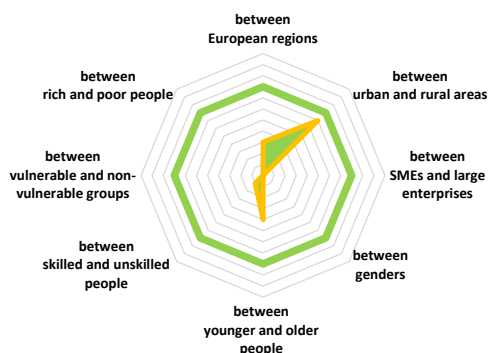| Megatrend 7	**Diversification of education and learning**	*'New generations and hyperconnectivity are rapidly changing both educational needs and modes of delivery.'*

DC cardinal points in the megatrend. Digitalisation drove a revolution in the diversification of education and learning that was further accelerated during the Covid-19 pandemic. Distance learning required a 'digital adaptation' of traditional school educators in terms of digital skills and fostered the widening of types of educational profiles and sources in the digital world (e.g., learning agents). Online, informal, unstructured and innovative learning approaches (e.g., AI-powered tutoring systems, augmented reality tools) which address the emerging educational demands of youth as well as the requirements of adult learning require secure and sustainable digital infrastructures.
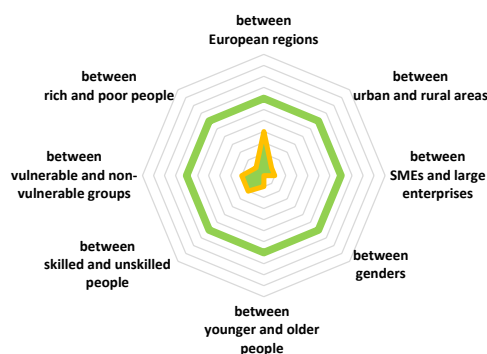
| Three relevant weak signals are associated with *diversification of education and learning.*	Secure and sustainable digital infrastructure	Digital transformation of businesses	Digitalisation of public services	Digital skills	Societal
Weak Signal short name					
5G networks / 6G networks	O				
Social and technological implications of the pandemic	O	O	O		O
SPOCs and MOOCs					O

#1. 5G network / 6G networks

#4. Social and technological implications of pandemic

#16. SPOCs and MOOCs
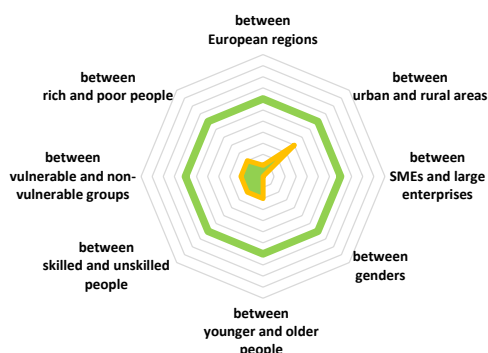
WS*#1* has (8/11) a positive impact in reducing the DD for most of the respondents. Its occurrence is expected to mainly have an impact on the reduction of the divide *between urban and rural areas* and on the digital access divide between different generations. A similar effect, although smaller in magnitude, is expected to be generated by the occurrence of WS*#16 SPOCs and MOOCs*. Together with WS*#4 Social and technological implications of the pandemic,* WS*#16* is expected to also reduce the DD *between skilled and unskilled people* and *between vulnerable and non-vulnerable groups.*

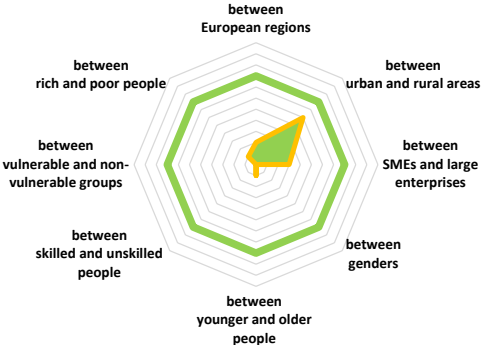|		
Megatrend 8	**Widening inequalities**	*'The absolute number of people living in extreme poverty has been declining. But the gap between the wealthiest and poorest of the population is widening.'*

DC cardinal points in the megatrend. Digital technologies contribute to limiting the widening of inequalities. Starting from the basic educational levels, disparities in accessing information and knowledge have a key role in determining divides and inequalities. For example, digital skills in daily life as well as in professional

careers may facilitate citizens' achievement of fair economic conditions and social mobility of the poorest part of the population. Digitalisation of public services implies better access to, for example, healthcare and consequent lower costs for both individuals and society at large. Adoption of digital technologies and digital transformation of businesses may boost the productivity of enterprises and, in turn, favour economic growth, especially in deprived regions.

| Four relevant weak signals are associated with *widening inequalities.*	Secure and sustainable digital infrastructure	Digital transformation of businesses	Digitalisation of public services	Digital skills	Societal
Weak Signal short name					
High-speed cloud computing	O	O	O		
Civic technologies	O		O		O
Algorithmic fairness	O				O
SPOCs and MOOCs					O

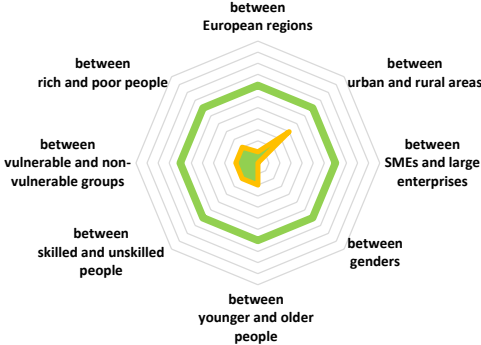### #2. High-speed cloud computing

#13. Civic technologies
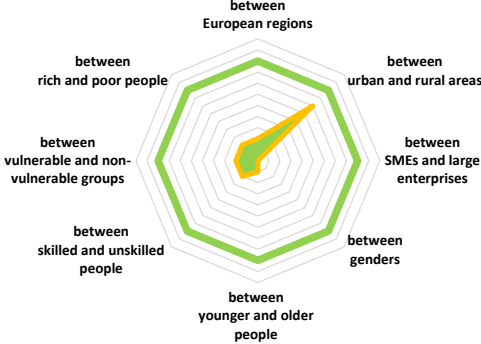
#15. Algorithmic fairness
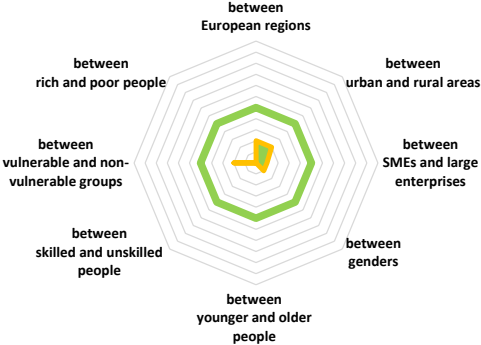
#16. SPOCs and MOOCs

WS#2, WS#13 and WS#16 are expected to have a positive impact in reducing the DD by the majority of the respondents. Their occurrence has the reduction of the divide *between urban and rural areas* as the main outcome. WS*#13 Civic technologies to improve public governance* and WS*#16 SPOCs and MOOCs* are expected to also reduce societal-oriented DDs such as those *between younger and older people, between skilled and unskilled people, between vulnerable and non-vulnerable groups* and *between rich and poor people. Algorithmic fairness* (WS#15) is expected to reduce the divide *between vulnerable and non-vulnerable groups.*

	Expanding influence of East and South	*'The shift of economic power from the established Western economies and Japan towards the emerging economies in the East and South is set to continue.'*

Megatrend 9

DC cardinal points in the megatrend. There are no prominent digital aspects in expanding influence of East and South, although Europe continues to depend on the import of raw materials needed for digital technologies (e.g., semiconductors, batteries). The shift of global economic power towards emerging economies may also occur in the digital world which would require adequate digital infrastructures.

No identified actual weak signals are associated with expanding influence of East and South. This megatrend has persisted for at least 10-15 years at the worldwide level.

	Growing consumption	*'By 2030, the consumer class is expected to reach almost 5 billion people. This means 1.3 billion more people with increased purchasing power than today.'*

Megatrend 10

DC cardinal points in the megatrend. Digital channels have diversified consumption behaviours and business models have been renewed through digital transformation in order to better address an increasing demand of goods and services. In addition, digital technologies such as those related to extended reality coupled with an increasing purchasing power favour growing consumption paths also in the digital world. Consumers' access to the digital world as well as their data management/protection and related data analytics processed and stored by businesses require secure and sustainable digital infrastructures.

One relevant weak signal is associated with *growing consumption.*	Secure and sustainable digital infrastructure	Digital transformation of businesses	Digitalisation of public services	Digital skills	Societal
Weak Signal short name					
High-speed cloud computing	O	O	O		

#2. High-speed cloud computing
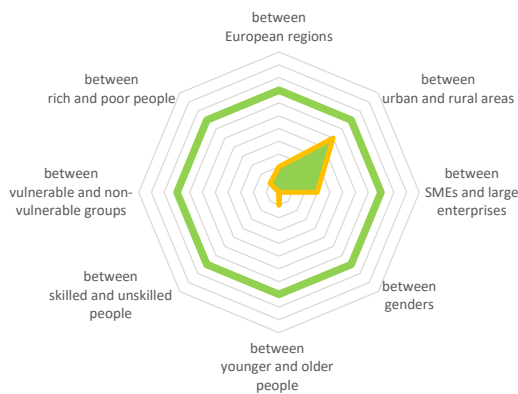
The occurrence of WS#2 *High-speed cloud computing* is expected to have a positive impact in reducing the digital divide in Europe by 73% of the respondents. Its positive effect is perceived especially in addressing the DDs *between urban and rural areas* and *between SMEs and large enterprises.*

Megatrend 11	**Increasing demographic imbalances**	*'The world's population will reach 9.7 billion by 2050, with rapid growth mainly in Sub-Saharan Africa and stagnating numbers of residents in the majority of developed countries.'*

DC cardinal points in the megatrend. There are no prominent digital aspects in increasing demographic imbalances. It is worth noting that European territories' endowment of digital skills (i.e., basic or advanced) is subject to ageing and/or migration flows.

No identified actual weak signals are associated with increasing demographic imbalances. This megatrend has persisted for at least 10-15 years in Europe, and could be accelerated in the midterm due to Russia's military invasion of Ukraine in late February 2022. This is in fact the occurrence of WC#4 Massive and sudden immigration within Europe as a consequence of a war conflict in the eastern borders. The actual migration flow, largely composed of women and children, may have social effects in specific European territories (see Megatrend 13).

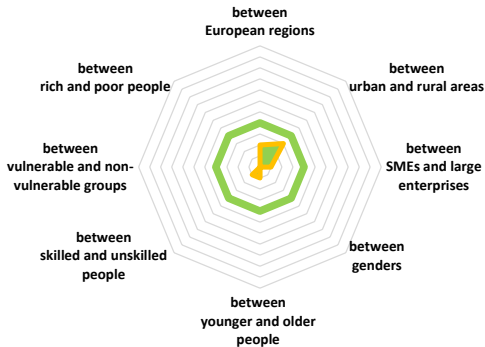| Megatrend 12	**Increasing influence of new governing systems**	*'Non-state actors, global conscientiousness, social media and the internationalisation of decision-making are forming new, multi-layered governing systems.'*

DC cardinal points in the megatrend. Digital technologies play a key role in increasing influence of new governing systems. Digital media platforms which

support more participatory forms of governance and decision-making based on collective intelligence require secure and sustainable digital infrastructures that guarantee connectivity to citizens. On the other side, hyperconnectivity may have two negative side-effects: it allows malicious information-based actions that may undermine public trust in democratic institutions and influencing societal opinions, and it increases competition in the digital world in terms of real-time news production risking reducing the quality of information and giving room to sources of fake news. Increasing influence of new governing systems requires public administrations to take a modernisation path that includes the digitalisation of public services. This digital transformation is also supported by automated decision-making processes.

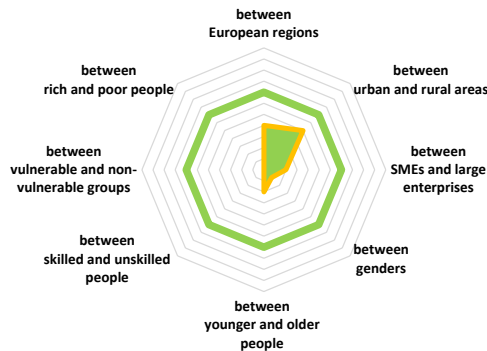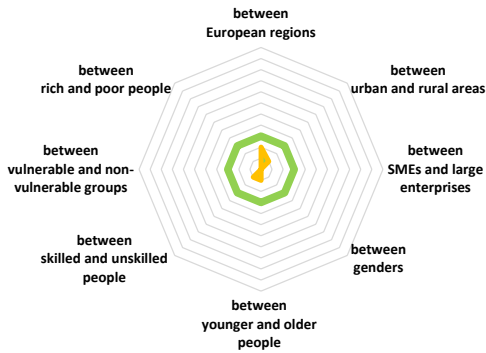| Eight relevant weak signals are associated with *increasing influence of new governing systems.*	Secure and sustainable digital infrastructure	Digital transformation of businesses	Digitalisation of public services	Digital skills	Societal
Weak Signal short name					
IoT malware	O	O	O		
Large-scale group decision-making	O		O		O
Infodemic					O
Digital constitutionalism			O		O
Civic technologies	O		O		O
Deepfake					O
Algorithmic fairness	O				O
Automated decision-making	O	O	O		

#5. IoT malware

#10. Large-scale group decision-making

The WS considered by most of the respondents (9/11) to have a positive impact in reducing the DD is WS*#13 Civic technologies*. Its occurrence is expected to reduce the divide *between urban and rural areas*. WS*#10 Large-scale group decision-making processes* follows, as it has a positive impact in reducing the DD for 64% of the respondents. Main effects are again on the divide *between urban and rural areas* and *between European regions*.
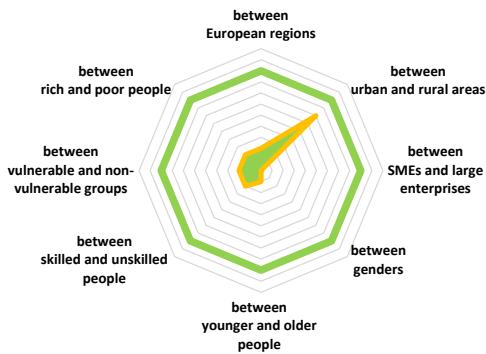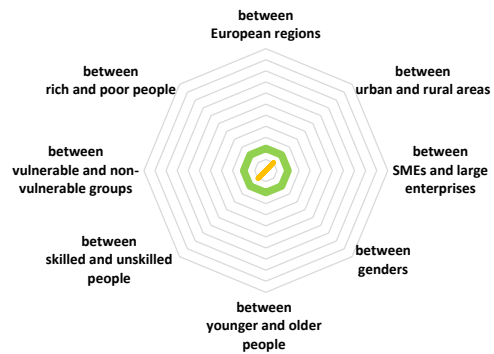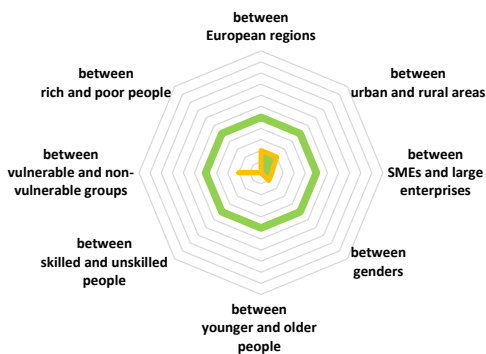
#11. Infodemic

between European regions
between urban and rural areas
between SMEs and large enterprises
between genders
between younger and older people
between skilled and unskilled people
between vulnerable and non-vulnerable groups
between rich and poor people

#12. Digital constitutionalism

between European regions
between urban and rural areas
between SMEs and large enterprises
between genders
between younger and older people
between skilled and unskilled people
between vulnerable and non-vulnerable groups
between rich and poor people

#13. Civic technologies

between European regions
between urban and rural areas
between SMEs and large enterprises
between genders
between younger and older people
between skilled and unskilled people
between vulnerable and non-vulnerable groups
between rich and poor people

#14. Deepfake

between European regions
between urban and rural areas
between SMEs and large enterprises
between genders
between younger and older people
between skilled and unskilled people
between vulnerable and non-vulnerable groups
between rich and poor people

#15. Algorithmic fairness

between European regions
between urban and rural areas
between SMEs and large enterprises
between genders
between younger and older people
between skilled and unskilled people
between vulnerable and non-vulnerable groups
between rich and poor people

#18. Automated decision-making

between European regions
between urban and rural areas
between SMEs and large enterprises
between genders
between younger and older people
between skilled and unskilled people
between vulnerable and non-vulnerable groups
between rich and poor people

Megatrend 13	**Increasing significance of migration**	*'The social and political significance of migration has increased. Migration flows and dynamics have become more mixed in an interconnected world.'*

DC cardinal points in the megatrend. There are no prominent digital aspects in increasing significance of migration. The level of digital competences (i.e., basic or advanced) of migrants can enrich or diminish the digital skills endowment of the receiving territories.

No identified actual weak signals are associated with increasing significance of migration. This megatrend has persisted for at least 10-15 years in Europe, and it has recently been accelerated by the occurrence of wild card #4 Massive and sudden immigration within Europe as a consequence of a war conflict in the eastern borders, following the Russian military invasion of Ukrainian territories on 24 February 2022. The occurrence of such wild card was assessed to have political and social effects in Europe and its relevance on digital cohesion in Europe was on average assessed 2.7 by thematic experts and 4.45 by CoR members in a 0 (not relevant) – 5 (very relevant) range.

Megatrend 14	**Shifting health challenges**	*'Science and better living standards have reduced infectious diseases. Unhealthy lifestyles, pollution and other anthropogenic causes are turning into health burdens.'*

DC cardinal points in the megatrend. Digital technologies in the shifting of the health challenges require secure and sustainable digital infrastructures that guarantee connectivity and storage of a large and sensitive amount of data (e.g., databases of patients' records). The need for effective and real-time management and monitoring of citizens' data during the Covid-19 pandemic has unlocked new digital opportunities in the health domain. Outside of emergency situations, secure and sustainable storage and processing are crucial for health data originating from remote monitoring devices and wearable technologies. Telemedicine (e-health) and personalised medicine require the digitalisation of public services.

Four relevant weak signals are associated with *shifting health challenges.*

| Weak Signal short name	Secure and sustainable digital infrastructure	Digital transformation of businesses	Digitalisation of public services	Digital skills	Societal
High-speed cloud computing	o	o	o		
Social and technological implications of the pandemic	o	o	o		o
AI Based Healthcare	o		o		
Wearable biosensors	o		o		

65

#2. High-speed cloud computing
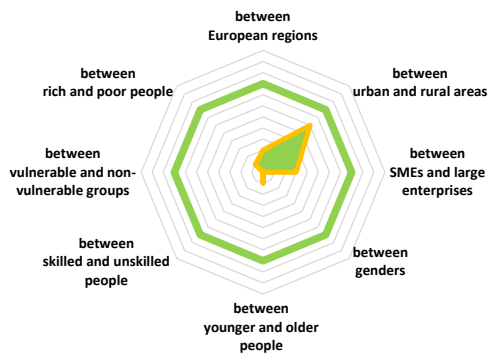
#4. Social and technological implications of the pandemic
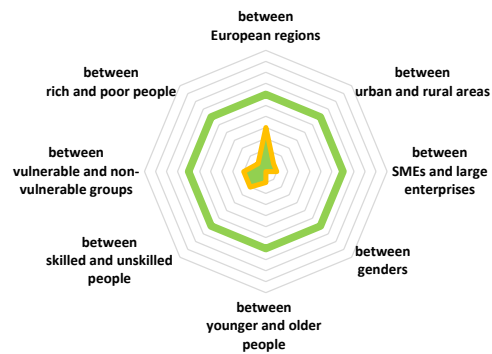
#8. AI-Based Healthcare
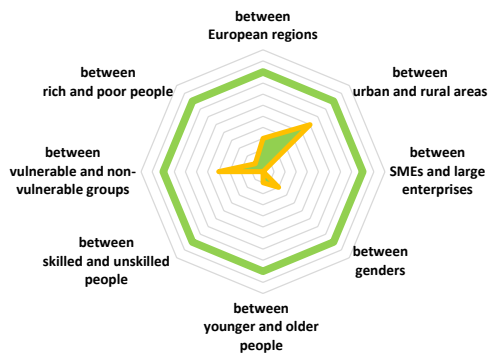
#9. Wearable biosensors
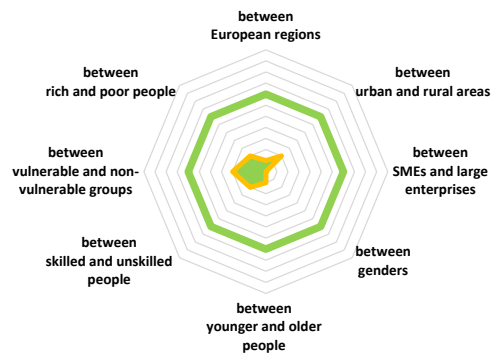
The WS considered by most of the respondents (8/11) to have a positive impact in reducing the DD is WS *#8 AI-based healthcare*. Its occurrence is expected to reduce the divides *between urban and rural areas* and *between vulnerable and non-vulnerable groups*. The divide *between urban and rural areas* is expected to be importantly addressed also by *WS#2 High-speed cloud computing*. In addition, WS*#4 Social and technological implications of the pandemic* and WS*#9 Wearable biosensors* are considered to have a positive impact in reducing the DD by 64% of the respondents. Main effects are expected on the divides *between European regions* and *between vulnerable and non-vulnerable groups*, respectively.

Megatrend 1	**Accelerating technological change and hyperconnectivity**	*'Technologies are changing how we live. They are also changing the nature and speed of new scientific discoveries and transforming systems of production, management and governance.'*

DC cardinal points in the megatrend. The acceleration of technological change and hyperconnectivity is undoubtedly a leading megatrend in Europe with transversal effects on other existing trends and megatrends. Sustainable and secure digital infrastructures are crucial for hyperconnectivity of people and things (i.e., Internet of Things). They assign a crucial role to the internet and data

66

(e.g., big data) and, in turn, to their reliability and security. Advanced digital technologies (i.e., artificial intelligence) are transforming businesses (i.e., digital transformation of business), shaping activities and competencies of citizens and workers (i.e., digital skills) and supporting public administrations in delivering services to citizens and enterprises (i.e., digitalisation of public services). Application fields range from urban mobility to healthcare, from space exploration to building management.

All of the 19 weak signals deemed relevant by the experts participating in the consultation have an embedded 'digital element'. Their links with the four components of the Digital Compass, plus societal aspects, have been already mapped in Table 3 in Part 1. The purpose of this chapter is to associate the identified weak signals with the megatrends currently identified for the EU and to investigate the potential reduction of the digital divide in case of occurrence of such weak signals. Therefore, the detailed outcomes for megatrend #1 are not presented as they would simply repeat what was presented above, megatrend by megatrend.

2.2   Scenarios for digital cohesion in Europe

2.2.1 Scenarios building

While in the previous chapter we analysed the expected megatrends in order to gather relevant information and frame the potential evolution of the current state, the goal of this section is to conduct scenarios building. The approach is positioned between the poles of exploration and pre-policy research. For this reason, scenarios are to be considered as vehicles of learning rather than tools for decision-making (Iversen, 2006).

In the context of this study, the scenarios building serves the purpose of exploring how digital cohesion can be achieved and of learning possible implications for the present. The approach takes into account the experts' consultation results to build four possible scenarios based on weak signals and the occurrence of wild cards.

2.2.2 Weak signals

Approach

The building process of scenarios is composed of both top-down and bottom-up elements. The weak signals selected and rated during the experts' consultation have been analysed with quantitative methods and represent the bottom-up approach. On the other hand, the creation of the scenarios narratives has been undertaken with a qualitative method representing the top-down approach.

Scenarios building can bundle, connect and present weak signals in a meaningful way. This is done in order to decrease the complexity in an unpredictable future environment and to support stakeholders in preparing for potential changes. Weak signals, for the purpose of the scenarios building process, have been considered as factors occurring simultaneously and contributing to the achievement of digital cohesion.

For each weak signal, the temporal horizon as indicated by the consultation's results has been considered transversally to each scenario, by selecting the resulting median values. According to the results, weak signals were considered to have an impact either in the short term (up to 5 years) or in the medium term (from 6 to 15 years). No weak signal has been deemed to have an impact in the long term (from 16 to 30 years). Therefore, all scenarios have a temporal horizon ranging from 1 to 15 years.

Results

The results have been consolidated into four scenarios:

- Scenario 1 - Change takes time, digital cohesion is in progress.
- Scenario 2 - Halfway there, digital cohesion is improving.
- Scenario 3 - Connected but unsafe, digital cohesion is still far off.
- Scenario 4 - So far so good, digital cohesion is achieved.

The overall result shows how the analysis of the data can present different scenarios. An assumption in the analysis and in the creation of each scenario's narrative is that weak signals that were found less relevant for digital cohesion can be interpreted as less pervasive due to different possible barriers (e.g., affordability, lack of the necessary infrastructure and also relevance for the general public). For each scenario, digital cohesion has been evaluated according to the dimensions described in the Digital Compass: digital skills, digital infrastructures, digital transformation of businesses and digital public services.

As mentioned before, weak signals deemed relevant for the short term (up to 5 years) have been graphically marked, all the others refer to the medium timespan (from 6 to 15 years). In the following Figure 15 the scenarios stemming from the rating of the weak signals have been represented graphically. The coloured boxes represent the relevance scale from 1 to 5, as used in the consultations, while 0 representing zero relevance has been omitted, e.g., large-scale group decision-making is not shown in scenario 3 because it has been rated as not relevant.
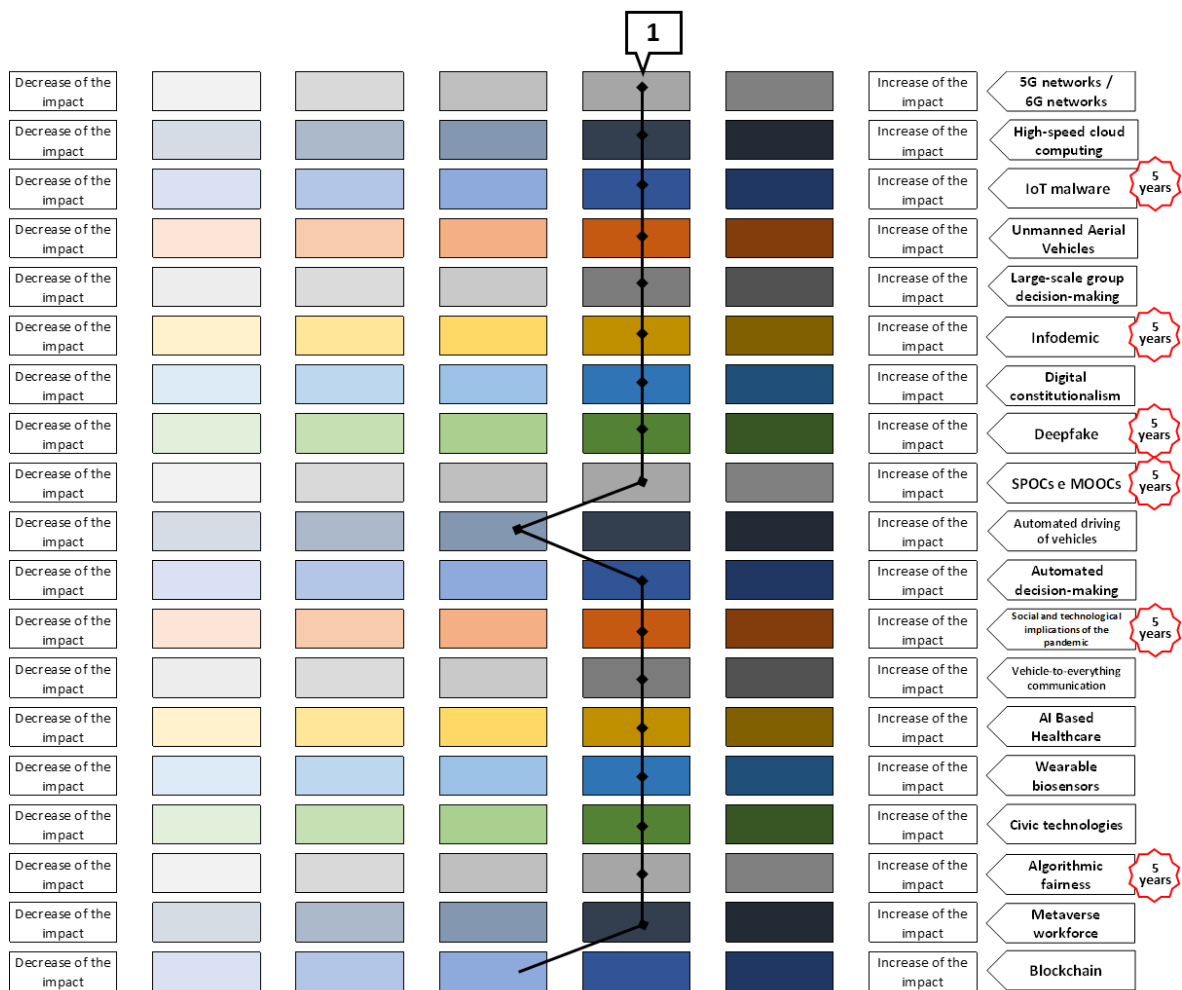
Figure 15. Representation of the scenarios built on the weak signal
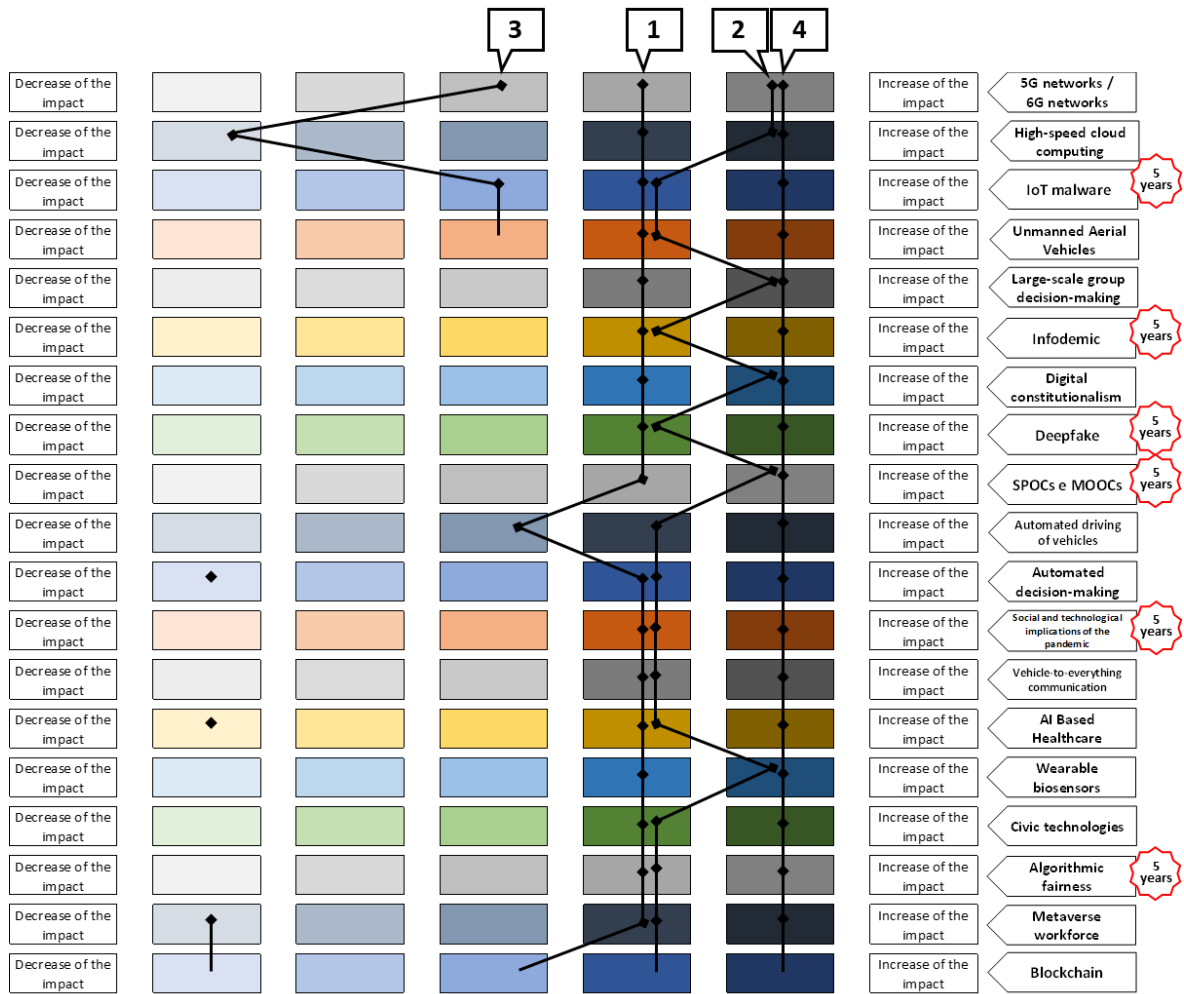
Each scenario is now presented focusing on the role of weak signals. In section 3.2 the analysis is enriched with the potential contributions of the relevant wild cards to each scenario.

Scenario 1 - Change takes time, digital cohesion is in progress

Figure 16. Representation of Scenario 1

Built on the **median** of the experts' consultation results, Scenario 1 depicted in Figure 16 is named « **Change takes time, digital cohesion is in progress** ». The approach employed to analyse the current weak signals of change outlines a future scenario where they are unevenly impacting society: only part of it is benefiting from technologies such as 5G/6G networks, high-speed cloud computing, unmanned aerial vehicles, large-scale group decision-making, SPOCs and MOOCs, vehicle-to-everything communication, AI based healthcare and wearable biosensors. The popularity of 5G/6G networks basically enables all the other technologies except for the SPOCs and MOOCs. The SPOCs and MOOCs, besides having been on the market for at least 10 years, clearly received a boost from the social distancing imposed by the pandemic.

All these technologies are expected to be widespread and used by public administrations, the private sector and citizens. Thus, the infrastructure has also been receiving attention (and incentives) for some time (EC webpage on 5G Action plan). Interestingly, other technologies such as automated driving and

blockchain are having less of an impact on digital cohesion. This is a possible sign that they are not being adopted on the market as much as expected but remain widespread in selected sectors.

A possible explanation for these two signals' scarcer relevance is that they present meaningful and not yet completely explored barriers. In spite of the huge media hype, automated driving requires specific (and flawless) infrastructures, sensors must be accurate enough to detect the differences of possible (non-autonomous) objects on the road (Nitsche *et al.*, 2014) and, most challenging, the cars need to be able to make ethical decisions in case of so-called 'edge cases' (Goodall, 2014). Moreover, the cost of such precision technology makes it too expensive for the majority of the population (Tanzmeister *et al.*, 2014). Blockchain, as a self-validating tool, poses an insurmountable problem for all the intermediaries such as banks (Iansiti and Lakhani, 2017). Furthermore, blockchain consumes an incredible amount of energy (Digiconomist, 2022), thus impacting the environment and operational costs. However, one of the main challenges for the uptake of blockchain is also linked to the lack of the necessary digital skills, especially in the private sector, which creates a skill gap in the job market (Shakina *et al.*, 2021).

According to the literature reviewed to discuss this scenario, the EU digital cohesion in the temporal horizon spanning over the next 15 years is shown in Figure 17.

Figure 17. Measure of digital cohesion in Scenario 1

Digital Compass dimensions	Advancement for digital cohesion
Digital infrastructures	low medium high
Digital skills	low medium high
Digital public services	low medium high
Digital transformation of businesses	low medium high

Scenario 2 - Halfway there, digital cohesion is improving

Figure 18. Representation of Scenario 2
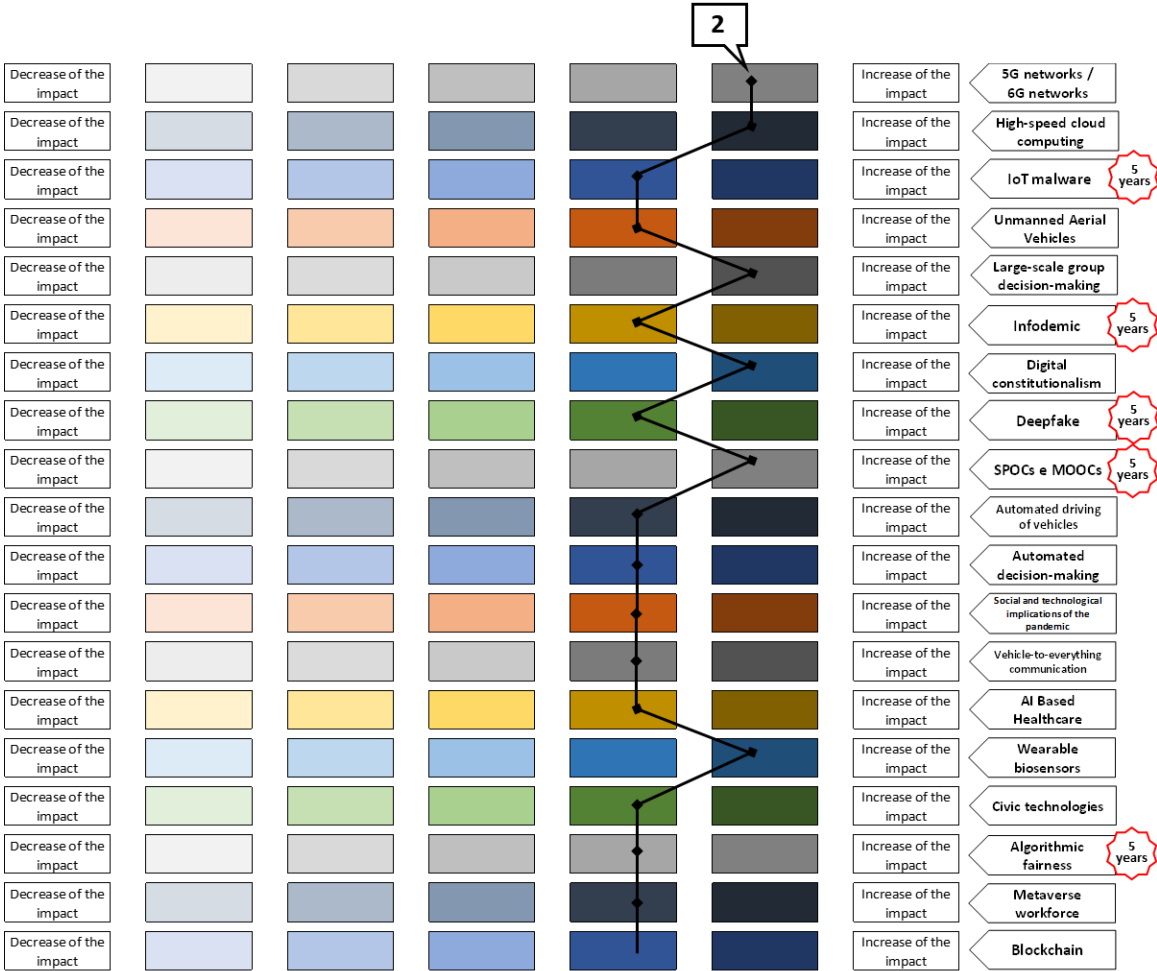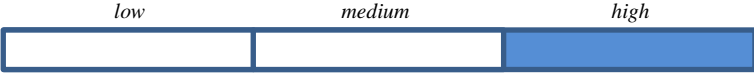
Scenario 2, named «**Halfway there, digital cohesion is improving**» and depicted in Figure 18, is built on the **mode** of the experts' consultation results. Here the technological uptake has increased: some technologies such as 5G/6G, high-speed computing, large-scale group decision-making and wearable biosensors are well-known and widespread while others have been less adopted such as unmanned aerial vehicle, automated driving, vehicle-to-everything communication, AI based healthcare and blockchain.

The first group of technologies can be considered as being more beneficial for all society, in part because they foster the digitalisation process of public sectors. The lower relevance of the second group can be explained with regard to possible barriers for the general public's uptake. For this second group of technologies the obstacles might be the lack of the appropriate digital skills (Van Dijk and Van Deursen, 2014) or digital infrastructures (Shenglin *et al.*, 2017), which for these specific technologies might still be too sectoral.

Some of the consequences of the technological evolution have had less impact than expected, such as IoT malwares, infodemics and deepfakes. This is probably because users have become more familiar with the digital skills required to handle these threats and maybe because of a better public governance of these malicious online threats. This can reflect the increased relevance of digital constitutionalism. Also, the consequences of Covid-19 and its social implication are not that pronounced. Conversely, opportunities are rising from the digital transformation such as a renewed attention to the importance of the educational and tailored opportunities offered by the SPOCs and MOOCs which are facilitating the acquisition of personalised and low-cost knowledge (Mahajan *et al.*, 2019).

According to the literature reviewed to discuss this scenario, the EU digital cohesion in the temporal horizon spanning over the next 15 years is shown in Figure 19.

Figure 19. Measure of digital cohesion in Scenario 2

Digital Compass dimensions	Advancement for digital cohesion
Digital infrastructures	*low* *medium* *high*
Digital skills	*low* *medium* *high*
Digital public services	*low* *medium* *high*
Digital transformation of businesses	*low* *medium* *high*

Scenario 3 - Connected but unsafe, digital cohesion is still far off

Figure 20. Representation of Scenario 3
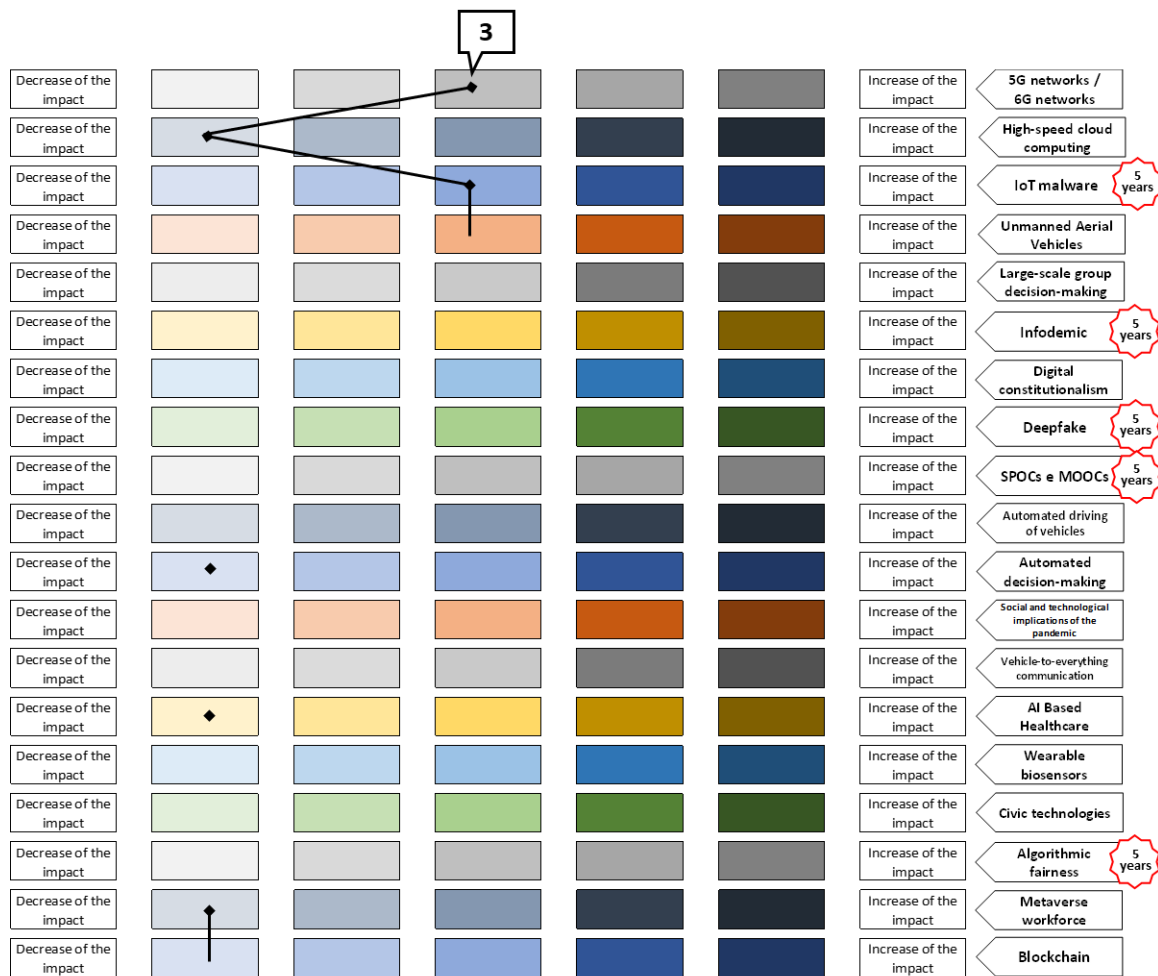
For creating Scenario 3 «**Connected but unsafe, digital cohesion is still far off**» depicted in Figure 20, the weak signals have been analysed by considering the **lowest value** of the experts' consultation results. In this scenario, 5G and 6G networks are the main factors which impact digital cohesion, both positively and negatively. This signal also triggers the spread of IoT malwares, which threatens institutions, the private sector and citizens' safety. This is a major threat for European digital cohesion, because digitalisation, particularly if it happens rapidly, is a catalyst for unpredictable cyberattacks and damages (Strelicz, 2021)

Unmanned aerial vehicles are also becoming increasingly popular. They are being employed both for personal and commercial purposes. The uptake of this technology presents opportunities in areas that address current business problems, such as low productivity, rather than more transformative applications, like air taxis, or areas that are only just beginning to generate interest, like infrastructure (McKinsey, 2017). Some rare forms of AI and high-speed computing and AI healthcare are used for specific and highly technical tasks. The vast majority of

the private sector, however, is still hesitant to move to high-speed computing due to cost, security, performance and the need for great power and cooling capacity (Thekkedath, 2020). These barriers also stopped the increased demand for this technology which was needed during the Covid-19 pandemic in order to enable AI biomedical research (Coughlin, 2021) and P4 (i.e., Predictive, Preventive, Personalized and Participatory) medicine.

In selected niche sectors, virtual reality is now used as a workplace and blockchain is employed as a safe way to protect payments and data exchange. However, the spread of these technologies remains limited. In general, the scenario depicts a reality where connectivity has improved but cyberattacks are an everyday threat, and only IT experts and some niche companies are benefiting from these technological advancements safely.

According to the literature reviewed to discuss this scenario, the EU digital cohesion in the temporal horizon spanning over the next 15 years is shown in Figure 21.

Figure 21. Measure of digital cohesion in Scenario 3

Digital Compass dimensions	Advancement for digital cohesion
Digital infrastructures	*low* · *medium* · *high* — high
Digital skills	*low* · *medium* · *high* — low
Digital public services	*low* · *medium* · *high* — low
Digital transformation of businesses	*low* · *medium* · *high* — medium

Scenario 4 - So far so good, digital cohesion is achieved

Figure 22. Representation of Scenario 4
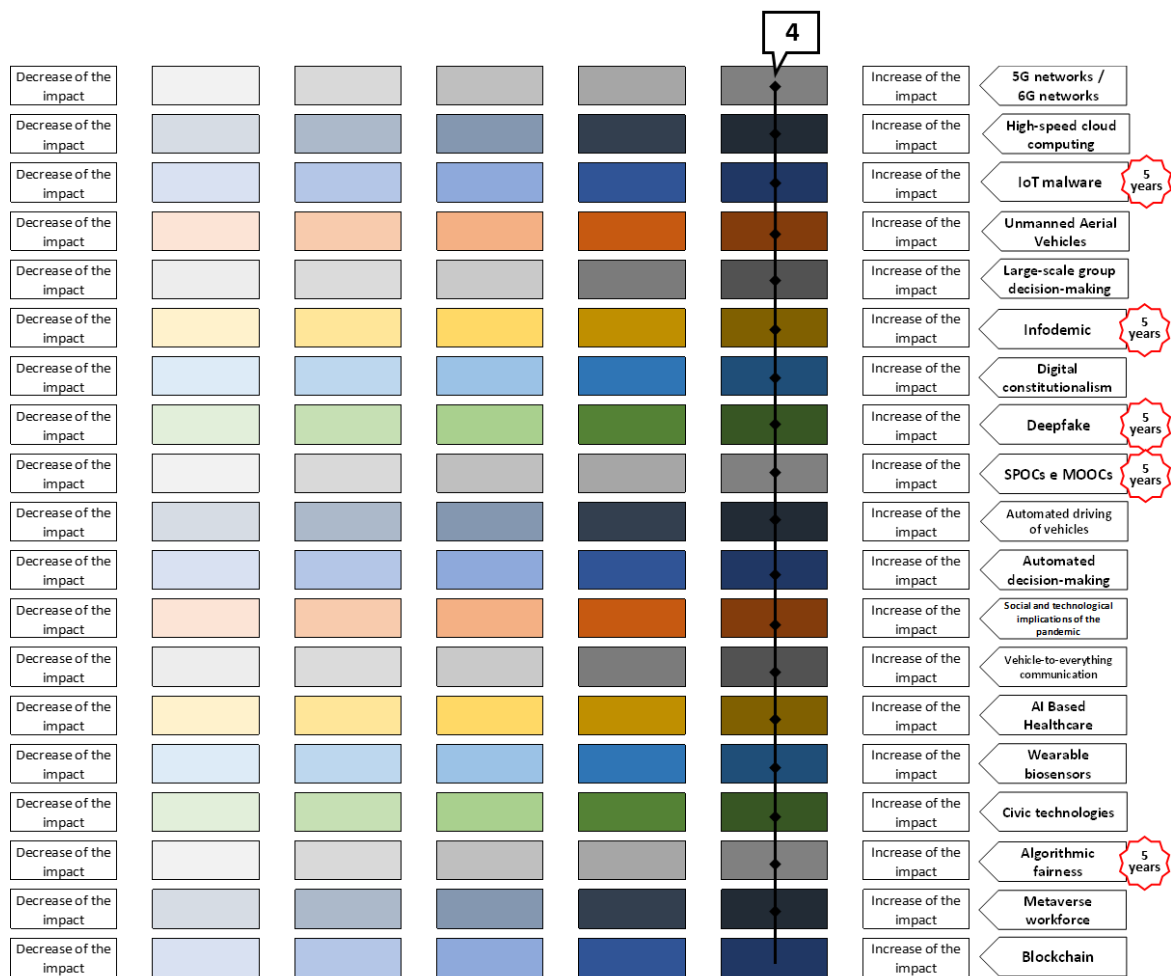
The Scenario 4 «**So far so good, digital cohesion is achieved**» is built by selecting the **highest values** of the experts' consultation results. For each signal, the scenario presents the maximum impact on digital cohesion. This results in an even uptake of the technologies by the public administration, the private sector and by citizens. Digital skills and digital infrastructures are the main enablers for the transformation of the public administration and of the private sector. This is because skills and connectivity are among the strongest drivers for the wide public adoption of these technologies (Lynn *et al.*, 2022; Vitolina, 2015). At the same time, digital cohesion achievement means all the barriers that generated the digital divide (e.g., affordability, geography, age and gender) have been overcome and digitalisation is a horizontal and shared aspect of the European society, accessible and accessed by all citizens (Vartanova and Gladkova, 2019).

The gain in relevance and participation in the digital society will also cause the increase of malicious attempts to influence or defraud through IoT malware,

deepfakes and infodemics, which will spread and impact the digital transformation at large.

According to the literature reviewed to discuss this scenario, the EU digital cohesion in the temporal horizon spanning over the next 15 years is shown in Figure 23.

Figure 23. Measure of digital cohesion in Scenario 4

Digital Compass dimensions	Advancement for digital cohesion
Digital infrastructures	*low* *medium* *high*
Digital skills	*low* *medium* *high*
Digital public services	*low* *medium* *high*
Digital transformation of businesses	*low* *medium* *high*

2.2.3 Wild Cards

Approach

Wild cards are disruptive events that impact society as a whole, at all levels. For the magnitude of their consequences, each wild card has been considered as a scenario itself. Each one has then been examined against its relevance towards achieving digital cohesion. The analysis is built based on available literature regarding the scenarios these wild cards may produce and the possible measures to mitigate them.

Results

According to the results of the experts' consultation, each wild card has been evaluated with respect to its relevance for digital cohesion. In the Figure 24 below, wild cards are represented in different sizes according to their relevance as rated in the experts' consultation reported in the following Table 8.

Figure 24. Representation of the of the experts' consultation results for wild cards

Table 8. Experts' consultation results for wild cards

WC#1	A disruptive digital pandemic	79%
WC#2	AI out of control	71%
WC#3	Extreme automation in PA	57%
WC#4	Massive immigration within Europe	57%
WC#5	End of Moore's Law	57%
WC#6	Failure of Europe	50%
WC#7	Energy as a luxury good	50%
WC#8	EU enlargement	50%

As shown in the table above, the experts consulted identified WC#1 and WC#2 as the main relevant WCs for digital cohesion.

Moreover, the wild cards can be divided into two groups, by referring to the PESTLE categorisation in Part 1 (Table 4). The first group is composed of wild cards classified in the technological domain and the second group is composed of wild cards classified in all the other domains. According to this criterion, the wild cards are divided as follows:

- Technological WCs: WC#1, WC#2, WC#3 and WC#5;
- Other WCs: WC#4, WC#6, WC#7 and WC#8.

Following the approach that weak signals can be precursors of wild cards, whether and how each scenario can lead to the occurrence of one of the four digital wild cards will be explored, as well as in which way it is impacting digital cohesion.

Additionally, policy needs for each scenario will be identified and further detailed in Part 3.

Scenario 1 and WC#2 'AI out of control'

Scenario 1 shows that there is a group of fast-developing technologies: 5G/6G networks, high-speed cloud computing, unmanned aerial vehicles, large-group decision-making, SPOCs and MOOCs, vehicle-to-everything communication, AI based healthcare and wearable biosensors. Besides SPOCs and MOOCs, these technologies are linked together by three 'technological enablers' which are high-speed computing, AI and IoT. Moreover, they are interconnected: high-speed computing enables the functioning of AI and IoT, while the convergence of AI and IoT can create intelligent machines that simulate smart behaviour and supports in decision-making with little or no human interference. In this context, where these technologies have the capacity to process an incredible amount of data and learn from it, the occurrence of WC#2 'AI out of control' does not seem so impossible. Even if in Scenario 1 these technologies do not seem to have reached the widest uptake, damage can still be extensive in a world where everything is interconnected. As mentioned in section 1.4.3, most scientists think that the most effective preventive measure is to have strict rules and control over the ethics and implications of AI.

Policy needs: the view for a future regulatory framework for AI in Europe, as advised by the EC High-Level Expert Group on Artificial Intelligence (AI HLEG) (EC - AI HLEG, 2019) could create an 'ecosystem of trust' with a human-centric approach, which could prevent AI from becoming harmful for society.

Scenario 2 and WC#3 'Extreme automation in PA'

Compared to the previous one, Scenario 2 presents a two-speed technological development: while the uptake of sectoral technologies is slowing down, the public administration and the general public are increasing the adoption of 5G/6G networks, high-speed computing, large-scale group decision-making and wearable biosensors. Applying these technologies (which gather and process huge amounts of personal data) to the public sector could lead to the occurrence of WC#3 'Extreme automation in PA'. By following an initial need for optimising the work, even with the rise in the importance of digital constitutionalism and the decrease in malicious cyberthreats, concerns linked with privacy and transparency of the processes would be inevitable.

Policy needs: there are many pilot projects[12], also mapped by the European Commission AI Watch Team, and foresight research (Andersen *et al.*, 2020; Barcevičius *et al.*, 2019; Misuraca and van Noordt, 2020) concerning which measures would help prevent an unfair extreme automation of the public administration. All the recommendations seem to point in the direction of international cooperation for the creation of standards and the assurance of transparency. In particular, there is a strong point in favour of transparent procedures for the assessment (Loi, 2021) of the design and appropriate mix of regulatory approaches on the public sector adoption of emerging digital technologies and their associated social, ethical and legal implications. This could also include putting public-private partnerships in place (Ubaldi *et al.*, 2019).

Scenario 3 and WC#1 'A disruptive digital pandemic'

Scenario 3 presents a situation where the occurrence of cyberattacks is a major societal threat. Together with a greater interconnectedness due to the development of 5G/6G networks, a digital pandemic (WC#1) would likely spread rapidly and have severe consequences. This is especially true for the public administration and the general public, which lack the necessary skills for managing cyberthreats and for containing the damages. Instead, their lack of skills could increase the infections caused by the malwares. Only the private sector, which has invested more in advanced skill training, would be better prepared but still not safe.

Policy needs: one of the most important actions for a preventive approach is to support research and innovation in the cybersecurity field. Moreover, the political step which is needed is increased accountability of Member States for the actions of non-state actors in their territories and for more effective sanctions for cybercrimes by the international community (Weber and Cygne Lara Toriser, 2021).

Scenario 4 and WC#5 'End of Moore's Law'

Scenario 4 describes a potential achievement of digital cohesion through the uptake of all the technologies by society at large. To envisage the full functioning of all these technologies it is logical to assume that the barriers existing in 2022 in terms of processing power will be overcome. These barriers are linked to the impossibility of further reducing the dimensions and increasing the processing power of current processors, making them inadequate to support the development of the above-mentioned technologies. It is the ending of Moore's Law which will trigger the exploration of new ways and concepts for empowering high-speed

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[12] See: https://trigger-project.eu/.

computing, IoT and AI and which will pave the way for the achievement of digital cohesion.

Policy needs: recent global semiconductor shortages have had a serious impact on many industries. As countries around the world are trying to secure semiconductor supplies, there is growing competition to convince companies to invest (Ezell, 2021). The sum of semiconductor incentives from European governments over 2020-2030 is respectively just 10% and 50% of what China and the US have promised over the same period. As part of a $2 trillion (Pramuk, 2021) economic stimulus package, U.S. President Joe Biden earmarked $50 billion for semiconductor manufacturing and research (Clifford, 2021). A bill known as the CHIPS for America Act is also working its way through the legislative process. Countries like Japan, South Korea and China are also all boosting investment into semiconductors. Therefore, the primary challenge for EU will be in attracting new players. The European Chips Act is an effort towards this objective: it will increase investment in chips with the aim of boosting Europe's share of global production. Since there are no European firms that can manufacture leading-edge chips, it will be crucial to convince Intel, Taiwan's TSMC or South Korea's Samsung to build factories.

Part 3 Vision and backcasting

In this part, a vision for digital cohesion is developed on the basis of the ideal implementation of key megatrends for Europe, also suggesting how progress towards the vision can be measured and discussing the use of relevant indicators and the existence of data gaps at the subnational level (section 3.1). A link between our vision, the digital divides and the four components of the Digital Compass is provided with the aim of proposing how to build a robust knowledge base for decision-makers according to which policies for digital cohesion are defined and implemented (section 3.2.1). Then, backcasting is applied to identify the necessary steps to be taken to achieve the vision (section 3.2.2). Potential barriers in implementing the vision are considered, in particular those related to change management and profound structural changes in organisations, and mitigation/contingency actions are suggested (section 3.2.3). Finally, the analysis is completed by outlining possible policy and strategy actions emerging from the assessment of the gaps and bottlenecks (section 3.2.4).

3.1 A vision for digital cohesion in Europe

The occurrence of weak signals (reinforcing/weakening actual trends or leading to wild cards), the realisation of wild cards, and the evolution of megatrends may depict several future states of digital cohesion in Europe. Visioning is a foresight approach that defines the most positive state at a precise horizon. Visioning is *'…where we move from plausible to desirable futures. Desirable futures can only become reality when they are imagined: a concrete vision of what exactly a desirable future would look like helps to identify concrete actions that lead towards that future.'* (van den Ende *et al.*, 2021, p.26). A vision is by necessity a broad description based on the definition of specific targets to be achieved within a horizon. A vision concerns a precise set of stakeholders: the beneficiaries of the realisation of the vision and the players that should act for the vision to realise.

Our vision is developed starting from the key megatrends included in the Megatrends Hub and investigated in Part 2 with respect to their contribution to the four components of the Digital Compass. It is also based on the appreciation that structural and coordinated interventions favouring digitalisation (e.g., legislative acts, policy actions) are able to determine the acceleration or deceleration of the megatrends. Stakeholders of our vision are citizens, enterprises, public administrations and policymakers at any administrative level in Europe.

Within this study, megatrends favouring digital cohesion are those whose evolution, acceleration or deceleration contributes to reducing one or more of the

eight types of digital divides previously identified in the study, namely *between European regions*, *between urban and rural areas*, *between SMEs and large enterprises*, *between rich and poor people*, *between vulnerable and non-vulnerable groups*, *between genders*, *between younger and older people* and *between skilled and unskilled people*. In particular, we identify elements of these megatrends that we imagine are able, once achieved, to close these divides.

Thus, **our vision is composed of eight sub-visions**, each of them focusing on the reduction or the disappearance of a specific digital divide. The description of each sub-vision is inferred by the narrative of the Megatrends in the Commission's Hub (accessed in April 2022).

These sub-visions create the image of an ideal future where digital cohesion in Europe approaches being a reality. Visioning builds upon the targets of the Digital Compass set for 2030 and looks further to 2050. Since it considers more specific divides than those addressed in the Digital Compass (e.g., *between European regions*), our vision also widens the scope of the targets, providing evidence of the existing digital divides, proposing indicators to measure and monitor the progress towards their closing and highlighting data gaps and opportunities driven by new types of data and indicators.

3.1.1   The sub-vision closing the digital divide between European regions

The digital economy keeps on contributing to the economic growth of the less developed regions in Europe, especially the depopulating ones. The limited relevance of localisation of workers and enterprises in the digital economy and the availability of digital private and public services has almost closed the divide across territories. In the health sector, the adoption of internet-based technologies and remote communication tools fosters personalised medicine as a public service. Distributed ledger technologies (DLTs) and blockchain technologies make digitally based cross-border cooperation and cross-country collaboration between public services easy and not dependent on interoperability. The rising need for new resources has given economic importance to previously less developed regions, increasing the need for their whole connectivity and interoperability. This digital integration among European regions is reinforcing a new geopolitical situation characterised by cooperation within Europe and by competition with the other world areas in order to ensure that the EU has the necessary supply of resources, especially raw materials.

Source: authors of the study inspired by the narrative of the following megatrends in the Commission's Hub: Accelerating technological change and hyperconnectivity, Aggravating resource scarcity, Changing nature of work, Widening inequalities.

The actual divide in Europe: how to measure it and monitor its progress over time.

At present, although widely recognised, the digital divide between European regions has still no precise indicators for its quantitative assessment. The most convincing theoretical framework to assess this divide is the one proposed by the Digital Compass and its four components, although data at the regional level (i.e., NUTS2) are missing for most of its indicators and proxies need to be identified to appreciate the disparities across regions (as proposed in the introduction of this study). Some piloting projects initiated by local and regional authorities have started developing Digital Compass-like regional frameworks by using indicators and proxies for which data are available for the concerned territories (e.g., the [Regional Digital Compass developed by the Council of the Tampere Region](#)). The Digital Preparedness of Regions (DPR) (Cavallini and Soldi, 2021) is an incipient framework of indicators proposed to appreciate the differences between regions in supporting the digital transformation of businesses[13].

Currently available data at the regional level (May 2022) from Eurostat allow the partial assessment of the digital divide from the users' perspectives only. Individuals and households use digital infrastructures and tools, access the internet, interact with administrations for public services and order private goods and services. Still, no indicators are available to properly appreciate the 'digital endowment' at the regional level (i.e., in terms of digital infrastructures, digital transformation of business and digitalisation of public services).

Suggested indicators to measure the closing of the divide between European regions

• All indicators related to individuals in the Eurostat category ICT usage in enterprises (isoc_e) can be used to assess the digital divide across regions. Among them, the following (the ones with data already at the NUTS2 level) are suggested:
     o Households with access to the internet at home (isoc_r_iacc_h).
     o Households with broadband access (isoc_r_broad_h).
     o Individuals who have never used a computer (isoc_r_cux_i).
     o Individuals who used the internet, frequency of use and activities (isoc_r_iuse_i).
     o Individuals who used the internet for interaction with public authorities (isoc_r_gov_i).

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[13] The framework of the DPR is composed of 10 indicators: Employment in information and communication, human resources graduated and employed in science and technology, presence of digital innovation hubs, number of enterprises in information and communication, number of unicorns, public money spent by LRAs in purchasing digital goods and services through public procurement, intramural R&D expenditure by source of funds, fast broadband coverage, broadband access, gross value added at basic prices in the information and communication sector.

- o Individuals who ordered goods or services over the internet for private use (isoc_r_blt12_i).
  - o Individuals who accessed the internet away from home or work (isoc_r_iumd_i).
- Most of the indicators in the Eurostat category digital skills (isoc_sk) can be used to appreciate specific aspects of the digital divide across regions. Among them, the following are suggested:
  - o Individuals' level of digital skills (from 2021 onwards) (isoc_sk_dskl_i21).
  - o Individuals' level of computer skills (2021 onwards) (isoc_sk_cskl_i21).
  - o Individuals' level of internet skills (isoc_sk_iskl_i).
  - o ICT competence and demand for ICT skills in enterprises (isoc_ske).
  - o Enterprises that employ ICT specialists (isoc_ske_itspen2).
  - o Persons with ICT education by labour status (isoc_ski_itemp).
- Most of the indicators in the Eurostat category ICT usage in enterprises (isoc_e) can be used to appreciate specific aspects of the digital divide across regions. Among them, the following are suggested:
  - o Digital Intensity (isoc_e_dii).
  - o Covid-19 Impact on ICT usage (isoc_e_cvd).
  - o Value of e-commerce sales (isoc_ec_evaln2).
  - o Use of computers and the internet by employees (isoc_ci_cm_pn2).
  - o Type of connections to the internet (isoc_ci_it_en2).
  - o Integration of internal processes (isoc_eb_iip)[concerning ebusiness].
  - o Integration with customers/suppliers, supply chain management (isoc_eb_ics) [concerning ebusiness].
  - o Cloud computing services (isoc_cicce_use).
  - o Big data analysis (isoc_eb_bd).
  - o 3D printing and robotics (isoc_eb_p3d).
  - o Internet of Things (isoc_eb_iot).
  - o Artificial intelligence (isoc_eb_ai).
- Most of the indicators in the Eurostat category *ICT sector* (isoc_se) can be used to appreciate specific aspects of the digital divide between regions. Among them, the following are suggested:
  - o Percentage of the ICT sector in GDP (isoc_bde15ag).
  - o Percentage of the ICT personnel in total employment (isoc_bde15ap).
  - o Percentage change of value added by ICT sector at current prices (isoc_bde15av).
  - o Business expenditure on R&D (BERD) in ICT sector as % of total R&D expenditure by NACE Rev. 2 activity (isoc_bde15ar2).
  - o Employer business demography by size class (from 2004 onwards, NACE Rev. 2) (bd_9fh_sz_cl_r2).
  - o Business demography by size class (from 2004 onwards, NACE Rev. 2) (bd_9bd_sz_cl_r2).
  - o Indicators with growth by 20% or more (from 2008 onwards, NACE Rev. 2) (bd_9n_r2).

Data gaps preventing the assessment of digital cohesion

- The geographical scope of statistics related to Digital skills (isoc_sk), ICT usage in enterprises (isoc_e) and *ICT sector* (isoc_se) is at the national level (NUTS0) so it only allows assessing the digital divide by country. The lack of these data at the NUTS2 level prevents assessing disparities across regions in the digital economy in general and in the digital transformation of businesses in particular.

Opportunities driven by new types of data or new indicators

- Data on access to e-government services through digital identity by individuals could help appreciate disparities across regions in the digitalisation of public services. A detailed breakdown can be included for specific e-health services. This data could be retrieved from the digital records of individuals' access.
- Data on access to e-government services by enterprises could help appreciate disparities across regions in the digitalisation of public services. This data could be retrieved from the digital records of enterprises' access.
- Data on the presence of scale-up enterprises and/or unicorns could allow disparities between regions in terms of economic impact of digitally-based enterprises to be measured.
- A Digital Intensity Index for public services delivery could allow digitalisation of public services in different areas to be compared and could make a potential divide across regions evident.
- Data on the minimum and maximum broadband coverage could be a starting point for a digital connectivity index at the NUTS2 level.
- Data on the value of LRAs' public procurement for digital needs (i.e., contracts for digital services and for the acquisition of ICT goods) could allow the divide in digitalisation of public services across regions to be appreciated. These data could be retrieved from the digital records of public procurement procedures of LRAs.
- Data on the ICT sector at the NUTS2 level could be crucial to appreciate the digital economy's contribution to regional growth (e.g., combined with other indicators such as the regional GDP or the regional added value).
- Data related to individuals living in Objective 1 regions/'Convergence' regions (IND_O1) and individuals living in Not Objective 1 regions/'Regional Competitiveness and Employment' Region that will be made available by Eurostat in the near future could support the comparison between structural divides and digital divides between regions.

3.1.2 The sub-vision closing the digital divide between urban and rural areas

The distinction between urban and rural is gradually fading away and being replaced by a degree of urbanisation. Smart cities are replaced by smart communities. Flying vehicles and autonomous delivery vehicles would make short distances unimportant. Satellites launched in the conquest of space make high-speed connection available anywhere on Earth. Alternatives to traditional food production are found in order to face the growing scarcity of natural resources (e.g., soil), thus changing the paradigm of concentration of agricultural practices in specific places or areas (i.e., current rural areas). The rural-urban divide is further narrowed by the virtualisation of work and employment. Jobs requiring a high level of physical input/proximity are disappearing. In the Gig economy, work is chosen through online platforms according to individual interests, skills and availability and is not dependent

on geography. SMEs are able to enter the digital market and compete regardless of their location. In addition, public services, health management and monitoring are available to citizens online, significantly reducing distance constraints.

Source: authors of the study inspired by the narrative of the following megatrends in the Commission's Hub: Accelerating technological change and hyperconnectivity, Aggravating resource scarcity, Changing nature of work, Continuing urbanisation, Shifting health challenges.

The actual divide in Europe: how to measure it and monitor its progress over time.

As shown in the introduction of this study (Another detail of particular significance is the indication of the share of individuals who never use the internet. Since broadband connectivity is guaranteed across the EU (see next chapter), the 'no use' condition is considered to imply the lack of digital skills and points to an audience that may need to be addressed by tailored digital inclusion policies. Figure 4 highlights the existence of a rural-urban divide for this indicator in the majority of the EU countries.

Figure 4), data on individuals never using the internet and living in cities, towns and suburbs and rural areas highlight a structural rural-urban divide in Europe. In 2021, the highest digital divide is found in Greece (14% in cities and 33% in rural areas), Bulgaria (17% in cities and 26% in rural areas) and Portugal (25% in cities and 16% in rural areas). On the contrary, in the Netherlands, the share of individuals never using the internet is higher in cities (4%) than in rural areas (2%) and in Belgium, Denmark, Ireland and Luxembourg there is no difference between individuals living in cities or in rural areas. At the EU27 level, on average, the share of individuals never using the internet is 5% for those who are living in cities, 8% for those who are living in towns and suburbs and 11% for those who are living in rural areas. A rural-urban divide is found in several of the aspects addressed by the Digital Compass. One of the most quoted examples is the rural-urban digital divide in terms of digital infrastructure. Reference is to Table 2 of the introduction and following Figure 5, Figure 6 and Figure 7.

Concerning the rural-urban divide, Eurostat has recently updated (March-April 2022) some of its statistics. A large part of statistics related to the digital economy and society (i.e., statistics on ICT usage in households and by individuals and on digital skills) has been made available characterising individuals according to the urbanisation level of the place where they live: in cities, in towns and suburbs, and in rural areas.

Suggested indicators to measure the closing of the divide between urban and rural regions

- All indicators related to individuals in the Eurostat category ICT usage in enterprises (isoc_e) can be used to assess the digital divide between urban and rural areas. Among them, the following are suggested:
    - Individuals - computer use (isoc_ci_cfp_cu).
    - Individuals - internet use (isoc_ci_ifp_iu).
    - Individuals - internet activities (isoc_ci_ac_i).
    - Internet purchases by individuals (2020 onwards) (isoc_ec_ib20).
    - Internet purchases - goods or services (2020 onwards) (isoc_ec_ibgs).
    - Internet purchases - money spent (2020 onwards) (isoc_ec_ibm).
    - Internet purchases - perceived barriers (2021 onwards) (isoc_ec_inb21).
    - E-government activities of individuals via websites (isoc_ciegi_ac).
    - Use of ICT at work and activities performed (isoc_iw_ap).
    - Work from home, from an external site or on the move (isoc_iw_hem).
- Most of the indicators in the Eurostat category digital skills (isoc_sk) can be used to appreciate specific aspects of the digital divide between rural and urban areas. Among them, the following are suggested:
    - Individuals' level of digital skills (from 2021 onwards) (isoc_sk_dskl_i21).
    - Individuals' level of computer skills (2021 onwards) (isoc_sk_cskl_i21).
    - Individuals' level of internet skills (isoc_sk_iskl_i).
    - Employed ICT specialists - total (isoc_sks_itspt).
    - Employed ICT specialists by sex (isoc_sks_itsps).
    - Employed ICT specialists by educational attainment level (isoc_sks_itspe).
    - Persons with ICT education by labour status (isoc_ski_itemp).
- Most of the indicators in the Eurostat category ICT usage in enterprises (isoc_e) can be used to appreciate specific aspects of the digital divide between urban and rural areas. Among them, the following are suggested:
    - Digital Intensity (isoc_e_dii).
    - Covid-19 Impact on ICT usage (isoc_e_cvd).
    - Value of e-commerce sales (isoc_ec_evaln2).
    - Use of computers and the internet by employees (isoc_ci_cm_pn2).
    - Type of connections to the internet (isoc_ci_it_en2).
    - Integration of internal processes (isoc_eb_iip)[concerning ebusiness].
    - Integration with customers/suppliers, supply chain management (isoc_eb_ics) [concerning ebusiness].
    - Cloud computing services (isoc_cicce_use).
    - Big data analysis (isoc_eb_bd).
    - 3D printing and robotics (isoc_eb_p3d).
    - Internet of Things (isoc_eb_iot).
    - Artificial intelligence (isoc_eb_ai).
- Most of the indicators in the Eurostat category *ICT sector* (isoc_se) can be used to appreciate specific aspects of the digital divide between urban and rural areas. Among them, the following are suggested:
    - Percentage of the ICT sector in GDP (isoc_bde15ag).
    - Percentage of the ICT personnel in total employment (isoc_bde15ap).
    - Percentage change of value added by ICT sector at current prices (isoc_bde15av).

Data gaps preventing the assessment of digital cohesion
• The geographical scope of these statistics related to ICT usage in enterprises (isoc_e) and the ICT sector (isoc_se) is at the national level (NUTS0) so it only allows the assessment of the digital divide by country. The lack of these data by the degree of urbanisation prevents assessing disparities across territories in the digital economy in general and in the digital transformation of businesses in particular.

Opportunities driven by new types of data or new indicators
• Data on the average cost of broadband access for citizens by degree of urbanisation could allow assessing if and how much the digital divide between urban and rural areas is affected by the cost of internet access.
• Data on access to e-government services through digital identity by individuals could help appreciate disparities between urban and rural areas in the digitalisation of public services. A detailed breakdown can be included for specific eHealth services. This data could be retrieved from the digital records of individuals' access.
• A Digital Intensity Index for public services delivery could allow digitalisation of public services in different areas to be compared and could make a potential divide between urban and rural areas evident.
• The degree of urbanisation may be used in combination with a digital connectivity index (see 'Opportunities driven by new types of data or new indicators' in the digital divide between regions). A Smart Community Index may be created to take into account the digital services/infrastructures (e.g., automated public transport) available to citizens and enterprises in a territory (urban/rural area). Main data sources are big data collected by local and regional authorities, their agencies, public service providers and utility network operators.
• The work carried out with the LORDI (Local and Regional Digital Indicators) may also expand the opportunities to define new proxies/data needs on digital aspects at the urban level.

3.1.3 The sub-vision closing the digital divide between SMEs and large enterprises

In 2050, the production of goods and delivery of services and their supply chains are almost entirely digitally-based. The digital market prevails. Opportunities for SMEs to enter the digital market have regularly grown since 2030 due to lower entry barriers than in the traditional market. The size of enterprises in terms of the number of employees loses relevance and enterprises are classified according to their turnover. The adaptation capacity of SMEs increases in the digital market due to collective resilience mechanisms which create economies of scale and are based on the existence of SME ecosystems. Plenty of digitally-transformed business models are exploited by SMEs. The adoption of advanced technologies (IoT, AI, cloud and big data/analytics) has made Industry 4.0 a reality for SMEs as well. Products and services continue to be more and more personalised to the needs of individual customers. Digital market opportunities for SMEs are driven by

the green economy (i.e., circularity, recycling, producing and delivering locally, and sharing according to a servitization culture), the need to keep an equilibrium between humanity and Earth's resources (e.g., AI-based accounting of individual carbon emission quota) and the need for storage and processing solutions to collect data and to allow data-driven decision-making. Digitally-based and new types of work and employment (e.g., non-standard forms of work and platform work that are often based on self-employment and/or creative/innovative enterprises) are easy to start up and are protected by legislation (e.g., in terms of social protection, unemployment benefits). The workplace has lost meaning for a large number of jobs. Fair competition in the digital market exists, and the creation of multi-national data companies empowered by owning consumers' data is avoided.

Source: authors of the study inspired by the narrative of the following megatrends in the Commission's Hub: Accelerating technological change and hyperconnectivity, Aggravating resource scarcity, Changing nature of work, Climate change and environmental degradation, Continuing urbanisation, Widening inequalities, Growing consumption.

The actual divide in Europe: how to measure it and monitor its progress over time.

The divide in the usage and adoption of digital technologies between enterprises of different sizes is currently a structural feature of the productive environment in Europe. A number of policies at the EU level are focusing on the digital transformation of enterprises with a specific focus on SMEs and on their gaps with respect to large enterprises. For example, the Eurostat Digital Intensity Index (DII) for 2020 indicates that 60% of the SMEs in the EU reached at least a basic level of digital intensity[14] (the share was 89% for large enterprises). According to the Digital Compass, the target for this share is 90% by 2030. The divide between SMEs and large enterprises is evident at all levels of digital intensity: only 2% of SMEs have a *very high* DII (vs. 9% for large enterprises); 25% of SMEs have a *high* DII (vs. 42% for large enterprises).

The other two indicators of the Digital Compass related to the digital transformation of businesses do not distinguish between SMEs and large enterprises. However, to achieve their targets a clear understanding of the

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[14] In 2020, the DII comprised the following 12 variables: more than 50% of persons employed having access to the internet for business purposes, employment of ICT specialists; fast broadband (30 Mbps or above); providing more than 20% of persons employed with a portable device allowing mobile internet connections; having a website; a website has sophisticated functionalities (at least one of: description of goods or services, price lists; possibility for visitors to customise or design online goods or services; tracking or status of orders placed; personalised content in the website for regular/ recurrent visitors); use of 3D printing; buying medium-high cloud computing services; sending invoices suitable for automated processing; use of industrial or service robots; having e-commerce sales accounting for at least 1% of total turnover; analysing big data internally from any data source or externally. The *basic level* entails the use of at least four technologies.

disparities between SMEs and large enterprises could be essential. Looking at the tech uptake, for example, one of the Digital Compass targets is 75% of EU enterprises using cloud services. In 2020, the share of SMEs that purchase such services is 35% against 65% of large enterprises.

In addition to the DII (which classifies enterprises in four levels of digital intensity, i.e., *very low, low, high, very high*), Eurostat has recently updated its statistics providing a consistent number of indicators on the ICT usage in enterprises and for all of them the breakdown by enterprise size is provided. Enterprises are classified in terms of the *number of employees and self-employed persons working in the enterprise* as small enterprises (10-49 employees and self-employed persons), medium enterprises (50-249) and large enterprises (250 or more)[15].

Suggested indicators to measure the closing of the divide between SMEs and large enterprises

• All indicators in the Eurostat category ICT usage in enterprises (isoc_e) can be used to appreciate specific aspects of the digital divide between SMEs and large enterprises. Among them, the following are suggested:
     ○ Digital Intensity (isoc_e_dii).
     ○ Value of e-commerce sales (isoc_ec_evaln2).
     ○ Type of connections to the internet (isoc_ci_it_en2).
     ○ Integration of internal processes (isoc_eb_iip)[concerning eBusiness].
     ○ Integration with customers/suppliers, supply chain management (isoc_eb_ics) [concerning eBusiness].
     ○ Cloud computing services (isoc_cicce_use).
     ○ Big data analysis (isoc_eb_bd).
     ○ 3D printing and robotics (isoc_eb_p3d).
     ○ Internet of Things (isoc_eb_iot).
     ○ Artificial intelligence (isoc_eb_ai).
 • Some of the indicators concerning competencies in enterprises in the Eurostat category Digital skills (isoc_sk) allow assessing the disparities between SMEs and large enterprises. Among them, the following are suggested:
     ○ Enterprises that employ ICT specialists (isoc_ske_itspen2).
     ○ Enterprises that provided training to develop/upgrade ICT skills of their personnel (isoc_ske_ittn2).

Data gaps preventing the assessment of digital cohesion
• The geographical scope of these statistics is at the national level (NUTS0) so it only allows assessing the digital divide by country. The lack of these data at the NUTS2 level prevents assessing disparities in the digital transformation of business across regions.

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[15] In some cases, data are provided also for micro enterprises (0-1) and mini enterprises (2-9).

Opportunities driven by new types of data or new indicators
• Data on employees or self-employed individuals structurally working in remote mode by enterprise size may help assess disparities between SMEs and large enterprises in terms of new types of work and employment.
• Over time, the Digital Intensity Index should be enriched by including new indicators referring to the adoption of frontier technologies. This will allow further appreciation of potential emerging digital divides between enterprises of different size.

3.1.4 The sub-vision closing the digital divide between rich and poor people

Digital end-users' purchasing power differences are flattened by widely-available high connectivity and affordable costs of devices for accessing digital (private and public) services. Individual personal data are given an economic value and people are paid for personal data by third parties. Personalised public healthcare is guaranteed by the massive and affordable use of wearable sensors, AI-based diagnostic and e-health big data management. Digitalisation increases the accessibility of prevention, diagnosis, treatment, monitoring and health management for all. Online civic participation in democratic processes makes the contribution of poor people equal to that of rich and influential people.

Source: authors of the study inspired by the narrative of the following megatrends in the Commission's Hub: Accelerating technological change and hyperconnectivity, Changing nature of work, Increasing influence of new governing systems.

The actual divide in Europe: how to measure it and monitor its progress over time.

The cost of accessing technologies is still a source of disparity for EU citizens in exploiting advantages provided by digital services. For example, at the EU level only 3% of the households indicate the too-high cost of access and equipment in 2019 as a reason for not having the internet at home. However, taking into account the households' income, the EU average percentage rises to 9% for the households with the lowest income and it is zero for the households with the highest income in almost all the EU27 countries.[16]

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[16] Eurostat statistics on the ICT usage in households and by individuals include a large number of indicators and, for all of them, the breakdown by income of the households or income of the individuals living in households is provided. Households or individuals living in households are classified into four groups according to the income quartile to which they belong (with the first quartile including 25% of the households/individuals with the lowest income and the fourth quartile including 25% of the households/individuals with the highest income).

Only 1% of the households with the lowest income in Denmark and the Netherlands consider the too-high cost of access and equipment as a reason for not having the internet at home. The countries with the maximum percentage of the households with the lowest income for whom the cost prevents internet access at home are Hungary (30%), Bulgaria (25%) and Portugal (25%). Looking at the households in Europe having a broadband connection (i.e., 89% in 2020), the difference between the households with the highest income and the households with the lowest income is 22 percentage points (p.p.). This income-based divide ranges from 6 p.p. in the Netherlands to 63 p.p.in Bulgaria.

Suggested indicators to measure the closing of the divide between rich and poor people
• All indicators in the Eurostat category ICT usage in households and by individuals (isoc_i) can be used to appreciate specific aspects of the digital divide between rich and poor people. Among them, the following are suggested: o Households - type of connection to the internet (isoc_ci_it_h). o Households - reasons for not having internet access at home (isoc_pibi_rni). o Households - availability of computers (isoc_ci_cm_h). o Individuals - internet activities (isoc_ci_ac_i). o Internet purchases by individuals (2020 onwards) (isoc_ec_ib20). o Internet purchases - goods or services (2020 onwards) (isoc_ec_ibgs). o Internet purchases - money spent (2020 onwards) (isoc_ec_ibm). o Internet purchases - perceived barriers (2021 onwards) (isoc_ec_inb21). o Financial activities over the internet (2020 onwards) (isoc_ec_ifi20). o E-government activities of individuals via websites (isoc_ciegi_ac).
Data gaps preventing the assessment of digital cohesion
• The geographical scope of these statistics is at the national level (NUTS0) so it only allows assessing the digital divide by country. The lack of these data at the NUTS2 level prevents assessing how much the poorest citizens are limited in exploiting opportunities offered by the digital technologies across regions. • Available data at the NUTS2 level related to the usage of ICT by households and individuals do not include any differentiation of users by income. Among the indicators that suffer from this limitation and that could be useful to measure and monitor the digital divide between rich and poor people are: o Households with access to the internet at home (isoc_r_iacc_h). o Households with broadband access (isoc_r_broad_h). o Individuals who used the internet for interaction with public authorities (isoc_r_gov_i). o Individuals who ordered goods or services over the internet for private use (isoc_r_blt12_i).
Opportunities driven by new types of data or new indicators
• Data on the access of individuals to public free broadband may allow proxying the level of accessibility to the internet independently from the income level. These data fall in the category of big data that public administrations can directly gather from the users at the local level (i.e., providing a base of data at the LAU level or at the NUTS3 level or contributing to the statistics provided by the degree of urbanisation).

3.1.5 The sub-vision closing the digital divide between vulnerable and non-vulnerable groups

> The digital world reduces traditional (physical and social) barriers and facilitates access and engagement of vulnerable groups. Technologies themselves reduce the vulnerability condition. Citizens' digital twin lives (made possible by extended reality technologies) allow the consumption of goods and services in the virtual world by everybody. New-frontier goods and services are available for citizens' avatars. In addition, soft skills are increasingly requested and represent an online employment opportunity for more vulnerable groups. Digital rights enforcement is increasing but 'digital vulnerable groups' still need protection. Cybersecurity challenges are reduced for the most vulnerable digital users by the adoption of new and/or appropriate legislative instruments. There is a more participatory democracy, driven by digital technologies, that allows the involvement of vulnerable groups.

Source: authors of the study inspired by the narrative of the following megatrends in the Commission's Hub: Accelerating technological change and hyperconnectivity, Diversification of education and learning, Widening inequalities, Growing consumption, Increasing influence of new governing systems.

The actual divide in Europe: how to measure it and monitor its progress over time.

If a comprehensive characterisation of vulnerable people is usually challenging[17], the identification of the types of individuals proxying the 'vulnerable groups' in official statistics is even more so. The digital divide is likely to worsen the socio-economic condition of vulnerable people, that, on the contrary, could benefit from inclusiveness favoured by digital technologies. Among the types of individuals considered by Eurostat in ICT usage in households and by individuals, there are individuals with at least two of the 3 following characteristics: 55 to 74 years old; low education; unemployed or inactive or retired. For example, in 2020, at the EU level, the percentage of these individuals (i.e., that can be considered at high risk of social exclusion) using the internet in the last 12 months is 70% against 89% of all the individuals. In Denmark, this share rises to 96% (against 99% of all individuals), while in Bulgaria it falls to 36% (against 74% of all individuals).

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[17] According to the definition provided by the DG Migration and Home Affairs, vulnerable persons are *"minors, unaccompanied minors, disabled people, elderly people, pregnant women, single parents with minor children, victims of trafficking in human beings, persons with serious illnesses, persons with mental disorders and persons who have been subjected to torture, rape or other serious forms of psychological, physical or sexual violence, such as victims of female genital mutilation".*

Among the other types of individuals considered in Eurostat statistics that can proxy vulnerable groups are, for example, nationals of non-EU countries, individuals living in households with the lowest income and individuals with at least one of the three following characteristics: 55 to 74 years old; low education; unemployed or inactive or retired.

Suggested indicators to measure the closing of the divide between vulnerable and non-vulnerable groups

• All indicators related to individuals in the Eurostat category ICT usage in households and by individuals (isoc_i) can be used to appreciate specific aspects of the digital divide affecting vulnerable groups. Among them, the following are suggested:
    o Individuals - computer use (isoc_ci_cfp_cu).
    o Individuals - frequency of computer use (isoc_ci_cfp_fu).
    o Individuals - internet use (isoc_ci_ifp_iu).
    o Individuals - frequency of internet use (isoc_ci_ifp_fu).
    o Individuals - internet activities (isoc_ci_ac_i).
    o Individuals - use of collaborative economy (until 2019) (isoc_ci_ce_i).
    o E-government activities of individuals via websites (isoc_ciegi_ac).
    o Privacy and protection of personal data (2020 onwards) (isoc_cisci_prv20).
    o Security related problems experienced when using the internet (isoc_cisci_pb).
    o Use of ICT at work and activities performed (isoc_iw_ap).
    o Impact of ICT on tasks and skills (isoc_iw_imp).
    o Internet of Things - use (isoc_iiot_use).
    o Internet of Things - barriers to use (isoc_iiot_bx).

Data gaps preventing the assessment of digital cohesion

• The geographical scope of these statistics is at the national level (NUTS0) so it only allows assessing the digital divide by country. The lack of these data at the NUTS2 level prevents assessing how much vulnerable citizens are limited in exploiting opportunities offered by the digital technologies across regions.
• Available data at the NUTS2 level related to the usage of ICT by households and individuals do not include any differentiation of individuals. Among the indicators that suffer from this limitation and that could be useful to measure and monitor the digital divide experienced by vulnerable groups are:
    o Individuals who have never used a computer (isoc_r_cux_i)
    o Individuals who used the internet, frequency of use and activities (isoc_r_iuse_i)
    o Individuals who used the internet for interaction with public authorities (isoc_r_gov_i)
    o Individuals who ordered goods or services over the internet for private use (isoc_r_blt12_i)

Opportunities driven by new types of data or new indicators
• Data on ICT usage need to be improved by including other categories of individuals that better proxy vulnerable people such as disabled people, Roma, migrants, refugees and asylum-seekers.

3.1.6 The sub-vision closing the digital divide between genders

> Online, there is acceptance of non-binary gender identities and expressions (*). Thus, for example, platform-based jobs do not discriminate according to personal data. Digitally-based and new types of work (e.g., Gig economy) allow more flexibility during day-time, entrance-exit from the labour market during the work life and increasing employment opportunities for women. Digital professional careers are based on competencies and capacities. Online, the gender salary gap is closed. The digitalisation of service provision increases women's access to quality education.

Source: authors of the study inspired by the narrative of the following megatrends in the Commission's Hub: Changing nature of work, Widening inequalities, Growing consumption, Shifting health challenges.

The actual divide in Europe: how to measure it and monitor its progress over time.

Nowadays, when referring to internet access, the digital divide between men and women is almost closed at the EU level and seems to concern mainly females over 55 years (i.e., Eurostat 2020 data on individuals having used the internet in the last 12 months). Instead, when referring to advanced digital skills, disparities between genders are significant. In 2020, only one in three 'science, technology, engineering and/or mathematics' (STEM) graduates are women (DESI webpage). While in the Digital Compass the target is to reach 20 million employed ICT specialists in the EU by 2030, with convergence between women and men, Eurostat data show that in 2021, employed ICT specialists are around 9 million and that only 19% of them are women. As reported in the introduction of this study, where the analysis is focused on the regional level, the gender digital divide is still consistent and evident when analysing employment in the I&C sector as a proxy of the gender convergence in the digital skills domain.

Eurostat statistics on ICT usage in households and by individuals and on Digital skills are provided with a breakdown of the individuals by gender associated both with age cohorts and level of formal education (i.e., low, medium, high).

Suggested indicators to measure the closing of the divide between genders

• All indicators related to individuals in the Eurostat category ICT usage in households and by individuals (isoc_i) can be used to appreciate specific aspects of the gender digital divide. Among them, the following are suggested:
    ○ Individuals - computer use (isoc_ci_cfp_cu).
    ○ Individuals - internet use (isoc_ci_ifp_iu).
    ○ Individuals - internet activities (isoc_ci_ac_i).
    ○ Individuals - use of collaborative economy (until 2019) (isoc_ci_ce_i).
    ○ Internet purchases by individuals (2020 onwards) (isoc_ec_ib20).
    ○ Internet purchases - problems encountered (2021 onwards) (isoc_ec_iprb21).

- o Internet purchases - perceived barriers (2021 onwards) (isoc_ec_inb21).
  - o E-government activities of individuals via websites (isoc_ciegi_ac).
  - o Reasons for not submitting completed forms to public authorities' websites (isoc_ciegi_rtx).
  - o Privacy and protection of personal data (2020 onwards) (isoc_cisci_prv20).
  - o Security related problems experienced when using the internet (isoc_cisci_pb).
  - o Activities via internet not done because of security concerns (isoc_cisci_ax).
  - o Use of ICT at work and activities performed (isoc_iw_ap).
  - o Impact of ICT on tasks and skills (isoc_iw_imp).
  - o Work from home, from an external site or on the move (isoc_iw_hem).
- All indicators in the Eurostat category digital skills (isoc_sk) can be used to appreciate specific aspects of the gender digital divide. Among them, the following are suggested:
  - o Individuals' level of digital skills (from 2021 onwards) (isoc_sk_dskl_i21).
  - o Individuals' level of computer skills (2021 onwards) (isoc_sk_cskl_i21).
  - o Evaluating data, information and digital content (2021 onwards) (isoc_sk_edic_i21).
  - o Individuals' level of internet skills (isoc_sk_iskl_i).
  - o Way of obtaining ICT skills (isoc_sk_how_i).
  - o ICT competence and demand for ICT skills in enterprises (isoc_ske).
  - o Employed ICT specialists by sex (isoc_sks_itsps).
  - o Employed persons with ICT education by sex (isoc_ski_itsex).

Data gaps preventing the assessment of digital cohesion

- The geographical scope of these statistics is at the national level (NUTS0) so it only allows assessing the digital divide by country. The lack of this data at the NUTS2 level prevents assessing the gender digital divide across regions.
- Available data at the NUTS2 level related to the usage of ICT by households and individuals do not include any differentiation of individuals. Among the indicators that suffer from this limitation and that could be useful to measure and monitor the gender digital divide are:
  - o Individuals who have never used a computer (isoc_r_cux_i)
  - o Individuals who used the internet, frequency of use and activities (isoc_r_iuse_i)
  - o Individuals who used the internet for interaction with public authorities (isoc_r_gov_i)
  - o Individuals who ordered goods or services over the internet for private use (isoc_r_blt12_i)

Opportunities driven by new types of data or new indicators

- Data on women who graduated in STEM at the regional level and by the degree of urbanisation could increase the opportunities to appreciate the gender disparities at the territorial level in terms of advanced digital skills.
- Data on enterprises in the ICT sector led by women/ boards with a majority of women could allow assessing the role of women in creating opportunities in the digital market (moving from the role of digital users to that of digital producers).

3.1.7 The sub-vision closing the digital divide between younger and older people

> In 2050, the 'young' of today will be middle aged. In 2050, the digital literacy rate in Europe is close to 100% and the digital divide across generations no longer exists. Digitally-based and new types of work (e.g., Gig economy) offer more job opportunities to both the youngest and the oldest citizens, breaking down the traditional age barriers.

Source: authors of the study inspired by the narrative of the following megatrends in the Commission's Hub: Changing nature of work.

The actual divide in Europe: how to measure it and monitor its progress over time.

In 2021, at the EU level, 54% of individuals have at least basic digital skills: one-half with basic digital skills and the other half with digital skills above the basic level. The share of young people aged 16-24 years and having at least basic digital skills is 71% while those of people aged 55-74 years is 35%. Digital divides between younger and older individuals are also evident at the national level. For example, in Romania, the share of individuals aged 16-24 years with at least basic digital skills is 47% (the lowest value across the EU); this share drops to 9% when individuals aged 55-74 years are considered. The target set in the Digital Compass is to reach 80% of the EU population with (at least) basic digital skills by 2030.

A breakdown by age cohorts of individuals is provided by Eurostat both in the statistics on ICT usage in households and by individuals and in the statistics on Digital skills. Individuals are grouped into 15 age cohorts ranging from individuals, 15 years old or less to individuals, 75 years old or more. Some of the age cohorts are associated both with gender and level of formal education (i.e., low, medium, high).

Suggested indicators to measure the closing of the divide between younger and older people

• All indicators related to individuals in the Eurostat category ICT usage in households and by individuals (isoc_i) can be used to appreciate specific aspects of the digital divide between younger and older people. Among them, the following are suggested:
    ○ Individuals - mobile internet access (isoc_ci_im_i).
    ○ Individuals - computer use (isoc_ci_cfp_cu).
    ○ Individuals - frequency of computer use (isoc_ci_cfp_fu).
    ○ Individuals - internet use (isoc_ci_ifp_iu).
    ○ Individuals - frequency of internet use (isoc_ci_ifp_fu).
    ○ Individuals - internet activities (isoc_ci_ac_i).
    ○ Individuals - use of collaborative economy (until 2019) (isoc_ci_ce_i).
    ○ Internet purchases by individuals (2020 onwards) (isoc_ec_ib20).

- o Internet purchases - problems encountered (2021 onwards) (isoc_ec_iprb21).
- o Internet purchases - perceived barriers (2021 onwards) (isoc_ec_inb21).
- o E-government activities of individuals via websites (isoc_ciegi_ac).
- o Trust, security and privacy - smartphones (2020 onwards) (isoc_cisci_sp20).
- o Privacy and protection of personal data (2020 onwards) (isoc_cisci_prv20).
- o Security related problems experienced when using the internet (isoc_cisci_pb).
- o Activities via internet not done because of security concerns (isoc_cisci_ax).
- • All indicators in the Eurostat category digital skills (isoc_sk) can be used to appreciate specific aspects of the digital divide between younger and older people. Among them, the following are suggested:
  - o Individuals' level of digital skills (from 2021 onwards) (isoc_sk_dskl_i21).
  - o Individuals' level of computer skills (2021 onwards) (isoc_sk_cskl_i21).
  - o Evaluating data, information and digital content (2021 onwards) (isoc_sk_edic_i21).
  - o Individuals' level of internet skills (isoc_sk_iskl_i).
  - o Way of obtaining ICT skills (isoc_sk_how_i).
  - o Employed persons with ICT education by age (isoc_ski_itage).

Data gaps preventing the assessment of digital cohesion

- • The geographical scope of these statistics is at the national level (NUTS0) so it only allows assessing the digital divide by country. The lack of these data at the NUTS2 level prevents assessing the digital divide between younger and older people across regions.
- • Available data at the NUTS2 level related to the usage of ICT by households and individuals do not include any differentiation of individuals. Among the indicators that suffer from this limitation and that could be useful to measure and monitor the digital divide between young and old people are:
  - o Individuals who have never used a computer (isoc_r_cux_i).
  - o Individuals who used the internet, frequency of use and activities (isoc_r_iuse_i).
  - o Individuals who used the internet for interaction with public authorities (isoc_r_gov_i).
  - o Individuals who ordered goods or services over the internet for private use (isoc_r_blt12_i).

Opportunities driven by new types of data or new indicators

- • Not identified.

3.1.8 The sub-vision closing the digital divide between the skilled and unskilled

The constant growth of digitally-available private and public services, as well as the pervasive adoption of autonomous robotics, 3D/4D manufacturing and AI, incentivises the (re-)skilling of employees and/or the skilling of the unskilled. Digital skills are essential for employment, regardless of the type of work. The paradigm shift in the conceptualisation of the market and of the

economy towards a digital market and a digital economy is advanced. In addition, '*By 2030, hyper-connected, tech savvy millennials will make up 75% of the workforce*'. These millennials grew up with tech and have an expectation for virtual tools to be readily available at their (physical or digital) workplace. Daily upskilling opportunities are increasingly made available to workers to ensure they are able to keep pace with and drive technological innovation in the digital market. 'Doing-by-learning' is the paradigm. Opportunities for lifelong and life-wide learning increase for everybody and everywhere (or are on their way to becoming the new normal), driven by the ubiquity of Information and Communication Technologies. Technology offers more interactive and personalised learning, making it attractive also to those persons unwilling to gain skills.

Source: authors of the study inspired by the narrative of the following megatrends in the Commission's Hub: Accelerating technological change and hyperconnectivity, Changing nature of work, Climate change and environmental degradation, Diversification of education and learning, Shifting health challenges.

The actual divide in Europe: how to measure it and monitor its progress over time.

Digital literacy in Europe is linked to the education level of individuals. This is particularly true for older people. In 2021, the EU average percentage of individuals with high formal education that used the internet in the last 3 months is 99% for people aged 16-24 as well as for people aged 25-54 and 95% for people aged 55-74. The difference between people with high formal education and low formal education among individuals that used the internet in the last 3 months is negligible for people aged 16-24 (i.e., 2 p.p.), 15 p.p. for people aged 25-54 and 37 p.p. for people aged 55-74. The introduction of this study provides evidence of the digital divide in terms of skills, taking into account the regional perspective.

Eurostat statistics on ICT usage in households and by individuals and on Digital skills are provided with a breakdown of the individuals by the level of formal education (i.e., low, medium, high) associated both with age cohorts and gender.

Suggested indicators to measure the closing of the divide between the skilled and unskilled
- All indicators related to individuals in the Eurostat category ICT usage in households and by individuals (isoc_i) can be used to appreciate specific aspects of the digital divide between skilled and unskilled people. Among them, the following are suggested: - Individuals - mobile internet access (isoc_ci_im_i).   - Individuals - computer use (isoc_ci_cfp_cu).   - Individuals - internet use (isoc_ci_ifp_iu).   - Financial activities over the internet (2020 onwards) (isoc_ec_ifi20).   - Trust, security and privacy - smartphones (2020 onwards) (isoc_cisci_sp20).

o Privacy and protection of personal data (2020 onwards) (isoc_cisci_prv20).
o Impact of ICT on tasks and skills (isoc_iw_imp).
• All indicators in the Eurostat category digital skills (isoc_sk) can be used to appreciate specific aspects of the digital divide between skilled and unskilled people. Among them, the following are suggested:
o Individuals' level of digital skills (from 2021 onwards) (isoc_sk_dskl_i21).
o Individuals' level of computer skills (2021 onwards) (isoc_sk_cskl_i21).
o Evaluating data, information and digital content (2021 onwards) (isoc_sk_edic_i21).
o Individuals' level of internet skills (isoc_sk_iskl_i).
o Way of obtaining ICT skills (isoc_sk_how_i).
o Employed persons with ICT education by educational attainment level (isoc_ski_itedu).
Data gaps preventing the assessment of digital cohesion
• The geographical scope of these statistics is at the national level (NUTS0) so it only allows assessing the digital divide by country. The lack of this data at the NUTS2 level prevents assessing the digital divide between skilled and unskilled people across regions.
• Available data at the NUTS2 level related to the usage of ICT by households and individuals do not include any differentiation of individuals. An indicator measuring and monitoring the digital divide between skilled and unskilled people, i.e., Individuals who have never used a computer (isoc_r_cux_i), would be useful.
Opportunities driven by new types of data or new indicators
• Not identified.

3.1.9 Our vision for digital cohesion, the digital divides and the Digital Compass

Our overall vision for 2050 (see Annex I) depicts a Europe where digital divides are tackled and digital cohesion is achieved. In our envisioned future, the digital dimension of societies and economies prevails and contributes to addressing social, economic and territorial disparities.

According to the definition provided in the introduction, digital cohesion implies the removal of the digital divide in accessibility and use of ICT by citizens, enterprises and public administrations. In practice, digital cohesion in 2050 can be achieved **by simultaneously reducing the divide in all four cardinal points of the Digital Compass.** This assumption leads to two main considerations.

The first consideration is that all policies (not only digital-related ones) should target digital divides and the reasons behind their existence. An increase in digital skills will structurally contribute to addressing all the identified divides. A larger availability of digital public services will guarantee a more equal and inclusive digital and real world. The improvement of digital infrastructures (and access to

them) will be key to being or becoming 'digital'. An increasing digital transformation of businesses will largely impact the economic performance of businesses themselves and of territories (Figure 25).

Figure 25. Mapping between the investigated digital divides and the four components of the Digital Compass.

DIGITAL DIVIDE IN EUROPE					
between **European regions**					
between **urban and rural areas**					
between **SMEs and large enterprises**					
between **rich and poor people**					
between **vulnerable and non-vulnerable groups**					
between **genders**					
between **younger and older people**					
between **skilled and unskilled people**					

The second consideration is connected to the relevance of the geographical scope of indicators that is needed to investigate how the closing of the digital divides in Europe leads to the achievement of digital cohesion. As cohesion policies strictly concern territories and their disparities, those related to the digital dimension also need to focus on the regional and local levels. Policies, strategies and actions to reduce the digital divides should be tailored to the digital needs of citizens, enterprises and public administrations. For this reason, the availability of data at the NUTS2 level and according to the degree of urbanisation will be crucial for statistics, indicators and indexes related to the digital divides in order to create the knowledge base for decision-makers in charge of achieving digital cohesion.

3.2 Backcasting to achieve digital cohesion in Europe

3.2.1 Definition of backcasting

According to Johnson and Davis (2014), the traditional process of strategic planning presents two possible shortcomings: being unable to move from the present state and/or being lost in the future. The approaches to overcoming these problems are many and they are all used in the Future Studies domain. In this perspective, backcasting is not concerned with predicting the future. Rather, it is a strategic problem-solving framework that starts from taking a range of

sustainable futures as a starting point for analysing their feasibility and potential, as well as possible ways of attaining those futures (Bibri, 2018).

Coined by Robinson (1982) in the description of a method of policy analysis, backcasting is defined as a strategic approach to build bridges from the present to a desirable future in a retrospective manner (Bers *et al.*, 2016) by determining intermediate steps, i.e., policies, to meet a future end-point Barrella and Amekudzi, 2011). End-points are usually chosen for a time far into the future, around 25-50 years. As an approach that focuses on complex long-term issues, it involves many aspects of society and technological innovation (Dreborg, 1996). Therefore, backcasting is used in cases when it is desired to actively dictate a future outcome rather than to merely predict it, by constructing a plausible causal chain leading from the present to the future ideal vision (Bibri, 2018).
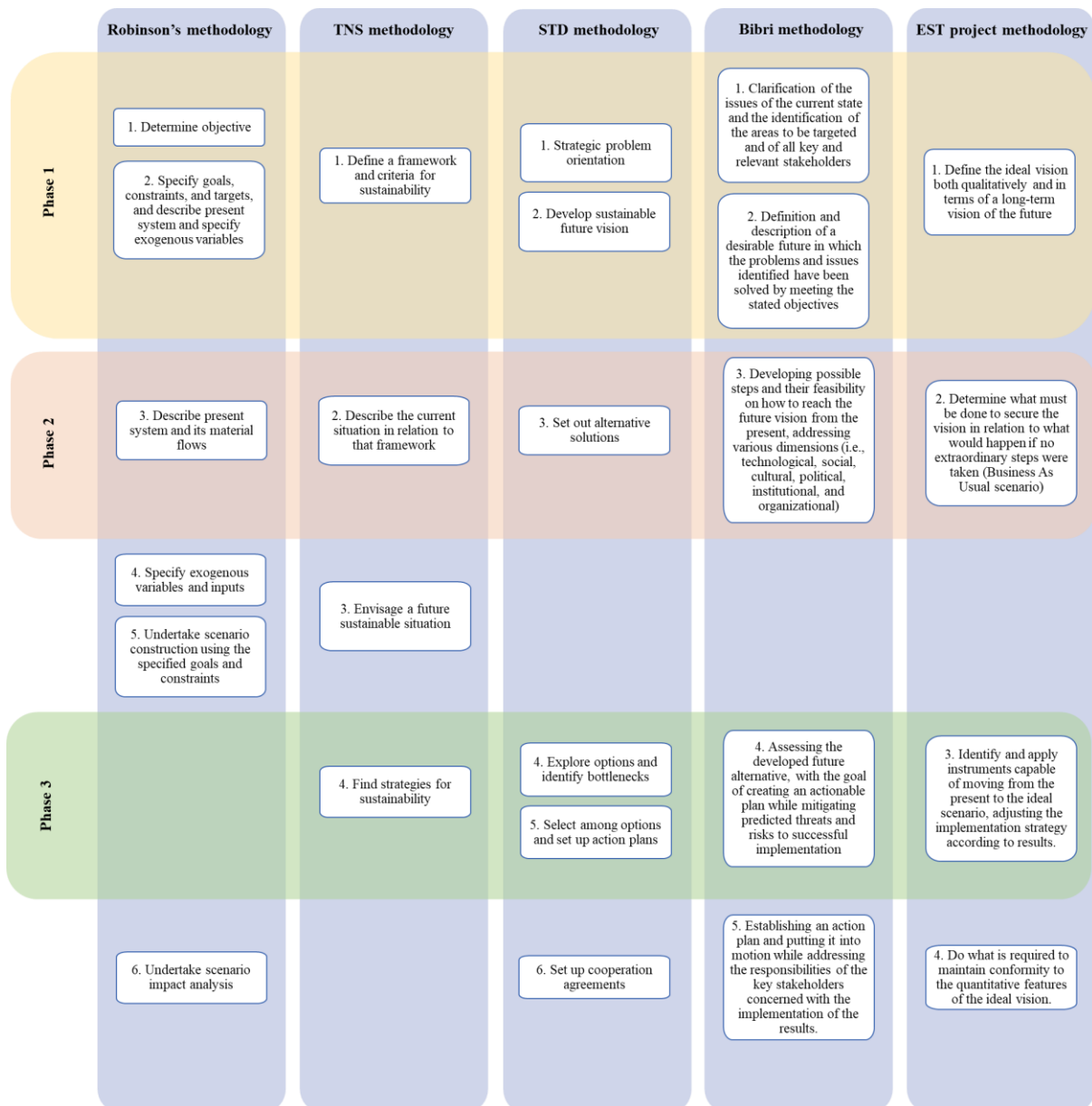
Objective of backcasting within this study

In the context of this study, backcasting is applied to the vision built in the previous section and it describes the pathways to connect the vision with concrete priorities for action, policies and programmes (Bers *et al.,* 2016). As part of the backcasting analysis, the present study also considers the potential barriers in implementing this vision, particularly the ones related to change management and profound structural changes in organisations and proposes possible mitigation and contingency actions.

Approach

Following the categorisation of Wangel (2011), it is possible to group the backcasting models according to their perspective: target-oriented backcasting focuses on what can change; pathway-oriented backcasting describes how to change; action-oriented backcasting uses the causal chain of change to identify the actions that can make change happen; and participation-oriented backcasting is directed towards the engagement of the stakeholders that can trigger change. The backcasting approach for this study is pathway-oriented, and it helps identify critical non-technical triggering measures (Bibri, 2020). The backcasting analysis can be conducted with various approaches, but none of them has a linear step-by-step methodology. Because backcasting is a dynamic exercise, iteration cycles are likely, as well as mutual influence between steps (Quist, 2007). However, for the purposes of this study, the approach adopted is a combination of selected steps from different models that have been successfully employed in past research activities and projects. Hereinafter, Figure 26 reports an overview of the different models taken as a basis for our methodology and of the phases envisaged by the adopted model.

Figure 26. Backcasting models comparison

	Robinson's methodology	TNS methodology	STD methodology	Bibri methodology	EST project methodology
Phase 1	1. Determine objective 2. Specify goals, constraints, and targets, and describe present system and specify exogenous variables	1. Define a framework and criteria for sustainability	1. Strategic problem orientation 2. Develop sustainable future vision	1. Clarification of the issues of the current state and the identification of the areas to be targeted and of all key and relevant stakeholders 2. Definition and description of a desirable future in which the problems and issues identified have been solved by meeting the stated objectives	1. Define the ideal vision both qualitatively and in terms of a long-term vision of the future
Phase 2	3. Describe present system and its material flows	2. Describe the current situation in relation to that framework	3. Set out alternative solutions	3. Developing possible steps and their feasibility on how to reach the future vision from the present, addressing various dimensions (i.e., technological, social, cultural, political, institutional, and organizational)	2. Determine what must be done to secure the vision in relation to what would happen if no extraordinary steps were taken (Business As Usual scenario)
	4. Specify exogenous variables and inputs 5. Undertake scenario construction using the specified goals and constraints	3. Envisage a future sustainable situation			
Phase 3		4. Find strategies for sustainability	4. Explore options and identify bottlenecks 5. Select among options and set up action plans	4. Assessing the developed future alternative, with the goal of creating an actionable plan while mitigating predicted threats and risks to successful implementation	3. Identify and apply instruments capable of moving from the present to the ideal scenario, adjusting the implementation strategy according to results.
	6. Undertake scenario impact analysis		6. Set up cooperation agreements	5. Establishing an action plan and putting it into motion while addressing the responsibilities of the key stakeholders concerned with the implementation of the results.	4. Do what is required to maintain conformity to the quantitative features of the ideal vision.

Source: adapted from Bibri (2020).

In Figure 26, the models adopted for previous foresight exercises are depicted, each including the visioning phase necessary to conduct the backcasting.

Robinson (1982) was the first to conceive the backcasting methodology as an alternative planning approach for electricity supply and demand, and particularly for targeting renewable energy technologies. After Robinson, other European research teams applied backcasting to different domains such as transportation (the Environmentally Sustainable Transport (EST) project) and climate change (Sustainable Technology Development (STD) project) (Weaver *et al.*, 2000). These approaches are characterised by creativity techniques, training and

involvement of different stakeholders, including employees of the organisations involved. Each one of these experiences contributed to the definition of a model for backcasting which has been further elaborated and summarised by Bibri (2020) in a 5-step approach.

Given the different scopes and objectives of each model, the steps are widely variable. However, they all included a visioning step as part of the backcasting exercise, while in the context of this study, visioning has been conducted in the previous chapter. The core and recurring phases of backcasting are selected from all the previously described models, adapted to the scope of the present research and can be summarised as follows:

- Phase 1: outlining components and enabling factors for achieving each sub-vision;
- Phase 2: mapping of the current state and identifying the gap towards each sub-vision;
- Phase 3: working backwards to identify the path towards each sub-vision.

As already mentioned, part of the steps included in Phase 1 have already been implemented in the visioning (see section 3.1). In this chapter, Phase 1 includes the analysis of each previously described sub-vision and its break-down in components, each one having one or more enabling factors, selected through the literature review and expert's knowledge, that will contribute to the achievement of digital cohesion in Europe. Afterwards, Phase 2 maps the current policies affecting the digital divides between European regions, between urban and rural areas, between SMEs and large enterprises, between rich and poor people, between vulnerable and non-vulnerable groups, between genders, between younger and older people and between skilled and unskilled people. From the review of the current policies that can favour or hamper digital cohesion, the most impacting one for each enabling factor is selected. Subsequently, the gap between each policy and the sub-vision is identified.

Finally, Phase 3 identifies barriers and possible policy and strategy actions whose implementation would result in the attainment of digital cohesion.

3.2.2 Assessing the gap for digital cohesion

Hereinafter, the Phases 1 and 2 of the adopted backcasting model bring forth the existing gaps for achieving the vision of digital cohesion. Only the digital and technological related components have been analysed. Moreover, Phase 3 analyses the potential barriers preventing the vision's achievement and consequently outlines the policy and strategy actions for encompassing the needs emerging from the analysis.

The model employed is composed of a phase of desk literature review followed by semi-structured brainstorming session within the study team. The desk literature, conducted between April and May 2022, served the aim of gathering an overview of the policies and scientific papers on each sub-vision component analysed. The research has been conducted using the EurLex legal database and the Google Scholar web search engine and using Boolean operators to combine search terms.

The data considered have been retrieved from a broad range of policies, strategies, working documents, assessments, research articles, case studies, books and book chapters, as well as reports, white papers and other literature. The literature found was screened in a three-step process covering an initial filtering based on the title as well as the reliability and validity of sources and a second scoping based on the abstract and keywords. Finally, the list of remaining sources underwent a full screening. An additional criterion is that the timespan of the documents considered has been set starting from the year 2000.

After the literature review, the study team summarised possible cause-effect chains retrieved on policies on the whiteboard. Concepts linked and causal loops were exploited to initiate discussion around causes and effects and to facilitate the building of a shared understanding of the problem. The concepts were roughly clustered [1.1.1] facilitator and then shown back to the group. Each chain was ranked using a five-point rating scale according to their relevance by each participant.

In the following Tables, the Phases 1 and 2 are depicted for each digital cohesion sub-vision.

[1.1.2]. **Backcasting for digital cohesion among European regions**

Sub-vision component	Backcasting	Reference Documents
1.1 Growth of the less developed regions in Europe generated by the digital economy [1.1.3]		

Enabling factor	Current policy	
Keeping digital markets fair and open to competition	Promoting fair competition / Addressing internal market fragmentation and fostering online cross-border trade	Digital Market Act and Digital Services Act

GAP

Lowering the costs for SMEs for complying with Liability rules; transparency reporting obligations

Enabling factor	Current policy	
Interoperability	Compulsory interoperability for instant messaging services	Digital Market Act

GAP

Increase interoperability between digital services by fostering wider open standards

1.1.4

Enabling factor	Current policy	
New technologies' uptake	Fostering cloud computing uptake by SMEs	SME Strategy for a sustainable and digital Europe

GAP

Availability and access to financial resources

1.2 Delocalisation of workers in the digital economy

1.2.1

Enabling factor	Current policy	
Legislative framework for digital workforce	General framework of rules on telework	EU Framework Agreement on Telework

GAP

Minimum standards for workers' health and employment conditions and regulation of cross-border work

1.2.2

Enabling factor	Current policy	
Relevant basic and specialistic digital skills	80% of adults with basic digital skills and 20M employed ICT specialists by 2030	European Pillar of Social Rights Action Plan and Digital Compass

GAP

Better forecasting of digital skills

1.3 Internet-based technologies and remote communication in health

1.3.1

Enabling factor: Legal and governance framework for access and exchange of health data

Current policy: Access to cross-border healthcare services

Directive 2011/24/EU on the application of patients' rights in cross-border healthcare

GAP

Safe exchange of patients' data for treatments, research and digital health services*

1.3.2

Enabling factor: Interoperability, data quality and standards in the health field

Current policy: Recommendations to public administrations to improve interoperability

European Interoperability Framework

GAP

Lack of incentives for transnational cooperation

1.4 Availability of raw materials within EU

1.4.1

Enabling factor: European long-term strategy on raw materials

Current policy: Reducing the dependency on primary critical raw materials from non-EU countries

Action Plan on Critical Raw Materials

GAP

Efficient and continous mechanism to update the Critical Raw Materials list

It should be included in the European Health Data Space legislative proposal expected in 2022

In the backcasting element 1.1.1, InvestEU, running from 2021 to 2027, is mentioned because it aims at supporting the private sector with simpler and more flexible financial instruments and one of the four policy areas targeted concerns the area of sustainable infrastructure for digital connectivity and access in rural areas. Since in the coming years the current solutions for the digital infrastructure can rapidly become obsolete with the rise of the IoT and AI, it is important to include investments for the development of the future digital infrastructure which are able to keep pace with the technological advancements.

In the backcasting element 1.1.2, the Digital Market Act and the Digital Services Act, have respectively the aims of enabling competition by making it easier for new platforms to enter the market and of enabling transparency, user safety and platform accountability. These acts mostly address due diligence and transparency obligations for large platforms, thus decreasing the potential for harm to competition and consumers. Particular concerns have been raised by SMEs on the matter of the restrictions foreseen for behavioural advertising which many SMEs use to reach consumers across Europe.

In the backcasting element 1.1.3, the Digital Market Act regulates interoperability requirements for large platforms, which is a very important step forward, but it does not include SMEs. Moreover, since the policy effort goes in the direction of making the digital economy fairer, it should also start creating a path towards a European way that overcomes the interoperability issue through the adoption of open standards.

In the backcasting element 1.1.4, the SME Strategy for a Sustainable and Digital Europe aims at supporting SMEs' transition to sustainability and digitalisation. It specifically mentions the fostering of cloud services through a facilitated market but it does not have specific provisions for the uptake of new technologies, especially considering the green ambition of the policy.

In the backcasting element 1.2.1, the Framework Agreement on Telework was farsighted when it was issued in 2002. However, the Covid-19 pandemic has expedited the transition to teleworking as, according to estimates of Eurofound, almost 40% of European workers shifted to remote working (Eurofound, 2020). In this view, considering the debate around the right to disconnect, there is a strong need for updating the framework to the new situation.

In the backcasting element 1.2.2, the first point of the European Pillar of Social Rights places life-long learning as a pivotal right for ensuring equal opportunities and access to the labour market. In its Action Plan, the ambition is to have at least 80% of people aged 16-74 with basic digital skills by 2030. Nevertheless, the rapid obsolescence of digital skills can impair the achievement of this target by neglecting a skill forecasting mechanism to keep 'basic digital skills' updated and relevant for the labour market.

In the backcasting element 1.3.1, the Directive on the application of patients' rights in cross-border healthcare from 2011 gives EU citizens the right to seek healthcare in another Member State. In the post-pandemic reality, though, an important lesson learnt underlines how crucial it is to address the fragmented health data ecosystem in the EU, and highlights the urgent need to ensure better coordination and interoperability of healthcare systems in order to effectively improve research, policymaking and health outcomes for all European citizens. The European Health Data Space, whose proposal is ongoing, seems to go in the direction of a reliable, secure and agile health data ecosystem.

In the backcasting element 1.3.2, the European Interoperability Framework provides specific guidance on how to set up interoperable digital public services. However, this framework did not take into account the health sector, which, as mentioned before, after the pandemic has become more aware of the problems caused by a lack of interoperable data among health public services in Europe.

The framework should foresee more incentives for improving cooperation among Member States in order to enhance the overall provision of healthcare in Europe and to enable the deployment of, and access to, future health technologies in all European regions.

In the backcasting element 1.4.1, the Action plan for critical raw materials has the aim of ensuring resilience through a secure and sustainable supply of critical raw materials. This Action plan is crucial to reduce dependencies and to improve resource efficiency and circularity, especially in the current geopolitical situation. The Commission reviews the list of critical raw materials every three years, but there is an ongoing debate on the need to widen the paradigm of critical raw materials and to envisage a more frequent review of the list, in order to support the rapid increase in demand for critical raw materials associated with the transition to green energy.

Table 10. Backcasting for digital cohesion between urban and rural areas

Sub-vision component	Backcasting	Reference Documents
	Same as enabling factor 1.1.1	
2.1 Smart cities are replaced by smart communities	**2.1.1** — *Enabling factor:* Human-centric technology; *Current policy:* Promote the establishment of a global coalition on human-centric AI; GAP: Regulate the use of AI from LEAs and potential algorithmic biases	Proposal for a Regulation on artificial intelligence
2.2 Flying vehicles and autonomous delivery	**2.2.1** — *Enabling factor:* Funnelling of EU funds for Connected and Automated Driving R&D; *Current policy:* Connected, Cooperative and Automated Mobility Partnership under Horizon Europe; GAP: Outlining a clearer definition of long-term goals, priorities and actions for CAD	Shaping Europe's digital future
	2.2.2 — *Enabling factor:* European regulation for CAD development, testing and driving; *Current policy:* Some EU Member States have national regulatory initiatives for CAD testing; GAP: Harmonise and expand the regulatory framework for CAD	National legislation (e.g., France, Spain, Sweden, Italy and Germany)

	2.2.3	
2.3 Satellites for high-speed make connection available anywhere on Earth	**2.3.1**	
	2.3.2	
2.4 Virtualisation of work and employment	Same as sub-vision component 1.2	
2.5 SMEs are able to enter the digital market and compete regardless of their location	Same as enabling factor 1.1.1, 1.1.2, 1.2.1	
2.6 Public services, health management and monitoring are available to citizens online	Same as sub-vision component 1.3	

In the backcasting element 2.1.1, the Proposal for a Regulation on Artificial Intelligence aims to create a clear regulatory environment for AI providers and users and to protect users from the harmful effects of AI deployment. The Act sets requirements for AI systems with high-risk implications for human rights. Unfortunately, it has broad exceptions in the use of biometric identification systems and predictive policing by law enforcement.

In the backcasting element 2.2.1, the Communication on Shaping Europe's digital future defines the EU priorities for the digital transition which encompass new technologies development, entrepreneurial ecosystem support and actions to address the societal aspects related to the digital domain. Stemming from this vision, a Connected, Cooperative and Automated Mobility partnership under Horizon Europe was set. Nevertheless, considering also that society is not yet prepared to accept this transition, concerns were raised concerning the fragmentation of R&I efforts and the lack of a coherent, longer-term vision in this domain. Other gaps and obstacles are also found in the national legislation of several Member States concerning the backcasting element 2.2.2 regarding the need for a European framework addressing the sector, which can impair the research and testing activities necessary to bring the technology to the proper readiness level required for its full deployment. Finally, concerning the backcasting element 2.2.3, the investment plan for the infrastructure development is also a major factor for enabling the potential of the sector, which at this stage is not considered.

In the backcasting element 2.3.1, the Outer Space Treaty is in need of a review to consider the space activities at the European level and not only at the national level and allow for a broader engagement as Union for exploiting the commercial opportunities provided by the Space market, such as the satellite-based broadband connection. With the same premise, in the backcasting element 2.3.2, the European Space Programme foresees the implementation of pilot projects for the satellite connection, but it inevitably misses a plan for a large-scale development, which would be able to increase the consumers' base and lower the cost for end-users.

Table 11. Backcasting for digital cohesion between SMEs and large enterprises

Sub-vision component	Backcasting	Reference Documents
3.1 Production of goods and delivery of services and their supply chains are almost entirely digitally-based		
3.2 Economies of scale driven by collective SMEs' resilience mechanisms	Same as enabling factor 1.1.4	
	Same as enabling factor 1.2.2	

	Same as enabling factor [3.1.1]
3.3 Increased adaptation capacity of SMEs because of existence of ecosystems of SMEs	**3.3.1** *Enabling factor* — Entrepreneurial ecosystem for SMEs *Current policy* — Knowledge and Innovation Communities and Digital Innovation Hubs GAP Facilitate the mobility and the scaling up of business within Europe Digital Market Act and Digital Services Act
3.4 Adoption of advanced technologies (IoT, AI, cloud and big data/analytics)	Same as enabling factor [1.1.4]
3.5 The need to keep an equilibrium between humanity and Earth's resources	**3.5.1** *Enabling factor* — Digital technologies for the green transition *Current policy* — Promote research and investment in green digital technologies GAP General and sectorial framework for ecodesign requirements on products intended for the EU market* European Green Deal / European Digital Programme
3.6 Hardware and software solutions for collecting data and allowing data-driven decision-making	**3.6.1** *Enabling factor* — Regulatory framework for processing data for decision making *Current policy* — Safeguards against adverse effects of automated decision-making on individuals GAP More specific regulation of fairness, accountability and transparency of algorithms, harmonising MS legislation General data protection regulation (GDPR)
3.7 Virtualisation of work and employment	Same as [sub-vision component 1.2]
3.8 Creation of multi-national data companies empowered by owning consumers' data is avoided	**3.8.1** *Enabling factor* — Barriers to the commercial use of data *Current policy* — Ban of targeted advertising based on sensitive data (e.g. sexual orientation, religion, ethnicity). GAP Data for commercial purposes are not collected but sold by consumers Digital Services Act

* The Regulation on Ecodesign for Sustainable Products is expected to be adopted in 2024

In the backcasting element 3.1.1, the transition towards digitally-based business models is partially covered by the Digital Europe Programme through the financing for the deployment of technologies such as High Performance Computing and AI as well as cybersecurity and digital skills. Nevertheless, the digital transition of the entrepreneurial system in Europe requires more than just supporting technology development. In particular, efforts should be devoted to the change management which is needed to adapt to the digital economy, including approaches such as Agility management and Open innovation.

In the backcasting element 3.3.1, the entrepreneurial ecosystem for SMEs is favoured through the implementation of the Knowledge and Innovation Communities and Digital Innovation Hubs included in the Digital Market Act and Digital Services Act. However, additional support should be provided in order to enable European SMEs to scale up their businesses within the European market and digital workforce in order to achieve mobility within the European market.

In the backcasting element 3.5.1, the digital technologies for the green transition are promoted by the European Green Deal and the Digital Europe Programme. There is however, a data gap on the environmental impacts of such technologies. The enforcement of the Regulation on Ecodesign for Sustainable Products is expected to address this gap and lay down a framework for setting ecodesign requirements based on sustainability and circularity aspects.

In the backcasting element 3.6.1, considering the evolution of AI towards the creation of decision-making systems, the General Data Protection Regulation should go beyond the protection from possible harmful use of such systems and foresee a shared European framework setting rules for fairness, accountability and transparency of the algorithms used.

In the backcasting element 3.8.1, the regulatory framework for the commercial use of data has been partially addressed by the Digital Services Act which bans targeted advertising based on sensitive data. According to the comments from several SMEs' networks, this kind of advertising is crucial for cross-border marketing and if - as it seems - the future technologies will be more and more based on data processing, it is worth considering alternative ways to empower individuals to manage and share their data for commercial use in a profitable and, of course, voluntary basis.

Table 12. Backcasting for digital cohesion for rich and poor people

Sub-vision component	Backcasting	Reference Documents
4.1.1 **4.1 Affordable costs of devices to access digital (private and public) services**	*Enabling factor*: Fostering secondary markets for device — *Current policy*: Creating a well-functioning EU market for secondary raw materials. GAP: Open ecosystem of tools, services, and data, for circular ecology of digital devices	Circular Economy Action Plan
4.2 Digitalisation increases the accessibility of prevention, diagnosis, treatment, monitoring and health management for all	Same as sub-vision component 1.3	
4.3.1 **4.3 Online civic participation in democratic processes makes the contribution of poor people equal to that of rich and influential people**	*Enabling factor*: Free and enforced civic participation tools — *Current policy*: Conference on the Future and European Citizens' Initiative. GAP: Extensive support in advertising initiatives and harmonization of legislation and processes across MS	European Democracy Action Plan

In the backcasting element 4.1.1, a possible key to foster the availability of affordable devices on the market, in line with the European green strategy, is represented by the circular economy, as mentioned in the Circular Economy Action Plan. Unfortunately, even if provisions are made for the promotion of a secondary market for raw materials, plans for other sectors have not been envisaged.

In the backcasting element 4.3.1, the fostering of free civic participation tools are mainly included in the European Democracy Action Plan as pilot initiatives, such as the Conference on the Future and the European Citizens' Initiative. Given the great potential of these tools for increasing the democratic participation and reaching currently inactive groups, it would be beneficial to give further support to the visibility of these initiatives and to the harmonisation of the national legislations.

Table 13. Backcasting for digital cohesion between vulnerable and non-vulnerable groups

Sub-vision component	Backcasting	Reference Documents
5.1 Citizens' digital twin lives allow the consumption of goods and services in the virtual world by everybody	5.1.1 — Enabling factor: Virtual worlds UX and devices developed with universal design; Current policy: MSs to ensure public sector websites and applications are accessible and set according to harmonised accessibility standards in the EU; GAP: Extension and review of the standard to cover virtual reality and continuous updating mechanism	EU Web Accessibility Directive
5.2 Cybersecurity challenges are reduced for the most vulnerable digital users by the adoption of new and/or appropriate legislative instruments	5.2.1 — Enabling factor: Accessible design of security systems; Current policy: EU cybersecurity certification schemes for conformity of ICT products, services or processes in all MS; GAP: European cybersecurity certification schemes to include accessibility requirements	Cybersecurity Act
5.3 There is a more participatory democracy, driven by digital technologies, that allows the involvement of vulnerable groups.	Same as enabling factor 4.3.1	

In the backcasting element 5.1.1, the development and spread of virtual realities calls for a review and an extension of the Web Accessibility Directive, in force since 2016, to cover the new technological panorama. In particular, virtual words are fostering the commercialisation of devices for digital interaction, which has the potential to reduce the physical barriers but, at the same time, requires an inclusive design.

In the backcasting element 5.2.1, the Cybersecurity Act, currently setting certification schemes for the conformity of ICT products, services or processes in all the Member States, should also include accessibility requirements to reduce the challenges faced by the most vulnerable users.

Table 14. Backcasting for digital cohesion between genders

Sub-vision component	Backcasting	Reference Documents
6.1 Digitally-based and new types of work allow more flexibility increasing employment opportunities for women	**6.1.1** *Enabling factor:* Companies transition to digitally-based work. *Current policy:* Definition of telework and regulation of its core aspects. *GAP:* Right to telework and right to disconnect	European Framework Agreement on Telework
6.2 The gender salary gap is closed thanks to digital professional careers	**6.2.1** *Enabling factor:* Promotion of gender-blind selection process. *Current policy:* Restrictions and regulatory actions for certain forms of behaviour involving gender. *GAP:* Gender-blind algorithm for recruitment	Artificial Intelligence Act

In the backcasting element 6.1.1, similarly to element 1.2.1, in order to support the transition to digitally-based work and to allow for equal opportunities in participating in the digital economy, a review of the telework framework is needed. In particular, to prevent telework from exacerbating the unequal distribution of unpaid care and domestic work for women, it should include protection mechanisms for workers and work-life balance.

In the backcasting element 6.2.1, a crucial point in addressing the gender salary gap is found in the recruitment process. In fact, particularly for remote working and digital based jobs, algorithms are increasingly used for recruitment. It is unfortunate that gender bias is not specifically addressed by the Proposal for an Artificial Intelligence Act and considering the trend, it would be forward-looking to address possible gender bias at an early stage by promoting a gender-blind algorithm and thus avoiding perpetuating historical patterns of discrimination.

Table 15. Backcasting for digital cohesion between younger and older people

Sub-vision component	Backcasting	Reference Documents
7.1 The digital divide across generations no longer exists	7.1.1 *Enabling factor* Lifelong learning framework for digital skills · *Current policy* European Digital Skills Certificate · GAP · European free online courses for lifelong learning for digital skills	Digital Education Action Plan
7.2 Digitally-based and new types of work offer more job opportunities	Same as enabling factor 6.1.1	

In coherence with element 1.2.2, the backcasting element 7.1.1 calls for a more effective strategy for the lifelong learning of digital skills. The Digital Education Action Plan envisages the creation of a European Digital Skills Certificate, which unquestionably creates the basis for a shared framework for digital skills in Europe and will determine a better alignment with job market needs. However, in light of the digital cohesion vision, digital skills education should be available throughout life to all citizens. In this sense, the possible creation of a European platform providing free courses for basic digital skills should be the next step to overcome the digital divide.

Table 16. Backcasting for digital cohesion between skilled and unskilled people

Sub-vision component	Backcasting	Reference Documents
8.1 Digital skills are essential for employment, regardless of the type of work	Same as enabling factor 7.1.1	

3.2.3 Identification of barriers

Based on the backcasting exercise, for each sub-vision bottlenecks preventing the achievement of digital cohesion are identified. The gaps and barriers stemming from the backcasting Phases 1 and 2 are considered in the recommendations outlined in Part 4.

Barriers to the sub-vision for digital cohesion for European Regions

Concerning this sub-vision, the main obstacle is represented by a non-optimal cooperation mechanism among Member States for overcoming national markets' fragmentation and for achieving the full potential of a borderless Digital Single Market (Colangelo and Cappai, 2021). In the backcasting exercise, it is important to note that some policies represent a crucial step towards the Digital Single Market (e.g., the Digital Services Act, the Digital Market Act and the InvestEu programme), even if policy gaps still remain, such as a more extensive focus on future technologies, on measures for lowering the administrative burden of SMEs for cross-border commerce and on a dedicated strategy for interoperability. In fact, interoperability and data exchange standards and protocols (such as the once-only principle) are powerful enablers which are not yet fully exploited (Kalvet *et al.,* 2018) and which can be addressed through the promotion of open standards. Other aspects require more efforts to be in line with the emerging trends such as the telework framework and the digital skills alignment with the job market.

Barriers to the sub-vision for digital cohesion for urban and rural areas

The main challenge for closing the digital divide between urban and rural areas concerns the digital infrastructure and physical access to the internet (Kos-Łabędowicz, 2017). This problem, together with a better mobility approach for citizens in rural areas, are addressed by the Digital Services Act, the Digital Market Act, Secure Connectivity Programme and the strategy 'Shaping Europe's Digital Future', with some gaps identifiable in the strategic planning and investing in new and future technologies such as cooperative automated driving and satellite-based broadband connection. In this regard, it is important to remark that a major challenge for rural areas is depopulation. This is a phenomenon that needs to be addressed through dedicated actions to support the digital transition of work, commerce and public service access (Suffia, 2021). Moreover, national initiatives aimed at providing citizens with informative and comparison tools on quality and prices of the telecommunication services proved to be effective in fostering digital inclusion by allowing citizens to find the offer that best suited their needs while maintaining competitive pressure on prices (BEREC, 2021).

Barriers to the sub-vision for digital cohesion for SMEs and large enterprises

Despite the growing economic value and still unexplored potential of the Digital Single Market, regulatory and interoperability barriers causing markets' fragmentation are still the major problem preventing or reducing the cross-border exchange of digital goods and services, and expanding the free flow of data (Shrivastava *et al.*, 2021). This is also the main inhibitor for overcoming the digital divide between large enterprises and SMEs, where the latter are slowed

down by regulations that have raised the overall level of digital restrictiveness and the cost of digital commerce (Erixon and Lamprecht, 2018). These challenges are taken into consideration in the Digital Europe programme, which together with the Digital Market Act, the Digital Services Act and the European Green Deal, encompass a wide range of measures. However, more appropriate measures for addressing the creation of capillary support for the SMEs ecosystem should be integrated into the vision.

Barriers to the sub-vision for digital cohesion for rich and poor people

The digital divide between rich and poor people is determined mainly by the unequal access to digital devices and to the internet. Where the digital economy represents a new opportunity for empowerment, at the same time, it has proven to be a potential accelerator of social inequality, worsening fragmentation and social exclusion (Bracciale and Mingo, 2015). In addition, low-income households with scarce and irregular access to the internet and to technological equipment have a reduced exposure to digital technologies and therefore have lower possibilities to develop digital skills (Vasilescu *et al.,* 2020). In analysing the gaps, benefits could come from further expanding the measures to support the circular economy as an important driver of social development and employment creation (Sheel *et al.*, 2020). Benefits could also be derived from strengthening the mechanisms for e-democracy, which could bridge the physical barriers to citizens' participation in the democratic processes (Lillemäe, 2018).

Barriers to the sub-vision for digital cohesion for vulnerable and non-vulnerable groups

Among the many challenges faced by vulnerable groups, and particularly by people with disabilities, the most crucial one is related to the design of digital devices and online content accessibility (Goggin, 2018). The European Union's commitment to make e-accessibility a priority is reflected by the transposition by Member States of the EU Web Accessibility Directive. However, efforts still need to be dedicated to awareness raising within the digital industry in particular, and in the wider private sector in general, for fostering universal design. This needs to particularly include the engagement of representative organisations of persons with disabilities in the regulatory and implementation process of ICT accessibility (ITU, 2021).

Barriers to the sub-vision for digital cohesion for genders

The gender digital divide arose from the very beginning of the information era, embracing the concept of the digital domain as a 'boys' toy' and reflecting masculine norms of acceptable behaviour and use of language (Joiner *et al.,*

2015). Despite the progress made, basic digital skills gaps by gender are still significant and likely to persist at many levels of society, and consequently, ICT skills are found to be the major driver to overcoming the gender digital divide (Hargittai and Shaw, 2015). Nevertheless, it is important to note that the gender digital divide does not only concern the basic digital skills necessary to enter the digital world but also specialistic digital skills, which are becoming increasingly important for future employment opportunities (Martínez-Cantos, 2017). In addition, the fostering of telework practice, together with measures able to combat the biases in the recruitment system, would greatly enhance women's access to the opportunities offered by the digital economy (Chung *et al.*, 2021) and prevent possible income inequalities driven by an uneven access to telework (BEREC, 2021).

Barriers to the sub-vision for digital cohesion for younger and older people

The digital divide between younger and older people, often called the 'grey digital divide' (Morris, 2007; Morris *et al.,* 2007), is not the only factor for digital exclusion but, as is true for the gender digital divide, it is exacerbated by other concurring socio-demographic variables such as gender, education and income (Huxhold *et al.,* 2020). The main bottleneck for closing the divide can be identified in the digital skills gap, addressed in the Digital Education Plan but with room for improvement. Some scientific literature claims that the grey digital divide will close by itself with the ageing of the population (Kavanaugh and Patterson, 2002). However, with the fast pace of technological change, it seems more likely that new technological tools and applications will require a constant updating of seniors' digital knowledge (Van Deursen and Van Dijk, 2018). Hence, the main challenge for the near future will be to foster digital skills in the form of a lifelong learning process (Alexopoulou, 2020). In this regard, it is useful to mention as best practice the Hungarian initiative 'Netre fel' which aims to bridge the digital divide among older and younger people with the involvement of the latter in pro-bono peer-learning in the perspective of 'digital solidarity' (BEREC, 2021).

Barriers to the sub-vision for digital cohesion for skilled and unskilled people

Given the slow yet constant growth in the pervasiveness and affordability of technological devices and internet access, in the last seven years digital skills have gained prominence in the debate on the digital divide (Andreasson, 2015). This has led the EU to take action towards the definition of a better classification for digital skills, both in terms of general and sector-specific ones. The work done in the framework of the European Digital Competence Framework, also known as DigComp, goes in the direction of listing and categorising digital skills in view of the future issuing of a European Certificate of Digital Skills. Defining a common

framework for digital skills is certainly the first step towards harmonising the digital education at the European level. However, the way ahead should point towards a European digital learning framework, free of charge and accessible for all, continuously updated and with a forecasting system able to anticipate the new digital skills required, a model of which has already proven to be a powerful tool for social inclusion (Castaño Muñoz *et al.,* 2017). Without this step, income, gender, disability and age will remain inhibiting factors for the closing of the digital divide.

3.2.4 Policy and strategy actions

The achievement of digital cohesion means overcoming all the digital divides and guaranteeing the right for all to participate in the opportunities offered by the digital economy. The vision for European digital cohesion has been analysed, and its enabling factors compared with the current state, thus highlighting what needs to be addressed to get closer to the goal. By combining the data from the previous Phases, in Phase 3 of this backcasting exercise the findings from the previous steps are structured to suggest possible policy and strategy actions emerging from the analysis of the gaps and bottlenecks.

There is a three-level dimension to be considered for digital cohesion:

- The public sector's mandate to foster and monitor the correct implementation of digital cohesion.
- The private sector's role to access and boost the digital economy.
- The citizens' right to have access to all the opportunities offered by the digital sector.

For each of these levels, achieving digital cohesion requires synergic and sometimes disruptive policy and strategy actions.

For the public sector, special attention should be given to guiding and coordinating efforts towards the harmonisation of the legislation at EU and international levels for sectors such as defence with particular regard to the new EU cybersecurity regulatory landscape (Chiara 2022), connected, cooperative and automated mobility (Alonso Raposo *et al.*, 2018; Botte *at al.*, 2019), space (Linden, 2015; von der Dunk, 2017) and e-democracy. These sectors are increasing in importance and will be key in the coming decades. On the other hand, improved monitoring is necessary for critical raw materials (Blengini *et al.*, 2017; Mancini *et al.*, 2019), algorithms' transparency (Cerrillo i Martínez, 2019; Schwalbe, 2018) and interoperability and open standards (Almeida *et al.*, 2011; Blind, 2022). These sectors, in fact, are undergoing major changes and strategic planning and actions are needed.

Concerning the private sector, the main challenge is supporting the development of the digital economy entrepreneurial environment. This could be achieved through the reinforcement of the Digital Single Market actions to include more decisive measures to facilitate the scaling up of business across Europe by lowering the cost for administrative obligations for SMEs (Kawa and Zdrenka, 2016; Ravšelj and Aristovnik, 2020) and by dedicated support to the development and uptake of new technologies (Giotopoulos *et al.*, 2017; Neirotti and Raguseo, 2017). Moreover, an essential part of this implies the fostering of the digital workforce (Iapichino *et al.*, 2018), which is crucial for the transition to digitally-based business models (Stalmachova *et al.*, 2021) and the development of agile and co-creative approaches (Pencarelli *et al.*, 2019). The digital workforce, a pivotal point for many aspects of digital cohesion, requires a legislative framework for the protection of workers (Bérastégui, 2021; Lodovici *et al.*, 2021; Demchenko, 2019) and a better digital skills forecasting system to allow the job market and the workforce to benefit from it (Gekara *et al.*, 2019; OECD, 2016; OECD, 2017).

Citizens should be empowered to exploit the benefits of the digital sector, through better protection and promotion of their digital rights as stated in the recent European Commission Declaration on digital rights and principles (EC, 2022c). The most important aspect is to tackle the unequal access to digital devices, internet content, digital infrastructure and the digital economy. First, access to devices should be facilitated by supporting the circular economy and secondary markets for second-hand devices (Rizos *et al.*, 2019) and access to the internet can be achieved by providing special tariffs for vulnerable groups (BEREC, 2021). It can also be fostered through a medium-term strategy aimed at investing in R&I for new digital infrastructure solutions such as satellite-based (Chiha *et al.*, 2020; Kim *et al.*, 2020) and new photonic-enabled broadband connections (Morichetti *et al.*, 2021). Furthermore, access to internet content can be realised through the adoption of the universal design principles by the public and private sectors (López Baldominos *et al.*, 2022). Finally, access to the digital economy should be regulated at the legislative level through the promotion of telework (Lodovici *et al.*, 2021), gender-blind recruiting processes (Brown, 2019) and the provision of free online courses for lifelong learning for digital skills (Beblavy *et al.*, 2019).

Part 4 Conclusions and recommendations for the achievement of digital cohesion in Europe

The present foresight study combines forecasting approaches and an exploratory backcasting model for investigating in a structured way the future role of digitalisation and the achievement of digital cohesion in Europe. The conclusions gathered are to give support to the expansion of the concept of cohesion, which currently encompasses the economic, social and territorial aspects, to include the digital dimension. The European Committee of the Regions is advocating for this inclusion, recognising it as pivotal to the promotion of an equal growth within the European Union.

The following recommendations are intended to give action-oriented and scientifically sound guidance to European institutions, Member States and LRAs. The first two sections address digital cohesion respectively in a horizonal and vertical approach, by first considering the weak signals and megatrends and afterwards the wild cards and the backcasting. A third section of recommendations is included in order to suggest how to better monitor and measure the progress in closing the digital divide and the achievement of digital cohesion.

4.1 Recommendations for the foreseeable future, based on weak signals and megatrends

Weak signals and megatrends analysis has the objective of foreseeing where the future is directed based on the existing context. Therefore, recommendations are formulated to address foreseeable risks and shortfalls of the current policies and to suggest strategies.

> Recommendation 1. The European Commission shall convey efforts towards a dedicated long-term strategy, resources and coordination mechanisms, leveraging on large-scale projects based on Member States' cooperation, to ensure that every citizen has up-to-date digital skills and infrastructures.

Digital skills and digital infrastructure are key for the development of all the other dimensions. As observed in the results of the expert and CoR members' consultations, promising technologies such as 5G/6G and SPOCs and MOOCs are relevant to reduce most of the existing digital divides. In this regard, the Digital

Compass is timely and welcome. Its foreseen multi-country projects, large-scale projects that no single Member State would be able to develop on its own, are a core element to enhance both digital skills and infrastructures combining investments from the EU budget and the private sector in order to cope with the critical digital capacities of the EU. In this regard, a mechanism for ensuring that the initiatives are rolled out where they are most needed, in terms of topics and geographical coverage, could better support the achievement of digital targets for 2030.

It is, in fact, required that digital skills – both basic and specialistic – and digital infrastructures development are placed at the forefront of the multi-country projects with dedicated resources and strategies. The future development and needs of the digital sector should also be taken into account in order to give new impetus to the vision for a digital Europe. As stated by ITU in its report summarising the Ministerial Roundtables Outcomes, it is crucial to put actions in place for '*bringing more people online and in reach of the opportunities opened up by digital technologies through infrastructure deployment, affordable devices and plans, relevant content and digital skills.*' (ITU, 2021).

> Recommendation 2. The European Commission shall put a comprehensive framework, legal acts and instruments in place to enforce European digital rights and foster closer cooperation with European citizens in order to ensure that digital principles are shared and respond to societal needs.

Digital rights are crucial for ensuring the correct development and use of technology. A decisive step in the direction of reflecting the Union's view for a free, inclusive and just digital society is the recently issued Declaration on digital rights and principles proposed by the European Commission to the European Parliament and the Council, which is aimed at '*Placing people and their rights at its centre, supporting solidarity and inclusion, ensuring the freedom of choice online, fostering participation in the digital public space, increasing safety, security and empowerment of individuals, and promoting the sustainability of the digital future.*' (EC, 2022b). However, there is a need to take a further step by revising the EU Charter for Fundamental Rights established in 2000 to include the digital rights in order to guide the EU's legislative work and harmonise Member States' approaches. This would also include reinforcing the trilogue mechanism for discussion with increased participation of EU citizens.

> Recommendation 3. The European Commission shall promote a more ample awareness campaign addressing citizens on the existing e-participation platforms at EU, national, regional and local levels, through better coordination with Member States and LRAs in order to develop a shared vision for fostering e-democracy.

E-democracy and civic technologies are powerful tools to promote democratic participation in Europe. Recent experiments such as the 'Conference on the Future of Europe' proved to be innovative, effective and inclusive in its online format, reaching an involvement of almost 700,000 participants. This participatory approach is a new and promising paradigm shift in the democratic exercise, because it enables citizens to express their views outside of the context of political elections. This is crucial to foster democratic participation and, as recalled by the European Parliament in its Resolution on e-democracy, it improves '*participation, transparency and accountability in decision-making, buttressing democratic oversight mechanisms and knowledge about the EU in order to give the citizens more voice in political life*.' (EP, 2017). Moreover, there is a need to give more visibility to these initiatives through dedicated national, regional and local campaigns in order to increase citizens' participation and promote the benefits of e-democracy.

Recommendation 4. Member States shall devote specific resources to the rollout of public-private partnerships, capillary awareness campaigns and training to prepare the citizens, the businesses and the public sector to face cybercrime as a horizontal issue of the digital transformation.

With the increase in connectivity, cyberthreats grow accordingly. As we experienced during the Covid-19 pandemic, the fast shift towards digital transition showed a dramatic increase in malicious exploitation of technologies. These include phenomena such as deepfakes and infodemics, in addition to cyberattacks, perpetrated through malwares and ransomwares. As stated in the 2021 Internet Organised Crime Threat Assessment from Europol '*The new reality that the global pandemic has brought forth requires rapid adaptation [...] Inevitably, these developments have also spurred innovation among cybercriminals as they have strived to capitalise on new opportunities.*' (Europol, 2021).

Moreover, with the growing pervasiveness of technologies in crucial aspects of economy and democracy, fostering cybersecurity and cyber hygiene principles is vital to protect citizens and the functioning of the Union itself from being manipulated and disrupted. This is particularly urgent in the context of the changing geo-political balances at the global level and to ensure that emerging technologies are developed with sound criteria for safety and inclusiveness. For this reason, special priority should be given to the fostering of public-private partnerships in order to enhance the early detection of cyberthreats and to spread information and training resources to provide citizens, private and public sector with the necessary skills to face online threats. Possible synergies with the strategy for digital literacy included in the Digital Compass should be considered.

4.2 Recommendations for the unforeseeable future, based on wild cards and backcasting towards a vision

Wild cards and backcasting towards a vision bring out additional measures and actions that are to be considered when aiming towards an ideal state, i.e., the closing of the digital divide and the full achievement of digital cohesion, while preparing for the occurrence of unexpected events that may impair it. The following recommendations aim at providing more topic-specific directions to prepare for the unforeseeable future and for correcting the course towards achieving digital cohesion.

Recommendation 5. The European Commission and the Member States shall address cross-national regulatory and interoperability barriers which prevent the full implementation of the Digital Single Market and hinder the scaling-up of business and technologies in Europe. In addition, LRAs shall provide definitions, principles, recommendations and practical use cases drawn from cities and communities from around Europe to facilitate the outlining of a common model.

The Digital Single Market Act, together with the Digital Services Act, sets a European way to address the challenges of the digital economy and to improve the transparency and accountability of the operators. Already with the 'Once Only Principle', as referenced in the Single Digital Gateway Regulation (SDGR), there has been a step towards a simplification for these procedures. Nevertheless, there are still a number of barriers (particularly for SMEs that are at the core of the European business ecosystem) preventing cross-border online trade, such as the costs of cross-border disputes, suppliers' restrictions to selling cross-border, delivery costs, taxation rules, and knowledge of the rules abroad. As remarked by the European Economic and Social Committee (EESC, 2020a), there is a need for '*appropriate national tax coordination in this field, as in half of the countries where hearings were held the lack of such coordination entails proportionately higher costs for SMEs than for large companies and hinders cross-border business.*' For this reason, there is a call for the European Union and the Member States to devote more of an effort to reduce the barriers which prevent the full implementation of the Digital Single Market. This effort can be enhanced by harmonising the national legislation and by outlining common requirements for overcoming interoperability issues at the EU level.

Recommendation 6. Member States shall prioritise the promotion of social dialogue to define sector-specific conditions for teleworking and the European Commission shall outline the guiding principles for a European telework framework.

The growing adoption of telework practices, boosted by the Covid-19 pandemic, requires taking decisive action to outline a regulatory framework firmly establishing the protection of workers' rights and the attainment of a work-life balance. Regulating telework is crucial on several aspects, because it allows mobility issues, human resources shortage in certain sectors and the rise of the unemployment in specific groups of the population (such as women, disabled people, young and old people, all of whom are still scarcely included in the opportunities offered by the digital economy) to be addressed. As the debate around the 'right to disconnect' is ongoing, there are other major grey areas that need to be addressed. The last Agreement on Telework between the European social partners dates back to 2002, and both the increasing trend and the specificity of national and sectoral requirements for telework are at risk of widening inequality and deteriorating conditions of work. For this reason, it is paramount to give priority to the definition of a European framework in order to shape the national consultations to be held by Member States with the social partners, as stressed by the European Economic and Social Committee (EESC, 2020b) '*social partners in the Member States to continue social dialogue and collective bargaining, and to draw up rules tailored to each of their countries and to each sector-specific situation.*'.

Recommendation 7. The European Commission shall develop a long-term vision for strategic autonomy in the field of semiconductors, through planning and investing in new materials and architecture for semiconductors, also considering future technologies' needs.

With the Chips Act Proposal, the Commission recommends a comprehensive set of measures to ensure the EU's security of supply, resilience and technological leadership in semiconductor technologies and applications. Nevertheless, the end of Moore's Law will shortly impose a paradigm change in material and architectures for managing the processing power required by future technologies. Moreover, to address European dependency on imports of semiconductors' equipment, materials, and raw materials in the long term, it is crucial to invest in the R&I of new materials, approaches and technologies. This is particularly important for the European strategic autonomy in the sector in order to avoid supply-chain disruptions. It also is essential for guaranteeing the necessary cybersecurity to avoid sabotage, industrial espionage and vulnerabilities in the critical infrastructures which use foreign technologies, as well as for mitigating the risk of a digital pandemic and its dramatic consequences for the Union. Europe needs to stay at the forefront of global competition as '*the further Europe falls behind on digital technologies, the lower its chances of shaping new technologies according to its own preferences.*' (EC-EPSC, 2019).

Recommendation 8. The European Commission shall broaden the impact assessment on the implications of AI technologies for citizens, in particular for vulnerable groups, by involving LRAs in the consultation and by defining stricter transparency and information requirements for high-risk AI technologies.

The EU's first draft Regulation on AI is part of a wider effort by the Union to develop human-centric AI by eliminating mistakes and biases in order to ensure it is safe and trustworthy. However, the proposal needs to be more focused on the social implications of AI, especially concerning the impact on digital divides between genders and between vulnerable and non-vulnerable people. A deeper reflection on the social impact of AI can also reduce the potential consequences of wild cards, such as the extreme automation in the public administration and AI out of control. This can be achieved by a more focused assessment of the societal risks at stake when AI is used to carry out social classification practices within the provision of public and private services. It can also be accomplished with stricter transparency requirements for the so-called high-risk technologies. For this reason, as stated in the CoR opinion on the Artificial Intelligence Act, there is an urgent need '*for the clear formulation of strong safeguards in order to ensure that the ban on social classification practices is not circumvented*' also by taking into account a broader scope for European interests including '*human rights, climate and the energy-efficient use of AI systems, safety, social inclusion, health, etc.*' (CoR, 2021).

4.3 Recommendations aimed at monitoring and measuring the progress of the reduction of the digital divide and the achievement of digital cohesion

Recommendation 9. The European Commission together with the Member States, Eurostat, national statistical offices and JRC shall promote a gradual, but continuous, increase of the geographical breakdown of existing data and widen the information scope to properly include aspects of the digital economy and of the digital society. The European Committee of the Regions shall be involved as the key actor to put forward the needs of LRAs in terms of data and information.

Any consideration about the achievement of digital cohesion is strictly linked to the disappearance of the various types of digital divides which affect citizens, businesses, public administrations and territories. All of these digital divides are directly or indirectly related to the 'digital' framework conditions in which citizens live, businesses operate and administrations provide public services. As

a consequence, data at the territorial level are crucial for measuring digital divides. At present, data on digital aspects are available for a very limited number of indicators at the regional level and even less at the local level. For this reason, the existing regular data collection process carried out by Eurostat and other European institutions shall first provide more digital-related data at NUTS2 and NUTS3 levels. Two additional challenges need to be tackled in order to face the actual data gap. The first relates to the 'fast-evolving' nature of the digital economy and society and of the phenomena that should be measured. A continuous joint effort by Eurostat and other European institutions is needed to define new variables and indicators that allow a proper appreciation of the digital aspects under investigation. The evolution process of the DESI and the partial change of its indicators in its last editions is an example of the adaptation of a statistical tool to better assess the progress of digitalisation and digital transformation in Europe[18]. The second challenge is linked to the unexploited potential of big data generated by the same digitalisation process. This huge amount of unstructured information requires proper storage, interoperability across the EU and new approaches for its analysis. In fact, big data refer to the entire population of users of a certain service in a precise area and no longer to samples with a certain significance (from the statistical point of view). The open data policy for public sector information (Directive EU 2019/1024) and the open research data initiative (Open Research Europe) are the first steps towards the establishment of a common data space in the EU and data re-use by public administrations, businesses, citizens as well as researchers. Big data and open data accessibility will indirectly improve the opportunities for measuring the level of digitalisation of the public administrations and, in turn, of their services' users (i.e., citizens and businesses) as well as the digital divides across territories.

> Recommendation 10. The European Commission and the European Committee of the Regions shall cooperate to move towards a Digital Compass that takes into account the territorial dimension. This will allow moving from the assessment of the progress in terms of digitalisation and digital transformation in Europe to the assessment of the evolution of digital cohesion across territories.

DESI and its indicators have been identified as the tool to assess the progress of the four components of the Digital Compass (i.e., digital skills, secure and sustainable digital infrastructures, digital transformation of businesses, digitalisation of public services) until 2030. Each of the four components includes a number of indicators for which specific targets of digitalisation/digital

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[18] For example, in the 2021 edition were included indicators that were not considered in the 2019 edition, such as the percentage of SMEs with at least a basic level of digital intensity, the percentage of enterprises using AI and the percentage of enterprises having medium/high intensity of green action through ICT.

transformation have been set to be reached at the EU level. Digital divides and disparities in Europe are not captured by the average EU performance. As for Recommendation 9, there is an urgent need for data at the local and the regional level to measure progress towards the Digital Compass' targets, taking into account the piloting experiences of some LRAs. In addition, at the EU level, it is necessary to widen the scope of the Digital Compass by not only referring to the EU average but also to variance or standard deviation. The use of different statistical measures improves the appreciation of the digital divide, including by the general public. This, in turn, increases awareness of disparities. In addition, upon the availability of data at the regional level, it would be possible to cluster regions by the degree of digitalisation/digital transformation with respect to the EU average (i.e., as already implemented in the cohesion policy). If the digital dimension is to enter the official assessment of cohesion at the EU level, reliable indicators at the regional level become essential to define regions lagging behind from the digital perspective, to properly tailor policies and to allocate 'digital cohesion funds' towards the reduction of digital divides.

Annex I. A vision for digital cohesion in Europe in 2050

European regions	The digital economy keeps on contributing to the economic growth of the less developed regions in Europe, especially the depopulating ones. The limited relevance of localisation of workers and enterprises in the digital economy and the availability of digital private and public services has almost closed the divide across territories. In the health sector, the adoption of internet-based technologies and remote communication tools fosters personalised medicine as a public service. Distributed ledger technologies (DLTs) and blockchain technologies make digitally based cross-border cooperation and cross-country collaboration between public services easy and not dependent on interoperability. The rising need for new resources has given economic importance to previously less developed regions, increasing the need for their whole connectivity and interoperability. This digital integration among European regions is reinforcing a new geopolitical situation characterised by cooperation within Europe and by competition with the other world areas in order to ensure that the EU has the necessary supply of resources, especially raw materials.
urban and rural areas	The distinction between urban and rural is gradually fading away and being replaced by a degree of urbanisation. Smart cities are replaced by smart communities. Flying vehicles and autonomous delivery vehicles would make short distances unimportant. Satellites launched in the conquest of space make high-speed connection available anywhere on Earth. Alternatives to traditional food production are found in order to face the growing scarcity of natural resources (e.g., soil), thus changing the paradigm of concentration of agricultural practices in specific places or areas (i.e., current rural areas). The rural-urban divide is further narrowed by the virtualisation of work and employment. Jobs requiring a high level of physical input/proximity are disappearing. In the Gig economy, work is chosen through online platforms according to individual interests, skills and availability and is not dependent on geography. SMEs are able to enter the digital market and compete regardless of their location. In addition, public services, health management and monitoring are available to citizens online, significantly reducing distance constraints.
SMEs and large enterprises	In 2050, the production of goods and delivery of services and their supply chains are almost entirely digitally-based. The digital market prevails. Opportunities for SMEs to enter the digital market have regularly grown since 2030 due to lower entry barriers than in the traditional market. The size of enterprises in terms of the number of employees loses relevance and enterprises are classified according to their turnover. The adaptation capacity of SMEs increases in the digital market due to collective resilience mechanisms which create economies of scale and are based on the existence of SME ecosystems. Plenty of digitally-transformed business models are exploited by SMEs. The adoption of advanced technologies (IoT, AI, cloud and big data/analytics) has made Industry 4.0 a reality for SMEs as well. Products and services continue to be more and more personalised to the needs of individual customers. Digital market opportunities for SMEs are driven by the green economy (i.e., circularity, recycling, producing and delivering locally, and sharing according to a servitization culture), the need to keep an equilibrium between humanity and Earth's resources (e.g., AI-based accounting

rich and poor people	of individual carbon emission quota) and the need for storage and processing solutions to collect data and to allow data-driven decision-making. Digitally-based and new types of work and employment (e.g., non-standard forms of work and platform work that are often based on self-employment and/or creative/innovative enterprises) are easy to start up and are protected by legislation (e.g., in terms of social protection, unemployment benefits). The workplace has lost meaning for a large number of jobs. Fair competition in the digital market exists, and the creation of multi-national data companies empowered by owning consumers' data is avoided.
	Digital end-users' purchasing power differences are flattened by widely-available high connectivity and affordable costs of devices for accessing digital (private and public) services. Individual personal data are given an economic value and people are paid for personal data by third parties. Personalised public healthcare is guaranteed by the massive and affordable use of wearable sensors, AI-based diagnostic and e-health big data management. Digitalisation increases the accessibility of prevention, diagnosis, treatment, monitoring and health management for all. Online civic participation in democratic processes makes the contribution of poor people equal to that of rich and influential people.
vulnerable and non-vulnerable groups	The digital world reduces traditional (physical and social) barriers and facilitates access and engagement of vulnerable groups. Technologies themselves reduce the vulnerability condition. Citizens' digital twin lives (made possible by extended reality technologies) allow the consumption of goods and services in the virtual world by everybody. New-frontier goods and services are available for citizens' avatars. In addition, soft skills are increasingly requested and represent an online employment opportunity for more vulnerable groups. Digital rights enforcement is increasing but 'digital vulnerable groups' still need protection. Cybersecurity challenges are reduced for the most vulnerable digital users by the adoption of new and/or appropriate legislative instruments. There is a more participatory democracy, driven by digital technologies, that allows the involvement of vulnerable groups.
genders	Online, there is acceptance of non-binary gender identities and expressions (*). Thus, for example, platform-based jobs do not discriminate according to personal data. Digitally-based and new types of work (e.g., Gig economy) allow more flexibility during day-time, entrance-exit from the labour market during the work life and increasing employment opportunities for women. Digital professional careers are based on competencies and capacities. Online, the gender salary gap is closed. The digitalisation of service provision increases women's access to quality education.
younger and older people	In 2050, the 'young' of today will be middle aged. In 2050, the digital literacy rate in Europe is close to 100% and the digital divide across generations no longer exists. Digitally-based and new types of work (e.g., Gig economy) offer more job opportunities to both the youngest and the oldest citizens, breaking down the traditional age barriers.
skilled and unskilled	The constant growth of digitally-available private and public services, as well as the pervasive adoption of autonomous robotics, 3D/4D manufacturing and AI, incentivises the (re-)skilling of employees and/or the skilling of the unskilled. Digital skills are essential for employment, regardless of the type of work. The paradigm shift in the conceptualisation of the market and of the economy towards a digital market and a digital economy is advanced. In addition, '_By 2030, hyper-connected, tech savvy millennials will make up 75% of the workforce_'. These

millennials grew up with tech and have an expectation for virtual tools to be readily available at their (physical or digital) workplace. Daily upskilling opportunities are increasingly made available to workers to ensure they are able to keep pace with and drive technological innovation in the digital market. 'Doing-by-learning' is the paradigm. Opportunities for lifelong and life-wide learning increase for everybody and everywhere (or are on their way to becoming the new normal), driven by the ubiquity of Information and Communication Technologies. Technology offers more interactive and personalised learning, making it attractive also to those persons unwilling to gain skills.

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