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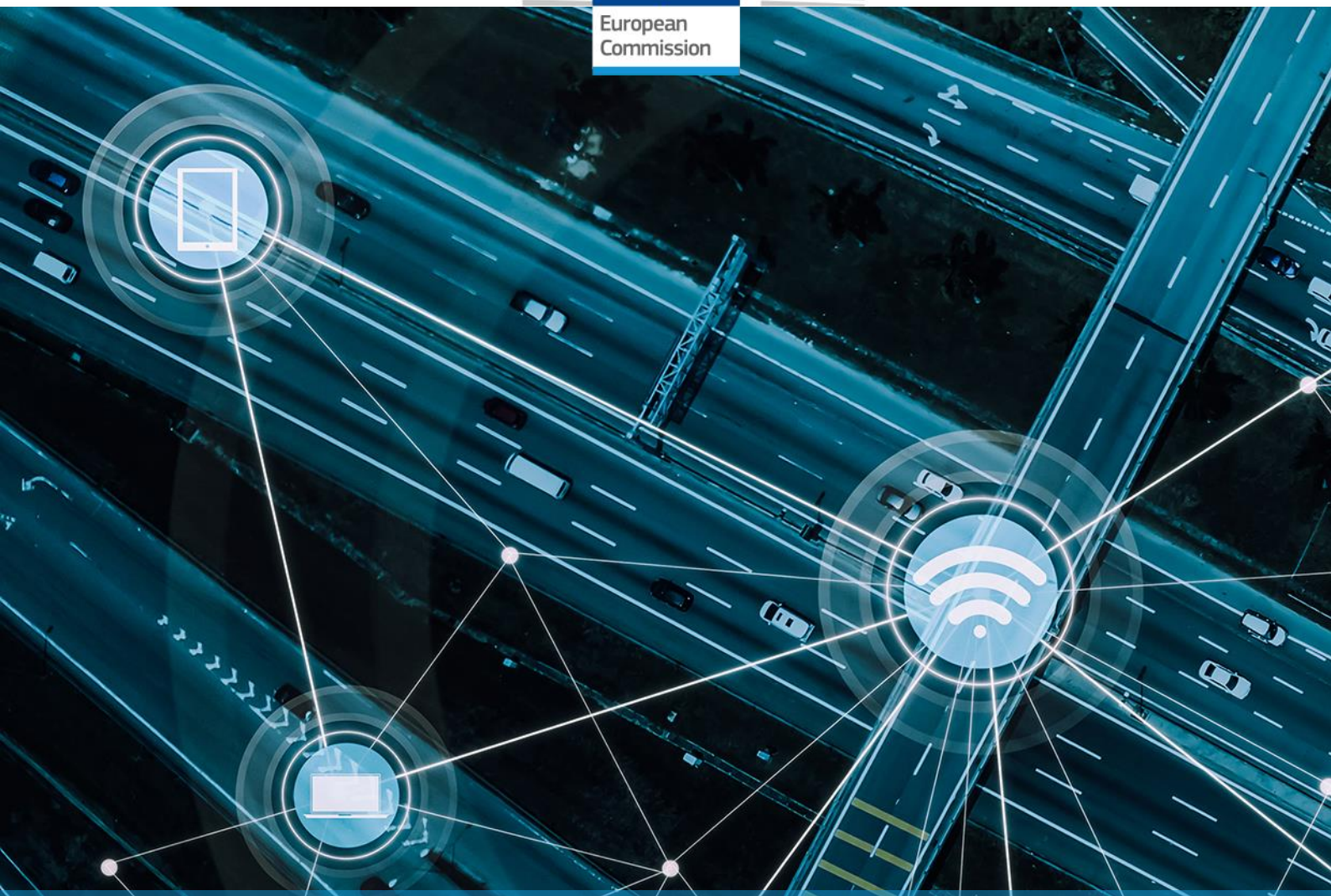

Monitoring European industrial ecosystems

Conceptual, Monitoring and Indicator Framework

July 2023

Prepared by Technopolis Group, Fraunhofer ISI, IDEA

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Introduction

The purpose of this document is to present the conceptual and methodological framework underpinning the choice of indicators and data calculations implemented as part of the **'Monitoring European industrial ecosystems'** project, initiated by the European Commission, Directorate General for Internal Market, Industry, Entrepreneurship and SMEs and the European Innovation Council and SMEs Executive Agency (EISMEA).

The overall objective of the project is to analyse the green and digital transformation of industrial ecosystems and progress made over time. The focus is on **14 industrial ecosystems and 16 green and digital technology groups** that are analysed from various perspectives in this project as presented in the following chapters.

The report is organised in 7 main chapters as follows:

- Chapter 1 outlines the concepts behind analysing the green and digital transition of industrial ecosystems and the theory behind their interactions
- Chapter 2 presents the green and digital technologies that are monitored in this project
- Chapter 3 takes stock of existing data and monitoring initiatives and other data collection that are important to consider in order to reflect about the twin transition of industrial ecosystems
- Chapter 4 describes the general indicator framework that is applicable across most of the industrial ecosystems
- Chapter 5 presents the methodology behind the calculations of each data source used in this project
- Chapter 6 presents the methodology of the foresight analysis
- Chapter 7 present the technology centres mapping exercise

The report is further supported by a number of appendices:

- Appendix A includes definitions of industrial ecosystems and technologies
- Appendix B describes the method used to calculate indicators at the industrial ecosystem level applied in cases with a complete industrial ecosystem coverage at NACE rev 2 level
- Appendix C describes the industrial ecosystem coverage by data source
- Appendix D describes the technologies by data source
- Appendix E includes the survey questionnaire
- Appendix F presents the representativeness analysis of the LinkedIn data source that captures professionals with digital and green skills

1 Conceptual framework of industrial transitions

1.1 The 'twin' green and digital transition

The green and digital transition has a fundamental impact on all industrial ecosystems and on the European economy. The 2020 European Industrial Strategy[1] and its update published in 2021 included a list of actions that support the green and digital transition of industry.

The green transition means a shift towards environmentally sustainable industrial activities that reduce their carbon footprint, promote the circular use of natural resources and are based on clean and low-carbon technological solutions[2]. Greening industry is fundamental for reaching the climate neutrality targets[3] of the European Union.

The European Green Deal[4] launched a concerted strategy for a climate-neutral, resource-efficient, and competitive economy. One of the main building blocks of the European Green Deal is the Circular Economy Action Plan, adopted in March 2020 with the aim of accelerating transformational change. Another cornerstone is the European Climate Law that sets in legislation the EU's objective of climate neutrality by 2050 with an intermediate target of reducing greenhouse gas emissions by at least 55% by 2030, compared to 1990. Most recently in March 2023, the European Commission has released its proposal for a Net-Zero Industry Act and a Critical Raw Materials Act that provides a more supportive environment for the scaling up of the EU's manufacturing capacity for net-zero technologies and products, reducing administrative burdens especially for SMEs.

The other twin challenge is related to Europe's digital future. Digital transformation has various impacts on industry including changes in the interactions along the supply chain, the delivery mode of services, and the launch of smart digital products. Harnessing the power of digital technologies allows making business and production processes more efficient. Digital transformation is seen as an opportunity for expanding into new markets and it is tightly linked to technology, organisational change, and people themselves[5].

The EU's digital strategy seeks to create the necessary framework for spreading trustworthy technology and providing businesses with competitive advantages enhanced by new digital skills and competences. Digital transformation is also expected to support the climate-neutral Europe. The Digital Compass[6] has been set up with the objective to translate the EU's digital ambitions for 2030 into concrete targets. Its key pillars are focused on digital transformation of businesses, but also on digital capacities in infrastructures, education/skills, and on public services. In several documents it has been highlighted that a major challenge for the EU is how to foster more private investment in digital innovations in all industrial sectors that needs a coordinated approach at regional, national and EU levels[7]. Responding to these challenges, several initiatives and legislative proposals have been published including the Digital Services Act, the Digital Markets Act, the European data strategy[8] and the Artificial Intelligence Act[9].

[1] https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age/european-industrial-strategy_en
[2] https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/industry-and-green-deal_en
[3] https://climate.ec.europa.eu/eu-action/european-green-deal/2030-climate-target-plan_en
[4] https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en
[5] Tratkowska, Kamila. (2020). Digital transformation: theoretical backgrounds of digital change. Management Sciences. 24. 32-37. 10.15611/ms.2019.4.05.
[6] https://futurium.ec.europa.eu/en/digital-compass/digital-businesses
[7] European Commission (2016), Digitising European Industry - Reaping the full benefits of a Digital Single Market, SWD (2016)110 Final, see: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52016DC0180
[8] https://ec.europa.eu/commission/presscorner/detail/en/ip_22_1113
[9] https://artificialintelligenceact.eu/

1.2 Industrial ecosystems and industrial transitions

The EU's updated industrial strategy from May 2021 has defined 14 industrial ecosystems that are in the focus of this monitoring exercise. These industrial ecosystems include aerospace and defence, agri-food, construction, cultural and creative industries, digital, electronics, energy intensive industries, energy-renewables, health, mobility – transport – automotive, proximity, social economy and civil security, retail, textile and tourism.

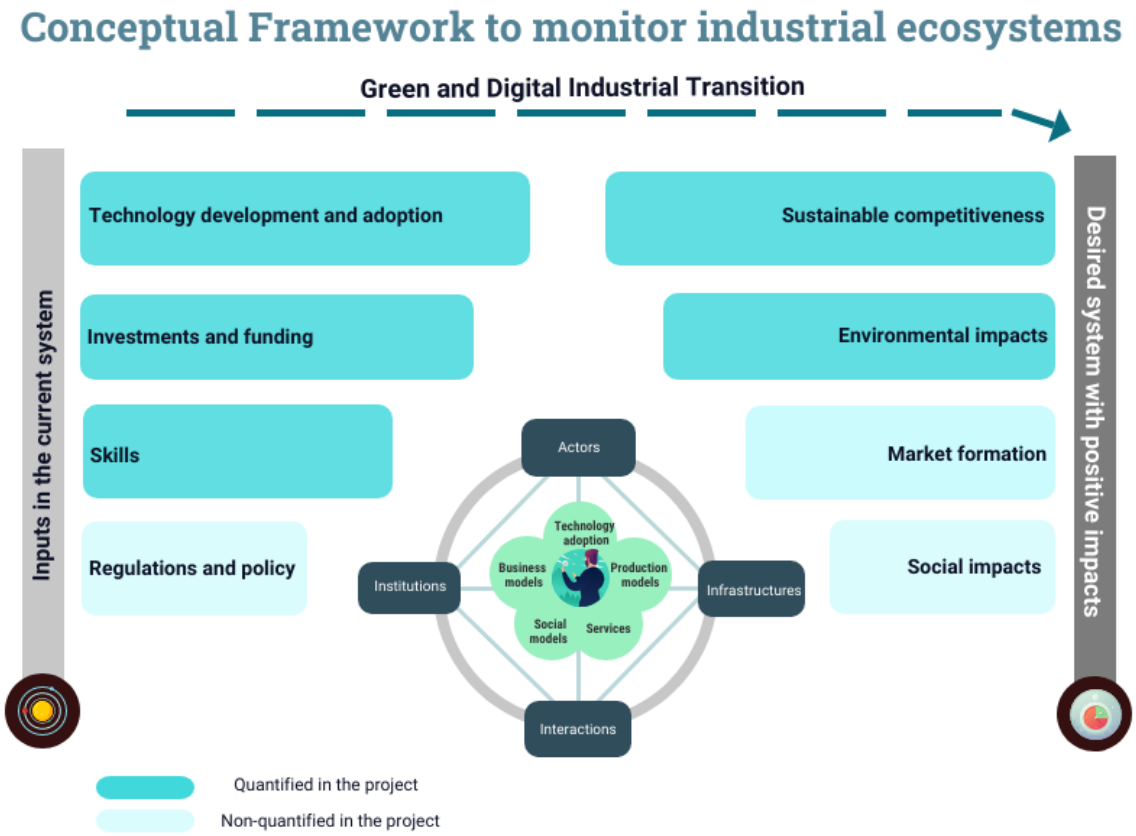
Figure 1: 14 industrial ecosystems as highlighted in the European industrial strategy in 2020

Source: European Commission, 2020

The suggested conceptual framework (depicted in Figure 1) builds upon the twin transitions of industrial ecosystems, the green transformation literature including the shift towards low carbon and the circular economy, on digital transformation and technological change and on the literature of socio-techno-economic systems (e.g. Wieczorek et Hekkert, 2012; Geels, 2018; Long et Holmen, 2021).

The industrial ecosystem and the related techno-socio-economic system has a structure (the components of the system) and functions or activities (processes) that serve the purpose of the system. Therefore, the transition and the direction of the transition (e.g., towards addressing environmental or digital challenges) of such a system and the uptake and diffusion of its constituent and complementary technologies, depends on the strengths and weakness of the structure and the functions of the system.

Figure 2: Conceptual framework



Source: Adaptation from JRC's report Marques Santos, A., Pontikakis, D. and Boden, M., 2021

Within the transformation of industrial ecosystems, the green transition including decarbonisation and the topic of the circular economy is the cornerstone of modern European R&I, industrial, climate and environmental policies. The readiness and deployment of the next generation of circular industrial technologies is more and more important due to its potential contribution to achieve a deep decarbonisation of the manufacturing industry, e.g. by over 50% of GHG emission reductions by the year 2050 (e.g. SITRA, 2018). Digital transformation is the other key horizontal megatrend, with the potential to radically change our economy and society and bring promising improvements – as well as many challenges – into all aspects of our lives.

Measuring performance and change is vital to allow policymakers and industry to track progress over time and get feedback whether the system is moving in the desired direction. To measure performance, key performance indicators captured in regular intervals (annually or biannually) are to be developed.

In its New Industrial Strategy in 2020[10] and its update in 2021[11] the European Commission brings the industrial ecosystems at the core of the industrial policy. Within the new policy framework, the industrial ecosystems are expected to be at the centre of the transformation of the European industry towards competitive sustainability. Such an industrial transition is driven by technological change (in particular by digital technologies and the shift to a circular economy), and it is in fact a complex, multi-level, and dynamic process. To make transition sustainable, technological change alone is not sufficient. Systemic changes across value chains of industrial ecosystems and other levels of the

[10] COM (2020) 102 final
[11] COM (2021) 350 final

socio-economic fabric – such as user practices, governance practices and policies, regulations public infrastructures and industrial networks – are inevitable and part of the transition of the industrial ecosystems from one stage to another. The systemic character of the transitions has significant implications for policy, as effective multi-level coordination, planning and intervention are key elements for the successful management of transformative changes.[12]

Due to the systemic character of transitions, old concepts such as value chains cannot capture all dimensions and types of change and interdependences and consequently, they provide limited policy insight. Despite its limitation the concept still can be used for mapping upstream and downstream linkages of actors and sector segments and identifying the links that are critical. Thus, our conceptual framework relies on the recently growing literature on transitions while we use value chain as an analytical tool for addressing specific questions such as the issue of technological independence.

In the current conceptual framework, the work on technological and socio-economic systems (e.g. Wieczorek et Hekkert, 2012; Geels, 2018; Long et Holmen, 2021) provides useful insight that can be used for the analysis of the transitions of industrial ecosystems driven by technological changes. The approach of monitoring industrial ecosystem transitions is visually presented below. Such a wider view of the industrial ecosystem highlights interconnections between its constituent parts that represent points of powerful policy leverage, especially if their identification enables coordinated and timely action. Literature cited above has also shown that negative consequences from the transition have common systemic causes and are often rooted in the direction of the system.

Each component of our conceptual framework is described in the sub-sequent sub-sections.

1.3 The structure of a techno-socio-economic system

Techno-socio-economic systems consist of components, which are the operating parts of the system. The components are linked and interact with each other forming specific relationships or interactions. The components are actors, institutions, infrastructures, and their interactions:[13]

Actors: Key actors of the ecosystem include companies (startups, SMEs, multinationals, large firms), knowledge and technology institutes (universities, technology institutes, research centres, technology support providers), and other parties (financial organisations/banks, intermediaries, technology brokers, cluster organisations, trade unions, but also actors relevant for the green transition such as environmental NGOs). Among the actors SMEs are of high importance not only due to their numbers but also due to their key role in the value chains and the suppliers' networks of the industrial ecosystems. Data on the number of companies and their size (number and share of large companies and SMEs) provides indication of the size of the ecosystems and the importance of each company group. The relevant actors are not only those within the boundaries of the industrial ecosystem, but also those across value chains that are important for the industrial ecosystem and the generation and diffusion of technologies.

Technologies: Technologies have a significant effect on the transition of industries. In addition to advanced technologies driving the transition of a specific industrial ecosystem, the bundle of complementary technologies and the related technological subsystems on which the main advanced technology relies are essential. *For example, the "digital for*

[12] JRC's report Marques Santos, A., Pontikakis, D. and Boden, M., POINT reviews: an overview, 2021, Publications Office of the European Union, Luxembourg, 2021. For the multi-level transition of technological systems see Schot, J. and Geels, F. (2008), "Strategic niche management and sustainable innovation journeys: theory, findings, research agenda, and policy"

[13] The selection and description of the components has been based on Wieczorek, A., & Hekkert, M. P. (2012). Systemic instruments for systemic innovation problems: A framework for policy makers and innovation scholars. Science and Public Policy, 39, 74–87. https://doi.org/doi:l0.1093/scipol/scr008

mobility" technologies which are critical for the transition of the industrial ecosystem "mobility – transport – automotive" are interdependent with other technological systems and solutions such as electric vehicles, renewable energy nexus, electric trains, high energy density batteries, autonomous driving, AI and Big Data.

Institutions: Institutions could be soft including habits, customs, common believes, traditions, attitudes, way of contacts or hard such as policies, laws, regulations, rules, norms, instructions. Relevant examples of the former are the perception of citizens towards the protection of the environment and consumption habits that can slowdown or accelerate the green transition. An example of hard institutions is the regulations that needs to be in place for the prevention or encouragement of certain technologies in the case of green transitions or regulations for security and protection of sensitive data in the case of digital transitions. The focus of the analysis was on identifying enablers or hindering factors for the uptake of technologies and the twin transitions of the industrial ecosystems.

Infrastructures: constitutes one of the basic national and regional endowments and comprise both digital infrastructures such as telecom networks, IoT networks, cloud infrastructures etc, or more conventional artefacts such as transport networks, buildings, electricity grid, power stations etc. Technology infrastructures such as facilities, equipment, capabilities, and support services required to develop, test and upscale technology to higher TRLs prior to competitive market entry are also included. Examples of such infrastructures are pilot lines, testing facilities, digital innovation hubs, open innovation testbeds, tech centres, demonstration facilities, etc.

Interactions: Interactions or links are dynamic and could be bilateral among two actors or multilateral occurring within networks. Industrial ecosystems overlap in diverse interactions in broad value networks. Both the interactions among actors of an industrial ecosystem or of different technological systems and interactions in a global context are important to monitor.

1.4 Functions of the ecosystem

Systems comprise of processes that serve specific purposes or functions and are important for the performance and the dynamics of the system. Among the various functions proposed in the literature, we were based on the work of Hekkert et al (2007) and Wieczorek, A., & Hekkert, M. P. (2012) to identify the functions that are most relevant for the project. Although their work focuses on systems with main purpose the technological change in our case the main purpose of the techno-socio-economic systems is the generation and diffusion of technology, the creation of economic value, fulfilment of societal needs and greening the economy.

The Industrial Forum's 'Blueprint for the development of transition pathways[14]' has put forward seven building blocks that covers a key aspect of the twin transition and the move to greater resilience. In this conceptual framework, these building blocks have been also partially adopted and integrated into the structure of the analysis. Further differentiation has been made between functions related to firm dynamics and the state of the broader ecosystem.

At the level of firms and organisations active within the industrial ecosystem, the following dimensions are listed that are also the pillars of the suggested indicator framework.

Technology development and adoption: Knowledge creation in the supply side is essential for the capability of technology producers to develop new technologies embodied into new or improved products and services, improve and adapt their products (after their introduction to the market) to the needs and characteristics of the targeted markets and finally create value for the economy, environment and society. Knowledge dissemination through existing networks is essential for the generation, uptake and diffusion of

[14] DocsRoom - European Commission (europa.eu)

technologies. During the diffusion process (i) the innovative processes and the embedded technologies are diffused through imitation, and (ii) the technology embodied in innovative products is adopted by firms to be used either in their processes opening a new cycle of process innovation, or to be embodied into a new product opening a new cycle of product innovation (Surinach et al, 2009). Service innovation plays an important role and servitisation of SMEs and new business models further drive innovation. Entrepreneurs are essential for the function of a technological system. Their presence and the characteristics of their activity are among the most important indications of the performance of a techno-socio-green-economic system. Not all technological solutions will contribute to the path of becoming climate neutral or creating a valuable society, hence the nature and impact of technological transformation needs to be monitored.

Investments and funding: The volume of financial resources dedicated to back the green and digital transition is key in terms of assessing the progress towards new developments. Firms invest in digital technologies, key enabling technologies, in clean production and green business models and they do so in order to become more competitive, to reach a higher level of cost-effectiveness and create a better value for the society. Funding for these digital and green transformation strategies can be obtained from shareholders, from private equity, venture capital investors, via loans from banks and from dedicated public government programmes. Investment strategies are often confidential to the firm, however, certain investment behaviour is revealed.

Skills: Human capital is essential for all the activities within a technological system. It is important for the technology developers who use skills and investments on R&D for the development and improvement of the technology. New technologies trigger needs for new labour resources, both for technology production and as a result of ongoing modernisation. At the supply side experienced personnel and acquisition of the necessary skills are essential for the development of the absorptive capacity of technology recipients.

Regulatory framework conditions and policy drivers (*regulation and public governance*): Prioritisation and direction are pivotal in transitions driven also by regulations, policy initiatives but also on the user side by cultural habits and user expectations. This is very important especially for the success of green transitions. This function includes all activities that make visible and clear the needs and wants of the various groups of technology users. Priority and direction setting is happening at various levels and actors such as industry, government and markets.

At the level of the broader ecosystem and the impact beyond its boundaries, there are various dimensions that require attention including the effects of industrial ecosystems on the environment, the link of technological transformation to production and employment and the state of industrial ecosystems in terms of autonomy and resilience. To this end, the following main building blocks can be highlighted without aiming at capturing the attributable impact of the twin transition on the environment, economy or the society:

Sustainable competitiveness: this building block aims to benchmark the performance of the industrial ecosystems in line with the Blueprint. As outlined, each ecosystem needs to identify its core strengths, weaknesses, opportunities and threats, thus revealing areas for improvements and stimulate sustainable production, investments and quality job creation.

Environmental performance: this dimension captures green transition in terms of the status of emissions, energy use and impact on the environment. It includes a reflection about the environmental footprint of each industrial ecosystem and the on-going trends and change over time.

Market formation: Market formation reflects the ability of new technologies to enter and get established in markets that are already dominated by competing technologies. In early stages of the transition the actors who help articulate demand include public funders, innovative companies (in the case of processes related products) early adopter communities of users (whose preferences and concerns may differ significantly from the

majority of users). However, broader demand articulation requires 'mainstreaming' of the consumption and use of the technologies and their products; key actors include industry standard- (and quality-) setters, producers positioned on the mass-end scale of the market. In this context, public procurement of innovation, green public procurement can enable market formation.

Social acceptance: The uptake of a new technologies and products and/or services embedding new technologies, requires technology either to overthrow existing technologies causing creative destruction or to be embedded in an existing regime. Changes in the current regime is expected to raise resistance from parties with vested interest. Therefore, a coalition of advocates and champions of the new technology is necessary for overcoming the resistance and create legitimacy. They can influence the setting of priorities and the formation of the research agenda, the development of human resources and direction of funding, and push for incentives that will help the creation of a market for the new technology.

Dependence and technological sovereignty: The Industry Strategy of March 2020 highlighted that the EU should build competitiveness for technologies that are strategically important for Europe's industrial future. In its staff working document the Commission has identified strategic dependencies in the digital ecosystem and especially in the cloud and microelectronics which are expected to have significant effects in other ecosystems. The assessment of strategic dependencies involves not only the identification of dependencies, but also an assessment of whether they are of a strategic nature that leads to a vulnerability for the EU. A bottom-up (quantitative) analysis taking trade statistics in products as its starting point, while characterised by data limitations and caveats, can provide first and indicative insights into areas where the EU's dependence on a limited number of suppliers is most prominent in particular for a number of more sensitive ecosystems. A top-down assessment needs to complement this bottom-up approach, taking into account (at a more detailed level) other risks and possible dependencies of strategic nature (e.g., related to services, infrastructures, technologies, skills, etc.) that cannot be captured by relying on quantitative trade statistics and data.

1.5 Linking the digital and green transition

The green and digital transitions of industrial ecosystems have an underexploited potential to reinforce each other. Both transitions are expected to be a source of renewed competitiveness for all industries[15]. The two transitions are not only concurrent but uniting them is also expected to accelerate necessary changes, for example by using distributed ledger technology to trace materials (aiding the circular economy) or using Digital Twins to optimize traffic flows (reducing emissions). Linking the two transitions could allow us to benefit from synergies and manage risks but will need proactive and integrative management.

The dynamics of the two transitions are different. The green transition is primarily being driven by the need to reach climate neutrality and sustainability goals, although also increasingly by profitability and economic reasons. On the other hand, the digital transition mainly concerns an ongoing process of technology-driven change, but to really make a change requires social acceptance. Private, state and civil society engagement is needed to steer and support both transitions and to make sure that in the end the digital transition is used as an instrument for a fair and just green transition.

Positive impacts of linking the digital and green transition

[15] European Commission (2022) Strategic Foresight Report. Twinning the green and digital transition in the new geopolitical context.

Links between the digital and green transition mentioned in literature are:

- **Optimisation** of production processes and smarter and more efficient management of machines and systems[16]
- **Better understanding** of climate change through modern information and communication technologies, with the potential to positively influence user behaviour, for example through smart packaging and labels communicating the environmental footprint of a product[17]
- **Supporting smart climate adaptation actions and crisis management** through digital technologies that provide timely and effective information through real-time monitoring, digital twins and machine learning, supporting government agencies, humanitarian organisations and citizens in risk assessment and decision making[5]
- **Modelling** its possible impacts by analysing large-scale interconnected databases with Artificial Intelligence (AI) to develop joint actions. Or for example smart cities and communities showing how the green and digital transition can take place in a holistic and systemic manner[6]
- **Use of less resources**, for example by creating a Digital Twin of a building and testing alternative cooling approaches to reduce energy consumption, or by forecasting water and electricity demand to balance demand and supply in energy grids[6]
- **Improving the health of ecosystems** (e.g. the automatic identification of oil spills or the classification of vegetation cover types) by processing large amounts of satellite image in relatively short time[6]
- **Support of maintenance, reuse and recycling** because of digital tracking through material passports or communicating sensors, collecting knowledge about the life cycle of products and to improve reparability and upgradability[6]

In fact, research indicates that AI could be an enabler of 93% of the SDG targets focused on environment[18]and digital technologies have the potential to help other industries save 20% of global CO2 emissions[19]. Solutions may also lie in the combination of digital technologies and tools. Furthermore, with data being the source of new innovation and business, there is a need for enough capacity to process data and for tools, methods and large datasets from various research fields to be combined. According to the JRC, positive impacts of digital transformation can mean the following[20]:

- **Monitoring and tracking** can be used to provide real-time information and catalyse the circular economy, for example by the monitoring of emissions, ecosystem statuses, and material flows
- **Simulation and forecasting** to improve efficiency, enabled by knowledge about the whole life cycle of products that can be gained through digital simulations, allowing for the identification of fracture points that lead to obsolescence

[16] Muench, S., Stoermer, E., Jensen, K., Asikainen, T., Salvi, M. and Scapolo, F., Towards a green and digital future, EUR 31075 EN, Publications Office of the European Union, Luxembourg, 2022, ISBN 978-92-76-52451-9, doi:10.2760/977331, JRC129319.
[17] Digital Europe (2021) 8 ideas to accelerate the twin transition. Retrieved from: https://www.digitaleurope.org/resources/digital-action-climate-action-8-ideas-to-accelerate-the-twin-transition/
[18] Vinuesa, R., Azizpour, H., Leite, I. et al. The role of artificial intelligence in achieving the Sustainable Development Goals. Nat Commun 11, 233 (2020). https://doi.org/10.1038/s41467-019-14108-y
[19] Strategy, A. (2015). SMARTer2030: ICT solutions for 21st century challenges. The Global eSustainability Initiative (GeSI), Brussels, Brussels-Capital Region, Belgium, Tech. Rep, 3.
[20] Muench, S., Stoermer, E., Jensen, K., Asikainen, T., Salvi, M. and Scapolo, F., Towards a green and digital future, EUR 31075 EN, Publications Office of the European Union, Luxembourg, 2022, ISBN 978-92-76-52451-9, doi:10.2760/977331, JRC129319.

- **Virtualisation** of production and consumption to reduce environmental impact by moving economic activities online, solving underlying needs through digital alternatives such as ebooks, videoconferences, extended reality experiences, or digital prototypes
- **Systems management** to cope with an increasing complexity while optimising operations, making production processes more efficient and less resource intensive

Negative impacts of linking the digital and green transition

While in many areas the green and digital transition could reinforce each other, they do not necessarily always align. An example is the energy consumption and environmental footprint of digital infrastructure. Another tension point between the two transitions is the climate impact of ICT itself, which is significant. Examples of negative impacts of ICT that should be taken into account are:

- **Energy need**: Data infrastructure is key building block for the digitalised world and accounts for approximately 2% of global electricity consumption[21]. Even if we are able to reduce the power consumption of computing itself, in the world of exponentially growing data, solutions based on energy efficiency improvement of the employed technology will not be enough. Data centres and supercomputers should for example also be powered with renewable energy, using free cooling and re-use of waste heat
- **E-waste**: Europe currently generates 16.2 kilograms of e-waste per capita per year, the most of any of the global regions covered in the Global E-waste Monitor report[22]
- **Extraction of raw materials** is crucial for the digital transition as ICT technologies require a diverse set of raw materials, which is mostly imported from China and Africa[23]. Europe as a whole however manages to recycle only 42% of its e-waste[9]
- **Direct and indirect effects** of further introduction of ICT services[24]. Direct effects being increased energy usage for producing, using and disposing of ICT and indirect effects such as efficiency gains and substitution of products that could lead to rebounds that trigger increased consumption elsewhere in the economy

To make sure the twin transition is successfully implemented, industrial ecosystems need to be ready to use digital technologies and take environmental actions. In 2021, the European Commission conducted a survey on the contribution of ICT to the environmental sustainability actions of EU businesses[25]. The survey showed that highly digitised (often large) enterprises are more likely to state that there is a 'green' motivation for their use of ICT and that their use of digital technologies has accelerated their environmental actions. It appears that larger enterprises are more likely to apply ICT for environmental sustainability, while smaller enterprises see the potential but may lack capacity to be able to apply it.

[21] Izsak, K. et al (2020) Advanced Technologies for Industry – Policy brief. Responsible digital transformation – the bridge between digital and circular economy policies. Retrieved from: https://ati.ec.europa.eu/reports/policy-briefs/responsible-digital-transformation-bridge-between-digital-and-circular
[22] Global E-waste Statistics Partnership (2020) The Global E-waste Monitor 2020 – Quantities, flows, and the circular economy potential. Retrieved from: https://ewastemonitor.info/gem-2020/
[23] European Commission (2020) Critical materials for strategic technologies and sectors in the EU - a foresight study. Retrieved from: https://ec.europa.eu/docsroom/documents/42882
[24] Nathaniel C Horner et al 2016 Environ. Res. Lett. 11 103001
[25] European Commission (2021) Survey on the contribution of ICT to the environmental sustainability of actions of EU enterprises. Retrieved from: https://digital-strategy.ec.europa.eu/en/library/survey-contribution-ict-environmental-sustainability-actions-eu-enterprises

Cross-impacts

While the text above mostly describes the impact the digital transition can have on our ambitions for sustainability and the green transition, there are also impacts that appear the other way around and where the transitions impact each other. Examples are:

- The green transition is also creating momentum and a clear reason to use digital technologies. An acceleration in adoption due to new demand and needs can be expected, for example when electricity operators need to forecast usage of energy resources[26]
- Wider stakeholder engagement occurs because of the need for collective action across governments, the private sectors, civil society and academia to accelerate the adoption and scaling of digital technologies for sustainability. Existing examples are the Coalition for Digital Environmental Sustainability (CODES)[27] and the European Green Digital Coalition[28]. Both transitions also need a cross-ministerial approach for strategy development and implementation
- Both transitions build on critical entities and infrastructures[29]. The need for data-sharing to ensure improved interoperability between generators and data users leads to a more inclusive process of innovation, but also requires a stronger cybersecurity and data sharing framework

Finally, the JRC[30] warns that the implementation of the green and digital transition will depend on several economic, social and political factors. Both transitions can only be rolled out at scale if these contextual factors are managed appropriately:

- Economic factors include the costs of the twin transitions, the economic opportunities created by the twin transitions, the shift of jobs between growing and declining sectors and the financing of the necessary investments
- Social factors include acceptance, fairness, and behavioural change
- Political factors include regulatory frameworks, standards and geopolitical aspects

[26] Khoury, Z. & Lee, J. (2022) The nexus of green and digital: An opportunity or a challenge? Retrieved from: https://blogs.worldbank.org/digital-development/nexus-green-and-digital-opportunity-or-challenge
[27] UNDP (2022) Global, multi-stakeholder digital coalition presents plan for a green digital revolution. Retrieved from: https://www.undp.org/press-releases/global-multi-stakeholder-digital-coalition-presents-plan-green-digital-revolution
[28] European Green Digital Coalition (2022) European Green Digital Coalition. Retrieved from: https://www.greendigitalcoalition.eu/
[29] European Commission (2022) Strategic Foresight Report. Twinning the green and digital transition in the new geopolitical context.
[30] JMuench, S., Stoermer, E., Jensen, K., Asikainen, T., Salvi, M. and Scapolo, F., Towards a green and digital future, EUR 31075 EN, Publications Office of the European Union, Luxembourg, 2022, ISBN 978-92-76-52451-9, doi:10.2760/977331, JRC129319.

2 Green and digital technologies and non-technological innovations

The monitoring framework applies a technological lens in the analysis of industrial ecosystems whereby most of the indicators are calculated not just per ecosystem but type of green and digital technology (as presented in the table below) at the same time.

In the case of some indicators, such as based on patent, trade and prodcom data, it is not possible to construct an indicator that is industry and technology-specific at the same time. Instead, indicators have been calculated separately, once only per technology and once only per industrial ecosystem. This approach helps advancing the understanding about trends in the general technological base that is underpinning all EU industry. In the table below, we indicate the overview of technologies that have been selected and are monitored in this project. The detailed definitions are included in Appendix A.

Figure 3: List of technologies and non-technological solutions monitored

Digital transformation		
	1	**Advanced Manufacturing and Robotics**
		Advanced Manufacturing (ICA and Mechanical Engineering)
		Robotics
	2	**Artificial Intelligence**
	3	**Augmented and Virtual Reality**
	4	**Big Data**
	5	**Blockchain**
	6	**Cloud technologies**
	7	**Digital Security & Networks/ Cybersecurity**
	8	**Internet of Things**
	9	**Micro- and Nanoelectronics & Photonics**
	10	**Online platforms**
Green transformation		
Green technologies	11	**Advanced Materials and Nanotechnology**
	12	**Biotechnology**
	13	**Energy Saving Technologies**
	14	**Renewable Energy Technologies**
		Solar Power
		Wind Power
		Other (geothermal, hydropower, biomass)
	15	**Clean Production Technologies**
	16	**Recycling Technologies**
Circular business models		**Circular business models including:** Remanufacturing Renting, leasing and related service models Repair and maintenance services Resell, reuse Circular design (products that can be disassembled and recycled) Design for durability (products that can last longer)

3 Synergies with other initiatives

For each industrial ecosystem relevant monitoring exercises are accounted for in the industrial ecosystem reports. A non-exhaustive overview of monitoring exercises from existing initiatives and studies for each industrial ecosystem is provided below. The mentioned initiatives have been screened and are referenced or built upon in the industrial ecosystem reports.

Figure 4: Review of existing observatories and ongoing data collection per industrial ecosystem

Industrial ecosystem	Existing key monitors and observatories
Aerospace & Defence	• Observatory for critical technologies • Climate Change and Defence Roadmap • Destination 2050 – A route to net zero European aviation • Space Sustainability Rating • European Space Agency Materiality Matrix • Staff Working Document For a resilient, sustainable and digital aerospace and defence industrial ecosystem: Scenarios for a transition patway
Agri-Food	• Agri-food Data Portal , i.e., DG AGRI's data portal on national and European agriculture and common agricultural policy (CAP) • Staff Working Document Co-creation of a transition pathways for a more resilient, sustainable and digital agri-food ecosystem
Construction	• Staff working document Co-creation of a transition pathway for a more resilient, digital and green retail ecosystem • Circular industrial technology roadmap for energy-intensive industry, textiles and construction • European Construction Observatory • Study "Measuring the Application of Circular Approaches in the Construction Industry Ecosystem" • Country fact sheet and data mapper of the European construction sector observatory (ECSO)
Creative & Cultural Industries	• Study on opportunities of AI in CCS • Green transition study
Digital	• The Digital Decade Policy Programme: outlines a monitoring mechanism with its own targets and KPIs, complementing the DESI
Electronics	• Study on the electronics ecosystem • EU Chips Act
Energy - Renewables	• Clean Energy Competitiveness Report • Clean Energy Technology Observatory CETO
Energy Intensive Industries	• The low carbon technology roadmap for energy intensive industries • The circular industrial technology roadmap for energy-intensive industry, textiles and construction • Sustainable chemicals initiative/ chemicals strategy • Transition pathway for the chemical industry

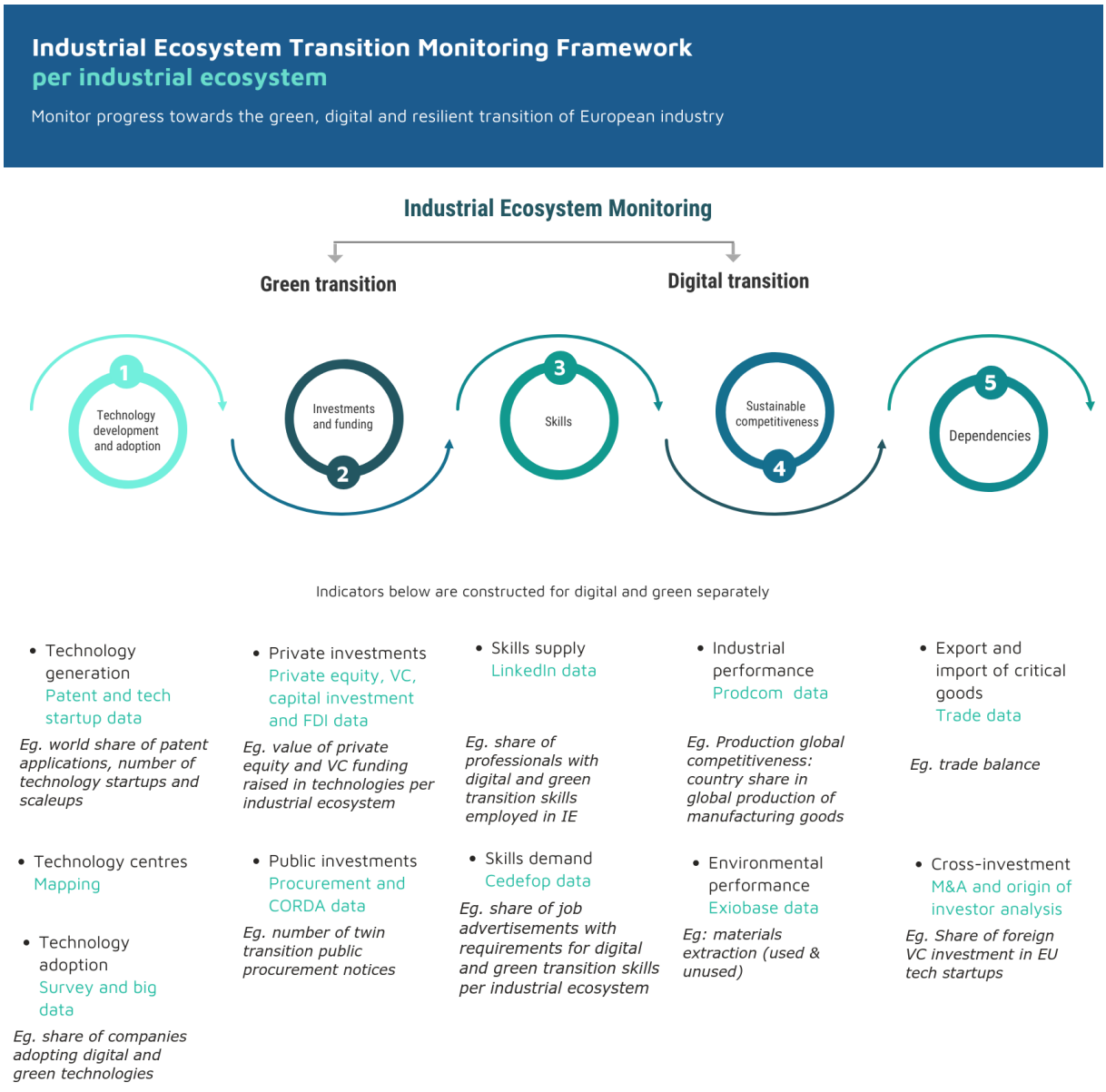
Industrial ecosystem	Existing key monitors and observatories
Healthcare	• Exchange of electronic health records across the EU, Electronic Health Record (EHR) and digital access to personal health data • EU funded R&D in e-health
Mobility, Transport & Automotive	• Emissions in the automotive sector • Staff Working Document For a resilient, innovative, sustainable, and digital mobility ecosystem. Scenarios for a transition pathway
Proximity and social economy	• Improving the Socio-economic Knowledge of the Proximity and Social Economy Ecosystem • Transition pathway of PSE • European Social Enterprise Monitor (ESEM), Euclid Network • EMES, EMergence des Enterprises Sociales en Europe, mapping study on social enterprise ecosystems
Retail	• Foresight on Demand Retail Ecosystem 2040 (DG RTD) • Study on Twin Transition of SME retailers (DG GROW) – Best Practices • Smart Industrial Remoting (DG CNECT) • Staff Working Document Co-creation of a transition pathway for a more resilient, digital and green retail ecosystem
Textiles	• Textiles transition pathway • EU Strategy for Sustainable Textiles • SRIA of the European Textiles Technology Platform • Circular industrial technology roadmap for energy-intensive industry, textiles and construction (DG RTD) • Data on the EU textiles ecosystem and its competitiveness
Tourism	• Transition pathway for Tourism • The Tourism dashboard • Virtual Tourism Observatory

Source: authors

4 Monitoring Framework

The conceptual framework describes the green, digital and resilient transition of industry as a multi-level, and dynamic process of the system. A monitoring framework as a tool for policy makers and industry representatives requires a systematic approach to collect and analyse data which show progress over time. It also accounts for the interconnections between the digital and green transition and how this impacts resilience. Although all components of the system are of relevance for the analysis of Industrial Ecosystems' transition the monitoring framework emphasises on a selection where quantitative data can be gathered and indicators constructed, namely: *1) Technologies and tech adoption, 2) Investments and Funding, 3) Skills 4) Sustainable competitiveness (including industrial and environmental performance 5) Dependencies.*

Figure 5 Dimensions of main indicators and sources used (general overview that is tailored and complemented by further specific data whenever applicable per industrial ecosystem)



Source: Technopolis Group

Main indicators are calculated in most cases across several industrial ecosystems (see Figure 6). Exceptions apply due to industry-specific differences e.g. Prodcom data calculations do not make sense for many of the service sectors, etc. while additional industrial ecosystem specific indicators are added where relevant.

Figure 6: Green, digital and resilient transformation related indicators calculated at the level of industrial ecosystems and digital and green technologies and business models

Pillar blueprint	Indicator	Source	Time series	Digital and Green Transition	IE	Country
Technology development and adoption	**Share of patent applications** in digital and green technologies in the country within the total global applications in the world	Patstat	2005-2020	Digital and Green (separately)	no	yes
Technology development and adoption	**Share of patent applications** in digital and green technologies per industrial ecosystem	Patstat	2005-2020	Digital and Green (separately)	yes	no
Technology development and adoption	**Technology startups and scaleups:** Number of technology startups and scaleups generating technologies; share in total	Crunchbase (mainly tech and digital) and NetZeroInsights (green startup data source)	2010-2022	Digital and Green (separately)	yes	yes
Technology development and adoption	**Share of companies adopting digital and green technologies**	Survey	2023	Digital and Green (separately)	yes	no
Technology development and adoption	**Number of technology centres** relevant for the digital and green transition of industrial ecosystems	TC Mapping	2023	Digital and Green (separately)	yes	yes
Investments and funding	**Private equity and Venture Capital investment in the green and digital Transition:** Value of private equity and VC funding raised in technologies per industrial ecosystem	Crunchbase (mainly tech and digital) and NetZeroInsights (green startup data source)	2015-2022	Digital and Green (separately)	yes	yes
Investments and funding	**Capital investment** in the green and digital transition	FDI insights	2016-2022	Digital and Green (separately)	yes	yes
Investments and funding	**Number of twin transition public procurement notices**	TED (+ National)	2022-2023	Digital and Green (separately)	yes	no
Investments and funding	**EU R&D funding in digital and green transitions per industrial ecosystem**	CORDA	2014-2022	Digital and Green (separately)	yes	yes
Skills	**Share of professionals with digital and green transition skills employed in industrial ecosystems**	LinkedIn	2019-2022	Digital and Green (separately)	yes	partially

Pillar blueprint	Indicator	Source	Time series	Digital and Green Transition	IE	Country
Skills	**Share of job advertisements with requirements for** digital and green transition skills per industrial ecosystem	Cedefop SkillsOvate	2022	Digital and Green (separately)	yes	partially
Sustainable competitiveness	**Production global competitiveness**: country share in global production of manufacturing goods	Prodcom	2008-2021	Digital and Green (separately)	yes	yes
Sustainable competitiveness	**Production country significance**: Share of production in AT over a country's total production of manufacturing goods	Prodcom	2008-2021	Digital and Green (separately)	yes	yes
Sustainable competitiveness	Country share in EU employment of digital and green technologies	Prodcom, Eurostat SBS	2008-2021	Digital and Green (separately)	no	yes
Sustainable competitiveness	Employment country significance: Share of production in digital and green technologies over a country's total employment	Prodcom, Eurostat SBS	2008-2021	Digital and Green (separately)	no	yes
Sustainable competitiveness	**GHG emissions**	Exiobase	2015-2021	Green	yes	yes
Sustainable competitiveness	**Materials extraction (used & unused)**	Exiobase	2015-2021	Green	yes	yes
Sustainable competitiveness	**Land use**	Exiobase	2015-2021	Green	yes	yes
Sustainable competitiveness	**Water use**	Exiobase	2015-2021	Green	yes	yes
Sustainable competitiveness	**Biodiversity (damage to the ecosystem)**	Exiobase	2015-2021	Green	yes	yes
Sustainable competitiveness	**Share of renewable energy:** (Terajoules) used in the total energy used	Eurostat and Exiobase	2010-2019	Green	yes	yes
Sustainable competitiveness	**Environmental management:** Number of organisations with registered environmental management system ISO 14001, EMAS and other	ISO	2010-2021	Green	yes	yes
Sustainable competitiveness	**Use of circular technologies** and business models	Survey	2023	Green	yes	no
Dependencies	**Trade balance:** difference between exports and imports in relation to the total trade volume (exports plus imports) of a country	UNCOMTRADE	2015-2020	Digital and Green (separately)	yes	no

Pillar blueprint	Indicator	Source	Time series	Digital and Green Transition	IE	Country
Dependencies	**Share of foreign VC investment in EU tech startups**	Crunchbase	2015-2023	Digital and Green (separately)	yes	no

Notes: Column 'IE' specifies the indicators calculated at the level of industrial Ecosystem and column 'Country' specifies the indicators calculated at country level.

Source: Consortium

5 Sources and methods

This chapter presents the methodological steps to collect data and calculate indicators per data source.

5.1 Technology development and adoption

5.1.1 Patent analysis

Patent data are a widely used measure for tracking technological development activities. With a view to the industrial ecosystems under study in this project, technology generation and hence patenting takes place in a relatively limited number of ecosystems, while others mainly profit from technologies generated elsewhere.

Patent data were calculated separately at the level of technologies and at the level of industrial ecosystems. First, it is important to focus at the level of technologies, as technologies such as Artificial Intelligence, Low-carbon technologies, Cloud computing, Edge computing, etc. are general purpose technologies, i.e. applicable in many if not all industrial ecosystems. Technology development is thus not specific to individual ecosystems but drives industrial transformation in a more general way. To simply focus on technologies developed by firms in a specific ecosystem would thus substantially underestimate the overall scope of technologies available & relevant to a specific industrial ecosystem. Second, it is nonetheless relevant to understand to which extent the firms of a specific industrial ecosystem make a contribution to technological development in different ways and in the different technological fields that belong to the ecosystem in a broader sense. Therefore, both approaches are used side by side in the reports - but only for very specific purposes mixed, in order to avoid confusing signals.

Moreover, it is important to acknowledge that there is a rather fundamental difference between technology generating ecosystems and those that primarily deploy technology. For the former, a patent analysis at ecosystem is essential and useful. For the latter, like e.g. the tourism ecosystems it is not appropriate. While, obviously, a lot of digital and green technologies are being applied in the transformation of the tourism or the cultural and creative industry, only a tiny fraction of those is generated within the ecosystems. To ask about their technology generation capacity is thus a meaningless - or at least potentially misleading question.

To ensure that only the most relevant patents are considered, the analysis focuses on 'transnational patents' (Frietsch/Schmoch, 2010) in line with the preceding ATI studies, i.e. on PCT/WIPO filings or direct applications at the EPO, excluding double counts. These patent applications stand out by being a) more expensive (application fee & potential maintenance) than others and b) protecting intellectual property at more than one patent office, i.e. potentially securing more than one national market. By using an effective, yet costly procedure that would not naturally be chosen unless the ambition to protect IP was sincere. In addition, using transnational patents for the analyses ensures that patents by all filing countries are measured at the same scale, without home advantages at domestic offices distorting the general picture. The patent analysis is conducted on an extended version of the EPO's Worldwide Patent Statistical Database that Fraunhofer ISI implemented locally.

For the analyses at the level of technologies, this study continues to use definitions developed for key enabling technologies (KETS) and central digital technologies in earlier studies to ensure comparability over time. In order to be able to address aspects of digitalisation and greening as well as to acknowledge the European Commission's recent revision of the KETS, new aggregate classes have been introduced which are, however, still grounded in existing definitions. For the analysis of technological development contributions at the level of ecosystems, 'technologies-relevant-to-ecosystems' have been

defined based on an internal consultation of experts, drawing on patent classifications (IPC) as well as use keywords to identify relevant applications across classes.

Industrial ecosystems where patent data were collected include:

Figure 7: Industrial ecosystems patent data

Industrial ecosystem	#	Industrial ecosystem	#
Aerospace & Defence	Yes	**Health**	Yes
Agri-food	Yes	**Mobility, Transport & Automotive**	Yes
Construction	Yes	Proximity and social economy	No
Creative and culture	no	**Renewable Energy**	Yes
Digital	Yes	Retail	No
Electronics	Yes	**Textiles**	Yes
Energy-intensive	Yes	Tourism	No

Source: Consortium

5.1.2 Technology startups

Technology startups represent key building blocks in the transition towards a more digital, green and resilient economic model. Entrepreneurial activity helps accelerate the diffusion of technologies in industrial ecosystems and startups that provide green and digital mobile solutions are relevant indicators of how the industrial ecosystem is transforming itself to reach environmental sustainability objectives. Therefore, we analyse tech startup creation as part of the technology generation dimension of this monitoring framework.

In this study, startups are defined as 'young, innovative, growth–oriented businesses in search of a sustainable and scalable business model' (NESTA, 2015). Tech startups are technology-based startups. More specifically, digital tech startups do not simply develop or adopt digital technologies but digital is an inherent part of their value proposition (Oestreicher-Singer and Zalmanson, 2012; Griva et al, 2023).

Environmental startups are another form of young, innovative business that develop and implement products, technologies and services that contribute to environmental sustainability, for example by reducing greenhouse gas emissions, improving energy efficiency, adopting a circular economy approach (see in Bergset et Klaus, 2015).

For the purposes of this analysis, startups have been defined as founded after 2015, however, in certain reports a longer time span is applied, and the evolution of tech companies established since 2010 are monitored.

With the objective of analyse tech startups and related venture capital investment we rely on two data sources notably Crunchbase and Net Zero Insights.

Crunchbase is a widely trusted source of primary data on venture capital and private equity innovative companies. It is a provider of innovative, investment-backed technology active companies in the EU27 and competing economies such as the US. According to Crunchbase, the total number of organisations included in the database in July 2022 includes around 376 000 companies from the European Union and 8 400 000 from the US. Crunchbase information includes investments and funding information, founding members and individuals in leadership positions, mergers and acquisitions, news, and industry trends. Originally built to track startups, the Crunchbase website contains information on public and private companies on a global scale.

Figure 8: Overview of Crunchbase Information

Company information	Financing information
Company information risk financing information Company size class Location (country, city and region) Primary role (firms, group, investor, university and other), status (operating, acquired, IPO or closed) Founding date Dates of the record Industry Group. Classification in terms of main activities of the organisations) Industry. Sub-classification in terms of activities of the organisations Social media information Contact (company and staff e-mail)	Amount of capital involved Type of round Number of rounds Number of investors involved Investment stage (e.g. VC, business angel, private equity) Profit/revenue information for 4 last years

Source: Consortium

Net Zero Insights is a specialised database of over 19 000 European startups identified as green innovators. It provides information about the location, age, investments, climate change challenge objectives, circular business models of the companies included. Additionally, it covers the SDGs addressed by each product/service offered by a company.

Figure 9: Overview of Net Zero Insights Information

Company information	Financing information
Company size class Location (country, city and region) Primary role (firms, group, investor, university and other), status (operating, acquired, IPO or closed) Founding date Dates of the record Sector. Classification in terms of main activities of the organisations Social media information Contact (company and staff e-mail)	Amount of total funding involved Number of investors involved Funding rounds (date, round, amount, raised to date, investor, source)

Source: Consortium

Data collection and processing methodology

As introduced above, Crunchbase and Net Zero Insights classify their data through a tagging taxonomy that includes industry tags as well as tags related to technologies (AI, Blockchain, etc). Appendix C provides an overview of the matching that has been done between the studied industrial ecosystems and the tags available in Crunchbase and Net Zero Insights, in collaboration with the experts of each industrial ecosystem. To overcome the limitations of the tagging taxonomy, and in order to capture all industrial segments of each ecosystem, the project team also used keywords to further scrape relevant companies.

For the Crunchbase data, the data collection was done through their API, which enabled quicker extractions and more sophisticated text mining of data. In the case of Net Zero Insights database, an additional scraping exercise was done to cover those industrial ecosystems that are currently not present in their sectoral classification.

Based on the pre-selected tags and keywords, our team collected startups founded during the period between 2010 until 2022 to allow for an analysis over time.

To further indicate the type of digital and green technology being developed, we run a text-mining exercise in which we classified the collected data according to a pre-defined technological taxonomy tailored to the industrial ecosystem.

5.1.3 Big data analysis – text mining of company websites

Using the OPIX data analytics platform, we strengthened and augmented the existing framework of indicators by leveraging data/text mining and natural language processing to help improve the understanding on the transition towards green and digital including the uptake of technologies and the generation of related products and processes in a selection of industrial ecosystems namely textiles, agri-food and energy-renewables.

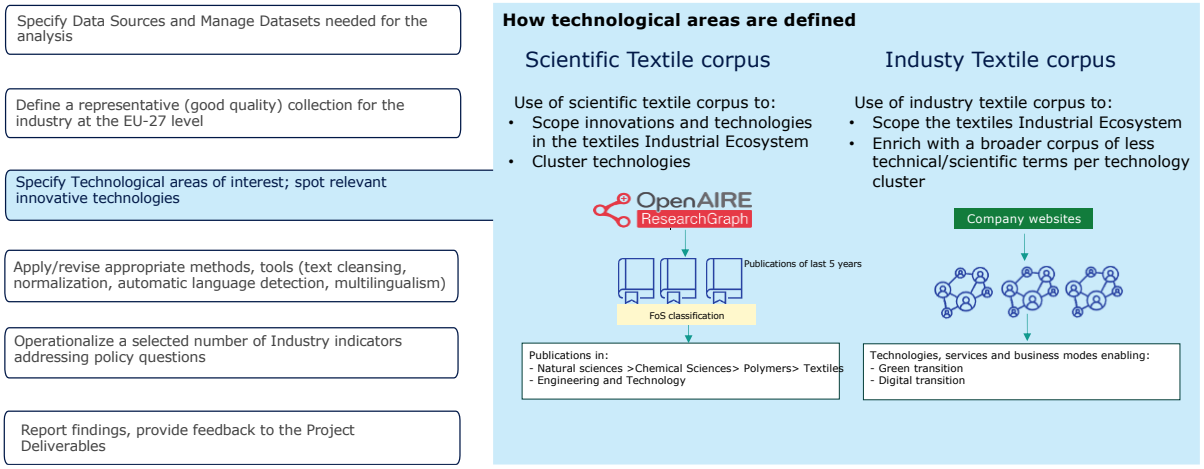
The methodological approach of the analysis is supported by models that utilize scientific and industry data corpuses specific to the industrial ecosystems. These models are designed to provide detailed insights into the scope of the green and digital transition pillars.

The models generate a list of High Priority Clusters (HPCs) that frame the green and digital transition pillars using key terms. This approach enables a high level of granularity in the analysis, allowing for a more precise understanding and interpretation of the activities undertaken by companies in each industrial ecosystem.

By utilising HPCs and their corresponding key terms, the analysis can set minimum thresholds for the presence and frequency of these terms within HPCs. These thresholds serve as qualifying criteria for companies, determining their inclusion within the Green and Digital transition pillars. The team conducting the analysis can adjust the level of stringency by setting specific thresholds for key terms, ensuring that companies meeting the criteria are considered in the analysis.

Overall, the use of models based on scientific and industry data corpuses, combined with the identification of HPCs and key terms, provides a robust and systematic approach to analyse the green and digital transition pillars within industrial ecosystems.

Figure 10 AI platform for industry website analytics - analytical steps



Source: Technopolis Group and Opix

5.1.4 Survey

The business survey collected data about the level of change towards the green and digital transition of European SMEs in the EU 27 across selected industrial ecosystems and gathered opinions about the related investments, challenges, opportunities and expected future developments. A random sample of companies was drawn focusing on high-level decision-makers that can duly reflect about the adoption of advanced technologies within their organisation.

The summary table below details the choices made in terms of method - based on Computer Assisted Telephone Interviewing (CATI), the company size –focused on SMEs, the target respondents – targeted towards top management level. The survey is unique as it is conducted at the industrial ecosystem level which implies for instance that only companies in manufacture of computer, electronic and optical products (C26) supplying the aerospace and defence industrial ecosystem are accounted for in the analysis and results for aerospace and defence. These considerations have been made for each industrial ecosystem and qualifying questions have been included in the questionnaires.

Figure 11: Survey summary

Survey components	Description
Total sample size	8 987
Data Collection Method	Computer-Assisted Telephone Interviewing (CATI) using the World Bank's Survey Solutions survey software
Company sizes	Small and Medium sized companies
Target respondent	Top-management level: General manager, CEO, COO, Owner
Industrial Ecosystem eligibility	In which of the following areas is your firm active? [List of IE's]
Digital/Green transition eligibility	Does your company consider digitalisation important for its business and has adopted any digital technology(ies) in the past ten years? Does your company have a policy or practice to improve its environmental sustainability performance and has adopted any environmental technologies or practices in the past ten years?

Source: authors

The total sample reached was 8 987 companies (SMEs) with an achieved accuracy below 5.5% at a 95 percent level of confidence for each industrial ecosystem. The details on the coverage for each industrial ecosystem per NACE rev2 category are provided in Appendix C. This analysis includes 12 industrial ecosystems and excluded the energy/renewables and the digital industrial ecosystem as their transition needs to be conceptualised in a different way and cannot be captured in the same way and same questionnaire. Their exclusion also allowed to increase the sample size for the other ecosystems.

Figure 12 Sample by Industrial Ecosystem

Industrial Ecosystem	Total – SMEs	
	Absolute numbers	Percentage in total
Tourism	836	9%
Aerospace & Defence	375	4%
Agri-food	1 045	12%

Industrial Ecosystem	Total – SMEs	
	Absolute numbers	Percentage in total
Construction	1 003	11%
Cultural and Creative Industries	647	7%
Digital	excluded	
Electronics	300	3%
Energy - Renewables	excluded	
Energy Intensive Industries	1 464	16%
Health	469	5%
Mobility - Transport - Automotive	946	11%
Proximity, Social Economy and Civil Security	309	3%
Retail	1 267	14%
Textile	326	4%

Source: authors
Note: In the case of the digital industrial ecosystem and energy – renewables industrial ecosystem no survey was conducted as such analysis is already being conducted elsewhere.

5.2 Investments and funding

5.2.1 Venture capital and private equity

Primary data on venture capital and private equity investment in innovative startups and firms have been sourced from Crunchbase and Net Zero databases. Based on the tags and keywords indicated in Appendix C, our team collected funding rounds dated after 2010 for any company (regardless of the founding date) providing a solution that supports the green/digital transition.

The study team developed a coherent and consistent methodology to classify the funding rounds across all IE. Moreover, and building on the text mining exercise performed to classify startups, we were able to further analyse investments stages also at the technological level.

- Seed. This stage includes all funding instruments that occur in the early phase of development of startups. Types of funding under this stage include: Pre-Seed, Seed, Angel, Accelerator/incubator, Product Crowdfunding, Equity Crowdfunding, Crowdfunding, Award/Prize
- Early Development. Here we include early Venture Capital investment rounds (up to €20 million), Convertible Note, Series A, Corporate and Private Equity (up to €20 million)
- Late Development. Operations within this stage include advanced VC rounds (>€20 million), starting from Series B.
- Exit. Here we include operations for very well establish startups, including offering corporate shares to the general public, acquisition and merger operations.

Figure 13 Summary of investment stages and instruments

Stage	Type of funding instrument
Seed	Pre-Seed

Stage	Type of funding instrument
	Seed
	Angel
	Initial Coin Offering
	Grant
	Crowdfunding
	Accelerator/incubator
Early development	Convertible Note
	Corporate Round
	Series A
	Early VC (up to €20 million)
	Equity round (up to €20 million)
Late development	Series B
	Series C
	Series D
	Series E
	Debt Financing/Debt
	Late Private Equity (above €20 million)
	Late Venture Capital
Exit	IPO (Initial Public Offering)
	Post-IPO Equity
	Acquisition
	Merger
	Secondary market

Source: Consortium

5.2.2 Foreign Direct Investment

FDI intelligence tracks cross-border greenfield investment covering all sectors and countries worldwide, it provides real-time monitoring of investment projects, capital investment and job creation with powerful tools to track and profile companies investing overseas. They only track real projects that will create new jobs, therefore they do not cover merges and acquisitions.

The main components of the data include the destination and source market (at country and NUTS level), sector (e.g. automotive, aerospace, medical devices etc.) and sub-sector (e.g. biomedical products), following the North American Industry Classification System (NAICS), activity (e.g. manufacturing, research and development, green investment, digital technologies), value of investment and jobs created (see Figure below for detailed information). Additionally, fDi Intelligence has a tag system and a keyword search function that allows to match projects to the digital and green investments. For example, a project in the ICT industry can be attached to the Artificial Intelligence tag. FDi Intelligence retrieves their data from open sources such as public announcements and news, companies' websites and agencies. Their algorithms collect data in 25 languages, achieving a representativeness of around 85% of the greenfield investments. As part of their quality control process, they monitor the identified transactions to make sure the information is valid.

FdI investments have been included within the monitoring framework as part of the investment building block. This data enabled our team to capture the total volume of large and mid-sized company investments by type of ecosystem, with additional differentiation between green and digital related projects.

Figure 26 in Appendix C provides an overview of the matching that has been done between the studied industrial ecosystems and the NAICS sectors.

Figure 14: Overview of fDi Intelligence information

Project information	Financing information
Destination and source markets Sector and sub sector information Type of project Company website Rationale for the project Capital expenditure Jobs created Data source Founding date Dates of the record Social media information Contact (company and staff e-mail)	Number of investors involved Funding rounds (date, round, amount, raised to date, investor, source)

Source: Fdi intelligence

5.2.3 Public Procurement

Public authorities are major consumers and can use their spending power to transform the market of many industries. By procuring environmentally friendly goods, solutions, and services, public authorities can contribute to the green transition of economies. Through innovative public procurement, governments can foster the uptake of innovative goods and services. While green public procurement can promote green and sustainable practices and encourage companies to develop new eco-friendly business measures, products, and services. Given the role public procurement can play in accelerating the transition and the expectation of its increased uptake by EU countries, it was included in the monitoring framework (building block: Investments and funding).

To monitor the twin transition in public procurement as part of the monitoring framework, a process was established to isolate the notices/awards of relevance to the Industrial Ecosystem and green and digital products, goods, or services procured. The approach was tailored for each Industrial Ecosystem and based on a combination of the Common Procurement Vocabulary (CPV) classification system and keywords. The CPV codes provided a bases for the industrial ecosystem definition and the keywords defined the technologies, these key words were searched for in the body of award notices. The main source was Tenders Electronic Daily, the online version of the 'Supplement to the Official Journal' of the EU, dedicated to European public procurement.

The period in focus was 2015 until today to allow for an analysis over time, including up-to-date information. The growth was measured both in terms of the absolute number of notices, their value, and their share in total notices per Industrial ecosystem. The geographic coverage was EU 27, with a split per country. To understand the way twin transition was pursued by public authorities through public procurement, the content of the notices was analysed and attributed in terms of types of goods, solutions, or services requested.

5.2.4 Research and innovation investments at EU level

Research and innovation investments to achieve industrial leadership have been made in Horizon 2020 under the pillar of 'Industrial Leadership' and continue in Horizon Europe under Cluster 4 'Digital, Industry, and Space'. Given the size of Horizon 2020 and Horizon Europe the Framework Programmes represent an essential part of the R&I capacity of countries and EU 27 as a whole in making progress towards twin transition and enabling a carbon-neutral EU by 2030. Monitoring Research and Innovation investments under the Framework Programme and attributed to Industrial Ecosystems informs the blueprint's building blocks of investments and funding as well as R&I, techniques and technological solutions, the identification of actors, infrastructures etc.

To collect Framework Programme data the CORDIS database was used. CORDIS contains information about participants, projects and their results which were funded by the EU under the Horizon 2020 framework programme from 2014-2020 and Horizon Europe. The main information gathered is summarised below. The data is attributed to ecosystems through a combination of: 1) NACE code of participants corresponding to the Industrial Ecosystem definition and 2) key word search of relevant green and digital technologies per Industrial Ecosystem from the project abstracts and 3) EuroSciVoc codes.

The main horizon 2020 programmes in focus are listed below:

- Leadership in Enabling and Industrial Technologies: Information and Communication Technologies (LEIT-ICT)
- Leadership in Enabling and Industrial Technologies: Nanotechnologies, advanced materials and advanced manufacturing and processing, biotechnology (LEIT-NMBP)
- Leadership in Enabling and Industrial Technologies: Space (LEIT-SPACE)
- SC2: Food security, sustainable agriculture and forestry, marine, maritime and inland water research, and the bioeconomy
- SC3: Secure, clean and efficient energy
- SC4: Smart, green and integrated transport
- SC5: Climate action, environment, resource efficiency and raw materials

For the IEs Proximity and Social Economy and Tourism the entire CORDIS was used.

The following indicators are calculated: 1) Technology funding by start year of the project; 2) Technology funding by source: total costs, EC contribution and other; 3) Technology funding by stakeholder type: SME; all private enterprises; public administration/other, Higher Education institutions.

5.3 Skills

5.3.1 Skills supply

Presence of professionals with skills related to the twin transition and to advanced technologies is key in the transformation of the industry. In the view of the present study, the uptake of advanced technologies and the spread of the twin transition in the different industrial ecosystems in focus depend partly on their ability to attract/retain/upskill the adequate skilled workforce.

However, measuring the presence of advanced skills within the industrial ecosystems' workforce is not trivial as the traditional data sources do not provide specific skills data.

Hence, to capture intelligence on the spread of green and digital skills within the European workforce, we rely on an alternative data stream, and we harvest data from LinkedIn - the largest professional online network with more than 86 million of European users.

The LinkedIn data is calculated on this entire professionals' base and is extremely timely as it represents live the state of play of the LinkedIn platform. To harvest the data from LinkedIn, keywords capturing twin transition skills have been defined, and queries have subsequently been constructed to filter the database by location and industrial ecosystems. Industrial ecosystems have been defined according to LinkedIn classification of industries, in parallel to the associated NACE codes (Rev 2). The outcome of the queries is used to assess the share of professionals within each industrial ecosystems who appear to master twin transition and advanced technologies skills. Furthermore, the growth rate of this highly skilled workforce in the ecosystem reflects the pace of the industrial transformation.

By its nature of voluntary professional online network, LinkedIn presents biases and data needs correction in order to confidently generalise the findings to the total population and allow for comparisons. The biases of the LinkedIn data arise from a varying popularity of LinkedIn across different subsets of the population and result in different degrees of representativeness of the LinkedIn population according to their country, their sector of activity, their gender and their education level. To correct (partly) these representativeness biases, we compare the LinkedIn population and the actual active population in terms of industry size and gender balance by country and derive a corrective weighting.

5.3.2 Skills demand

Cedefop Skills intelligence provides valuable insights into the job market and skills demand through its dataset 'online job advertisement'. This extensive tool comprises 530 online job advertisement sources from 424 distinct open-access websites, covering 27 EU Member States.

The dataset, which has been continuously updated since July 2018, analyses over 100 million online job ads, offering information on the most sought-after occupations and skills across European countries. By utilising internationally recognized classifications such as ISCO-08 for occupations, ESCO for skills, and NACE rev. 2 for sectors, the dataset provides comprehensive and up-to-date information for the 27 EU Member States and other European countries. Access to the data is facilitated through Web Intelligence Hub (WIH).

In our analysis, skills are filtered by pre-defined green and digital skills, while we use the NACE rev. 2 to define each IE. The green predefined skills are from ESCO v1.1[31] and the digital are predefined from ESCO v1.1.1[32] which is currently being updated. To further complement our analysis, we created our own taxonomy of advanced digital skills.

The period in focus was 2019 until 2022 to allow for an analysis over time. The growth was measured both in terms of the absolute number of adverts, and their share in total notices per industrial ecosystem. The outcome of the queries is used to assess the share of job adverts within each industrial ecosystem which demand the transition skills. Furthermore, the growth rate of the job advertisements in the ecosystem reflects the change in demand for the companies for the transition skills.

[31] ESCO green skills download: https://esco.ec.europa.eu/en/use-esco/download
[32] ESCO digital skills download: https://esco.ec.europa.eu/en/use-esco/download

Nonetheless, there are some limitations to the database due to its novel and experimental data which leads us to be precarious when analysing the data. It is important to note that all online job advertisements prior to the year 2022 (specifically, from 2018 to 2021) are desecrated due to updates in methodologies for analysing online job advertisements and revising ESCO skill classifications. Despite utilising up-to-date technologies, the tools used for data processing may still be prone to errors. Constant improvement is required for the ontologies developed and utilised to sort and organize the complex and diverse universe of online job advertisement data, which affects our ability to track trends over time. Online job advertisements represent only a portion of the overall job demand, as not all job vacancies are advertised online. It is also worth mentioning that the validation of the data is limited due to restricted access to the source data.

5.4 Sustainable competitiveness

5.4.1 Production

One way to capture the development of new markets, is to capture the production of technology products. In addition to measuring the uptake of technology through production of manufacturing goods, the Prodcom data allows to estimate the dynamics of technologies in products by focusing on the specific components and elements of green and digital technologies that are in turn contributing to the green and digital transition. Production data allows to measure how much these technology-related products are being produced. The production indicators are calculated based on product-level data from the Eurostat's Prodcom database. Prodcom is the title of the EU production statistics for Mining, Quarrying and Manufacturing, i.e. Sections B and C of the Statistical Classification of Economic Activities in the European Community (NACE Rev. 2). The headings of the Prodcom list are derived from the Harmonized System (HS) or the Combined Nomenclature (CN), which thus enables comparisons to be made between production and trade statistics. Similar to the earlier ATI project, attention has been devoted to aligning the definitions and analysis of the HS and Prodcom based analysis.

In addition, technology uptake is embedded in the vast academic literature on technology diffusion (Geroski, 2000) that deals with the success, rate and failure of new technologies in moving across a market. Diffusion of technologies is seen primarily as the outcome of a learning or a commercial process and resistance to adopt an innovation as a function of the individual's propensity. New technologies are also seen as an opportunity to increase productivity and to impact economic growth, employment or the environment. Within the Advanced Technologies for Industry Project, an updated method for analysis was developed to account for the addition of the digital technologies and evolutions in advanced technologies that have occurred in recent years.

The approach took the additional added value for core technologies as well as from direct application industries into account, while avoiding an expert rating regarding concrete weights. The selection of relevant Prodcom codes for the production of manufacturing goods was revised to ensure alignment with the EU industrial ecosystems and to contribute to the assessment of progress towards the green and digital transition. Production data provides information on the ability of EU countries to realise and use green and digital technologies to improve their overall competitiveness and apply these technologies in target application areas. They provide insight in the diffusion of the technology to other application areas and wider sectors and highlight to what extent the EU can use the potential of green and digital technologies to improve its competitiveness by manufacturing ATI based products and applying them in the production of manufacturing goods. As basis for the production indicators of EU27, data from the Prodcom database were used. The production data of manufacturing goods serve as input for the calculation of the share of labour resources needed for advanced technology.

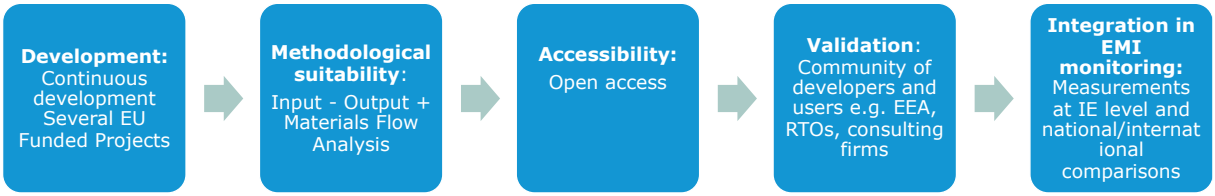
As production data is sometimes confidential for certain technologies and particular Member States, a close collaboration with EUROSTAT was needed.

The production data of manufacturing goods serve as input for the calculation of the labour resources (employment) needed for advanced technology. Therefore, the respective production values of relevant production codes were multiplied with the employment per m € production ratio from the Structural Business statistics for the respective 4-th digit sector. The resulting employment numbers on the level of the advanced technologies indicate how much workforce is needed for the production and use of advanced technologies, and at the same time are secured in industrial countries as value chains remain competitive by adopting innovative solutions.

5.4.2 Environmental impact

The main data sources of green performance indicators are Eurostat and Exiobase. Exiobase has two types of data. Production-based accounts and consumption-based accounts. Production-based accounts consider national trade embodied impacts of domestic industrial activities. Consumption-based accounts consider also international trade (exports and imports) embodied impacts of domestic industrial activities. Consumption-based accounts capture complex international supply chain forward and backward flows characterising the current global production networks. This monitoring framework monitors industrial ecosystems; hence the production-based accounts are used. However, when data is not available, consumption-based accounts are used instead.[33] [34] [35] [36]

Figure 15 Exiobase Assessment process and criteria



Source: Technopolis Group

Exiobase has impact at NACE 1, thus concordance tables were used to transfer impacts to NACE rev 2 industries. The 2021 Annual Single Market's report on industrial ecosystems weights were then used to estimate impacts at ecosystem level.

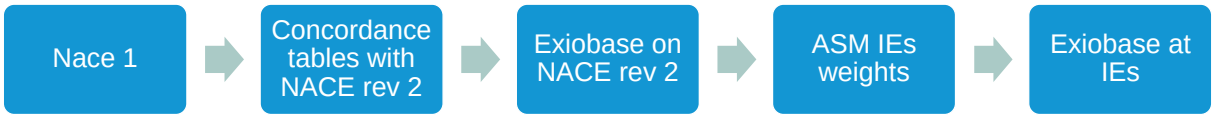
[33] Beylot, A., Secchi, M., Cerutti, A., Stefano, M., Schmidt, J. and Sala, S., Assessing the environmental impacts of EU consumption at macro-scale, JOURNAL OF CLEANER PRODUCTION, ISSN 0959-6526, 216, 2019, p. 382-393, JRC115227. https://dx.doi.org/10.1016/j.jclepro.2019.01.134

[34] Lingas, Manshoven, Fogh Mortensen, Paulsen, European Environmental Agency (2023) ETC/CE Report 2023/4 EU exports of used textiles in Europe's circular economy. https://www.eionet.europa.eu/etcs/etc-ce/products/etc-ce-report-2023-4-eu-exports-of-used-textiles-in-europe2019s-circular-economy

[35] European Commission (2021) COMMISSION STAFF WORKING DOCUMENT IMPACT ASSESSMENT REPORT. Accompanying the document Proposal for a regulation of the European Parliament and of the Council establishing a carbon border adjustment mechanism. SWD(2021) 643 final https://eur-lex.europa.eu/resource.html?uri=cellar:be5a8c64-e558-11eb-a1a5-01aa75ed71a1.0001.02/DOC_2&format=PDF

[36] UN Economic Commission for Europe (2016) The Figaro project: The EU inter-country supply, use and input-output tables. https://unece.org/fileadmin/DAM/stats/documents/ece/ces/ge.20/2016/ECE.CES.GE.20.27_Eurostat.pdf

Figure 16 Exiobase preparation for integration to the EMI Monitoring Framework



Source: Technopolis Group

Adapting European Environmental Agency's environmental indicators typology, this framework considers: Pressures to the environment or impacts and circularity responses, both of which can help develop performance indicators by applying impacts or responses per unit of outputs.

The green transition impacts and responses in this section are sourced from Eurostat and Exiobase 3.8.[37] Whilst Eurostat represents the official statistics, Exiobase is a legitimate source of information referred to for example by the European Environmental Agency[38], the EC/JRC community[39], Eurostat[40], and by the European Commission to propose the regulation on carbon border adjustment mechanisms.[41]

Pressures to the environment refer to trade-embodied resources utilisation, and trade-embodied impacts. Resources utilisation is captured with four main dimensions and considered for cross-industry comparisons: embodied Land use, embodied Water consumption, embodied Materials Consumption, and Energy mix supplied to the industrial activity.

In terms of impacts, there are three dimensions monitored: Air emissions (incl. GHG), Waste generation, and damage to the ecosystem. An additional circularity measure includes the Recycling services supplied to the industry, environmental management certificates, and renewable energy supplied to the industry.

The following table shows the summary of environmental performance indicators.

Figure 17: Summary table of environmental performance indicators

Indicator type	Dimension	Indicator	Source
Pressures/ Impacts	Release of substances	Global Emissions (G Tons CO2e)	Exiobase
		Local emissions (G Tons PM10, PM25)	Exiobase

[37] Exiobase is a time series of environmentally extended multi-regional input- output (EE MRIO) tables. Its coverage is by country and industry from 1995 to 2021 and has EU and extra rest of the world coverage. Source: Stadler, Konstantin, Wood, Richard, Bulavskaya, Tatyana, Södersten, Carl-Johan, Simas, Moana, Schmidt, Sarah, Usubiaga, Arkaitz, Acosta-Fernández, José, Kuenen, Jeroen, Bruckner, Martin, Giljum, Stefan, Lutter, Stephan, Merciai, Stefano, Schmidt, Jannick H, Theurl, Michaela C, Plutzar, Christoph, Kastner, Thomas, Eisenmenger, Nina, Erb, Karl-Heinz, … Tukker, Arnold. (2021). EXIOBASE 3 (3.8.2) [Data set]. Zenodo. https://doi.org/10.5281/zenodo.5589597

[38] EEA 2022. Visit 12/10/2022. https://www.eea.europa.eu/data-and-maps/data/external/exiobase

[39] Beylot, A., Secchi, M., Cerutti, A., Merciai, S., Schmidt, J. and Sala, S., 2019. Assessing the environmental impacts of EU consumption at macro-scale. Journal of cleaner production, 216, pp.382-393. https://doi.org/10.1016/j.jclepro.2019.01.134

[40] Remond-Tiedrez, I. and Rueda-Cantuche, J.M. eds., 2019. EU Inter-country Supply, Use and Input-output Tables: Full International and Global Accounts for Research in Input-output Analysis (FIGARO). Luxembourg: Publications Office of the European Union.

[41] EC (2021) REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL. Establishing a carbon border adjustment mechanism. COM(2021) 564 final.

Indicator type	Dimension	Indicator	Source
	Resources consumption	Materials extraction (used and unused cops, grazing, timber, minerals, iron ore, metals, etc.) (G Tons Tons)	Exiobase
		Land use (10^{12} * km2)	Exiobase
		Water consumption Blue (10^{18} * m^3)	Exiobase
	Pressures to environment	Biodiversity loss – Damage to the ecosystem by ecotoxic emissions (10^{12} * PDF)	Exiobase
Green transition response	Efforts to achieve objectives	Share of renewable energy (Terajoules) used in the total energy used.	Eurostat (ENV_AC_PEFASU)
		Environmental certificates (ISO 14000) last av. year 2020	ISO

Source: Consortium

5.5 Dependencies

Europe's vulnerability and hence dependencies in specific technology domains were investigated by quantitative analysis by combining findings from trade and prodcom data. The analysis is included only in the EU report of the project.

More specifically, the EU's dependency on non-European imports of relevant goods was established for all industrial ecosystems and put in relation to Europe's own production capacities in those. On this basis, trends in external dependency in relation to own production capacity were visualised and traced for all industrial ecosystems dealing with tangible goods. Complementing the production and trade figures already included in the reports, this monitoring of dependency was prepared the ground for further in-depth analysis of resilience related issues.

In addition, an analysis of external dependence was performed for a selection of main technologies relevant for each ecosystem, selecting from the European Commission's established range of digital and green technologies.

The purpose of this analysis was to provide an 'at a glance' first insight into how Europe is internationally positioned in a specific industrial ecosystem.

5.5.1 Trade

Trade data provide a relevant indication of industrial development at the TRL 8-9 level. First, they inform on countries' comparative and competitive advantage in specific product areas. In today's interconnected global economy, however, that indication is certainly far less direct than suggested by classic trade theory and figures subject to various additional factors of influence such as whether the country is an assembly location for goods it cannot design or even simply a shipping hub. That notwithstanding, export strengths in certain technological areas still mark a specific relevance of technology relevant goods for a particular economy. Overall, they among the most reliable indicators of many nations' competitive performance.

One of the most relevant qualifications of sheer export figures is the parallel consideration of imports - which allows to filter assembly and shipping hub situation. The analysis focused primarily on trade balances rather than gross exports. By putting exports in relation to parallel imports, it is at least to a degree possible to assess whether a country displays

genuine strengths grounded in technological capacities. In addition, a careful analysis of trade data is one of the few available tools to at least trace international production chains. For example, they can help reveal how technologically strong nations are nonetheless intricately involved in supply chains that involve both substantial imports and relevant exports.

In practical terms, technology and ecosystem specific trade portfolios were defined based on HS (Harmonised System) codes, drawing on both a revision of those already available from earlier projects and in close consultation with the team performing the Prodcom analysis. In addition, an in-depth manual review of possible definitions for different ecosystems and technology fields was conducted to complete delineations for :

- At **ecosystem level** for all non-service ecosystems to assess the overall extent of trade affected when addressing policy efforts to a specific industrial ecosystem
- Based on an embeddedness logic[42] for the **complete list of technologies relevant for digitalisation and greening**

Once agreed, the definitions were translated into bespoke queries and data generated from an in-house version of the UN's COMTRADE database that Fraunhofer ISI maintains.

[42] As some key technologies like artificial intelligence, big data and digital security lack a clear material basis, the best possibly approach was to define lists of "goods relevant for a specific technologies", i.e. in the listed cases certain microchips, storage modules or network equipment that stands in close relation to these technologies, into which they need to be 'embedded'. Analyses thus show whether the Union or specific countries have the material basis to develop and implement activities in these areas, fully acknowledging that the core contribution to do so is of an immaterial nature and cannot be captured by production or trade data.

6 Foresight analysis

The objective of the Foresight Report is to give an outlook about advanced future technologies and cross-cutting issues that will play an important, maybe even disruptive role for production, production processes, innovation systems, consumption or future well-being in the European Union. Foresight is understood as the structured debate about complex futures.

This exercise builds upon existing systematic approaches and takes a long- or medium-term view to support decision-making in the present (Cuhls 2003) and needs elements of Horizon Scanning, discussion formats and assessments for priority-setting (see Cuhls 2019, EFFLA 2013). The Foresight Report is expected to summarise the findings of a Horizon Scanning by applying an advanced technology 'lens' approach. This includes the search for future cross-cutting issues in advanced industrial production and technologies (holistic, systems approach), issues in the context of industrial production as well as future developments in the context of the digital and green transitions.

The process behind the Foresight Report makes use and builds upon the previous work of this project. The starting point for the analysis is data collected as part of WP3 and analysis conducted in WP4.1 under the industrial ecosystem reports.

The following steps are being implemented:

1. Generate a (long) list of cross-cutting issues

- Challenging digitalisation - simplifying digital processes, avoiding bureaucracy, pragmatic use of digital technologies while maintaining privacy and security
- Twin transition - digital + green, where are the opportunities?
- Circular economy + green: Who can afford it? Who is realising it? How can the networks be built? How is bringing back and recycling in a clean way organised? How is it paid? Why should people be motivated to do it?
- Energy and time costs of digitalisation
- More than services - technology and physical instalments: if there is AI and if digital technologies are all around us, and all people want to earn money in digital jobs, who is doing the installations, heavy and dirty jobs? Who is still prepared for and acting in the real physical world? Products need to be physically treated, transported, installed. Do we have enough people with the necessary skills for these installations or for any other crafts that might be necessary? Who is doing the real repair service beyond the "digital help" and the "digital twin" simulations?

2. Internal meeting with workshop character with the European Commission took place on the 30 May.

3. Workshop with external experts will be organised in Brussels with Deep Dive discussions - Which pathways into the 10 year future can be imagined? Are there alternative possible pathways? What are desirable pathways?

4. About 10-12 interviews concerning the Deep Dives

5. Foresight Report writing

7 Technology centre mapping

Innovation actors are at the core of industrial ecosystems and gathering and sharing information about them in a structured way is crucial to detect gaps, improve collaboration, foster innovation, and strengthen innovation ecosystems. To this end, this project includes an exercise on mapping Technology Centres across the EU.

Technology centres that are key actors in innovation ecosystems due to their technical expertise and their ability to bring together and steer collaboration among various types of actors in their own ecosystems and beyond.

The mapping includes the following list of technologies covered under this project:

- Digitalisation and industrial modernisation
  - Advanced Manufacturing & Robotics
  - Artificial Intelligence
  - Augmented and virtual reality
  - Big Data and Cloud Computing
  - Blockchain
  - Digital Security & Networks/Cybersecurity
  - Digital Tech for Mobility
  - Internet of Things
  - Micro- and Nanoelectronics & Photonics
- Greening, energy and resource efficiency
  - Advanced Materials and Nanotechnology
  - Biotechnology including Medical Biotechnology
  - Energy Saving Technologies
  - Renewable Energy Technologies (including solar, wind, batteries, geothermal, hydropower, biomass, hydrogen)
  - Recycling technologies relevant for the circular economy

An additional search was performed to identify technology centres that comply with the eligibility criteria to be included in the mapping (see Box 1). This process led to the elaboration of a long list of 2 126 technology centres potentially eligible to be included in the mapping tool.

Box 1: Eligibility criteria

Technology centres have to comply with 3 qualitative criteria

- Provide services to industry and SMEs
- Be active in at least one of the Advanced Technologies for Industry
- Be active in the higher Technology Readiness Levels (TRL) -have activities in TRL5, TRL6, TRL 7 or TRL 8

Technology Centres have to comply with at least 2 additional quantitative criteria among the following 4:

- More than 10 projects with SMEs in the last two years.
- More than 2 major investments in equipment for close-to-market R&D activities with industry in the last 3 years. The Centre should provide a short description of these investments (type, functionality and investment amount)
- At least 15% from industrial funding in the total annual funding of the Centre in the last 2 years.
- At least 7% from projects with SMEs in the total turnover of the Centre in the last 2 years.

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https://www.mckinsey.com/~/media/mckinsey/business%20functions/mckinsey%20digital/our%20insights/how%20six%20companies%20are%20using%20technology%20and%20data%20to%20transform%20themselves/the-next-normal-the-recovery-will-be-digital.pdf

9 Appendix A: Definitions of Industrial Ecosystems and Technologies

Industrial Ecosystems

Industrial ecosystems that are core to this analysis have been specifically defined in the Annual Single Market Report 2021 (see Table 6). This monitoring framework aims at capturing transformative trends at the level of the ecosystem whenever it is possible, however, in certain cases aggregations do not make sense or add value, hence a level of granularity was kept. For each indicator the objective is to collect the data at the lowest level of granularity matching the ecosystem definition (i.e. NACE rev2 two digit). This decision is in line with the needs expressed by the units/DGs in charge of the Industrial Ecosystems during bilateral exchanges.

Figure 18: Ecosystem definitions and levels of analysis

Industrial ecosystem	Definition	
Technology generating industrial ecosystems		
Aerospace & Defence	The Aerospace and Defence ecosystem covers manufacturing companies in aeronautics, space, and defence; space operators and data and service providers; research institutes.	
Digital	The digital ecosystem covers ICT Manufacturing, Services (excluding telecommunications), Telecommunications. ICT Services account for the 95% of the total ICT value added.	
Electronics	The electronics ecosystem covers design and manufacturing of electronic components; includes raw materials (semiconductor wafers) and manufacturing tools. The value chain stretches from design to semiconductor manufacturing to 'assembly-test-packaging' facilities, before reaching end-user companies, which integrate the chips into their product solution. Materials, equipment and related services and tools, including specific design tools and so-called functional blocks, enable design and manufacturing.	
Healthcare	Manufacturing of pharmaceuticals and their key inputs, medical devices and equipment and personal protective equipment; Healthcare services (medical and residential care); Health tech and related services. Companies are often part of global and complex supply chains.	
Mobility, Transport & Automotive	The Mobility – Transport – Automotive Ecosystem covers automotive, rail and waterborne. It is characterised by long and complex supply chain. The ecosystem is dominated by a few players that became global players.	
Energy/ Renewable Energy	Renewables include wind energy, solar energy (photovoltaics, thermal and concentrated solar power), hydropower, bioenergy (including sustainable biofuels), geothermal energy, ocean energy, and heat pumps. Furthermore, sustainable energy storage solutions, smart infrastructure technologies and energy conversion technologies, including electrolysers, are an important part of a clean energy ecosystem.	
Technology uptake-oriented industries		
Construction	The construction ecosystem covers contractors for building and infrastructure projects, some construction product manufacturers, engineering and architectural services as well as a range of other economic activities (e.g., rental and leasing of machinery and equipment, employment agencies).	
Agri-Food	The agri-food ecosystem covers all operators in the food supply chain (farmers, food industry, food retail and wholesale, and food service) and their suppliers of inputs and services (seeds, pesticides, fertiliser, machinery, packaging, repair, transport, finance, advice and logistics).	
Energy Intensive Industries	The Energy-Intensive Industries (EIIs) Ecosystem covers chemicals, Steel, Paper, Plastics, Mining, extraction and quarrying, Refineries, Cement, Wood, Rubber, Non-ferrous metals, Glass, Ceramics. They supply intermediate products to each other and to many downstream sectors of the economy, are closely integrated with energy providers as well as with the waste and recycling industries due to their need for secondary raw materials.	

Industrial ecosystem	Definition	
Textiles	The textile ecosystem includes transformation of natural (e.g., cotton, flax, wool), man-made and artificial (synthetic polyester and viscose) fibres into yarns and fabrics, production of yarns, home textiles, industrial filters, technical textiles, carpets, and clothing. The ecosystem also includes production of footwear and leather. The ecosystem is particularly competitive in high-end clothing and technical textile for automotive applications, medical textile, agro textile and protective clothing. Most companies operate in complex value chains, making them dependent on external supplies, which can easily be disrupted.	
Service ecosystems		
Creative & Cultural Industries	The CCIs are a varied group. The biggest industries are audiovisual (TV, videogames, VOD, cinema, VR/AR), music, books and press publishing, advertising, cultural heritage (museums, historical sites), performance (theatre, dance) and visual arts.	
Proximity & Social Economy	The 'social economy' encompasses a variety of businesses, organisations and legal forms, including non-profit associations, cooperatives, mutual societies, foundations and social enterprises. They share the objective of systematically putting people first and producing a positive impact on local communities. The 'proximity economy' includes services and businesses fostering local and short value chains for mainly local production and consumption. Proximity businesses include local SMEs operating personal and contact services, small shops, bars and restaurants, repair, cleaning, and maintenance services, etc.	
Retail	Retail (large companies, SMEs, online and offline), relevant wholesale, online platforms. E-commerce represents 10-15% of total retail sales (much less for grocery retail). Market concentration differs across EU. The largest are mainly grocery chains, cosmetics, textiles, and furniture sellers. Most important e-commerce players come from outside the EU. The performance of the ecosystem is key for household budgets and suppliers.	
Tourism	In the EU, services providers at destination level (hospitality, attractions) are, in their majority, small local owners. Part of them are franchisees of a few multinational companies providing branding, marketing, management and selling services. The sector of cross-border passenger transporters is consolidating around a large operator (airlines and cruises in particular) but to a lesser extent than in the US or China. They distribute their services directly or through travel agencies.	

Source: definitions from the Annual Single Market Report 2021, European Commission (2021).

Technology definitions

The monitoring framework applies a technological lens in the analysis of industrial ecosystems whereby most of the indicators are calculated not just per ecosystem but type of green and digital technology at the same time (whenever the technology is relevant for the industrial ecosystem). Patent, Trade and Prodcom-based indicators are also calculated only per technology with the objective to provide evidence about trends in the general technological base that is underpinning the EU industry. In the table below, we indicate the overview of technologies analysed.

Figure 19: List of technologies

Digital transformation	
Basic digital	**Online platform**
	Software
Advanced digital	**Advanced Manufacturing & Robotics**
	Advanced Manufacturing (ICA and Mechanical Engineering)
	Robotics
	Artificial Intelligence
	Augmented and virtual reality
	Big Data and Cloud Computing
	Blockchain

Digital transformation	
	Digital Security & Networks/ Cybersecurity
	Internet of Things
	Micro- and Nanoelectronics & Photonics
Green transformation	
Green technologies	**Advanced Materials**
	Biotechnology
	Energy Saving Technologies
	Renewable Energy Technologies
	Solar Power
	Wind Power
	Other (geothermal, hydropower, biomass)
	Clean production technologies
	Recycling and waste management technologies
Circular business models	**Circular business models including:** Remanufacturing Renting, leasing and related service models Repair and maintenance services Resell, reuse Circular design (products that can be disassembled and recycled) Design for durability (products that can last longer)

Source: Consortium

Advanced Manufacturing Technology

Advanced Manufacturing technologies (AMTs) are broad technological bundles which support the design and fabrication of products, a higher level of connectivity, and the optimised planning of resources[43]. Overall, they improve products or processes that drive innovation in manufacturing. It covers two types of technologies: process technologies to produce other advanced technologies or manufactured products, and process technologies based on Robotics, automation technology or computer-integrated manufacturing that support the manufacturing processes. For the former, such process technology typically relates to production apparatus, equipment and procedures for the manufacture of specific materials, components, or final products. For the latter, process technology includes measuring, control and testing devices for machines, machine tools and various areas of automated or IT-based manufacturing technology[44].

Advanced Materials

Advanced Materials are materials that respond to changes to their environment and as a result, go through a material property change[45]. They reduce the substitution costs of existing materials and add higher value to products and services. They are applied in a wide variety of fields, e.g. in aerospace, transport, building and health care. They facilitate

[43] Stornelli, A., Ozcan, S. and Simms, C., 2021. Advanced manufacturing technology adoption and innovation: A systematic literature review on barriers, enablers, and innovation types. Research Policy, 50(6), p.104229.
[44] EC EISMEA/GROW (2021) Advanced Technologies for Industries – Methodological Report. Indicator Framework and Data Calculations. ISBN 978-92-9202-952-4. doi:10.2826/911991.
[45] Ryan, K.R., Down, M.P. and Banks, C.E., 2021. Future of additive manufacturing: Overview of 4D and 3D printed smart and advanced materials and their applications. Chemical Engineering Journal, 403, p.126162.

recycling, lowering the carbon footprint and energy demand as well as limiting the need for raw materials that are scarce in Europe[46].

Artificial Intelligence

Artificial intelligence (AI) systems are software (and possibly also hardware) systems designed by humans that, given a complex goal, act in the physical or digital dimension by perceiving their environment through data acquisition, interpreting the collected structured or unstructured data, reasoning on the knowledge, or processing the information, derived from this data and deciding the best action(s) to take to achieve the given goal. AI systems can either use symbolic rules or learn a numeric model, and they can also adapt their behaviour by analysing how the environment is affected by their previous actions[47]. Artificial Intelligence is a heterogenous field in terms of its technology base. While some aspects like sensors, chips, robots as well as certain applications like autonomous driving, logistics or medical instruments refer to hardware components, a relevant part of AI is rooted in algorithms and software[48].

Augmented/Virtual Reality

Augmented/Virtual Reality is an immersive technology in which users can experience all of their human senses in a prominent virtual scene in a virtual world[49]. As such, the user is able to see his/her surroundings while also seeing the AR content -Virtual reality devices place end users into a completely new reality, obscuring the view of their existing reality.

Big Data

Big Data is an Information asset of High Volume, Velocity and Variety, that require specific Technology and Analytical Methods for its transformation into Value[50]. From a technology point of view, Big Data encompasses hardware and software that integrate, organise, manage, analyse and present data. Big Data technologies are new generation of technologies and architectures, designed to economically extract value from very large volumes of a wide variety of data, by enabling high-velocity capture, discovery and/or analysis[51].

Blockchain

Blockchain is part of the broader family of Distributed Ledger Technologies (DLTs). DLTs are particular types of databases in which data is recorded, shared and synchronised across a distributed network of computers or participants. Blockchain technologies are a particular type of DLT that employs cryptographic techniques to record and synchronize data in 'chains of blocks'. All types of Blockchain are DLTs but not all DLTs are Blockchains[52]. Blockchain entails three technologies, the blockchain itself, distributed ledger technologies,

[46] EC EISMEA/GROW (2021) Advanced Technologies for Industries – Methodological Report. Indicator Framework and Data Calculations. ISBN 978-92-9202-952-4. doi:10.2826/911991.
[47] High Level Expert Group on Artificial Intelligence (AI HLEG) (2019a), A definition of AI: Main capabilities and disciplines, 8 April. In Samoili, S., López Cobo, M., Delipetrev, B., Martínez-Plumed, F., Gómez, E., and De Prato, G., AI Watch. Defining Artificial Intelligence 2.0. Towards an operational definition and taxonomy for the AI landscape, EUR 30873 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-42648-6, doi:10.2760/019901, JRC126426
[48] EC EISMEA/GROW (2021) Advanced Technologies for Industries – Methodological Report. Indicator Framework and Data Calculations. ISBN 978-92-9202-952-4. doi:10.2826/911991.
[49] Nee AYC, Ong SK, Chryssolouris G, Mourtzis D. Augmented reality applications in design and manufacturing. CIRP Ann - Manuf Technol 2012;61:657–79. https://doi.org/10.1016/j.cirp.2012.05.010
[50] De Mauro, A., Greco, M. and Grimaldi, M. (2016), "A formal definition of Big Data based on its essential features", Library Review, Vol. 65 No. 3, pp. 122-135. https://doi.org/10.1108/LR-06-2015-0061
[51] EC EISMEA/GROW (2021) Advanced Technologies for Industries – Methodological Report. Indicator Framework and Data Calculations. ISBN 978-92-9202-952-4. doi:10.2826/911991.
[52] Nascimento S., Pólvora A. , Sousa Lourenço J. (2018) #Blockchain4EU: Blockchain for Industrial Transformations, EUR 29215 EN, Publications Office of the European Union, Luxembourg, 2018, ISBN 978-92-79-85719-5 (pdf),978-92-79-85718-8 (print), doi:10.2760/204920 (online),10.2760/410134 (print), JRC111095

and smart contracts. Together they represent a fault-tolerant systems synchronising data through consensus mechanisms, able to verify - peer to peer - the correctness of such data through hash functions and values without central authorities, and executed upon some basic premises and protocols specified in digital form'[53].

Cloud computing

Cloud technologies offer a model of on-demand data storage and processing, both in centralised data centres and in distributed connected devices close to the user (at the 'edge' of the network). As cloud technologies are faster, cheaper and more flexible than conventional computing methods, many of our everyday services are based on the cloud, such as web-based email, entertainment systems, and public services including health and transportation. Whereas conventional cloud computing takes place in centralised data centres, edge computing data is processed in connected objects closer to the users. This allows for much faster operations and gives users more control over their data[54].

Biotechnology

Biotechnology is the application of biotechnology for the industrial processing and production of chemicals, materials and fuels. It relies on manipulating and growing bacteria, yeast, and filamentous fungi[55] to generate industrially useful products in a more efficient way (e.g. less energy use or less by-products), or generate substances and chemical building blocks with specific capabilities that conventional petrochemical processes cannot provide. There are many examples of such bio-based products already on the market. The most mature applications are related to enzymes used in the food, feed and detergents sectors. More recent applications include the production of biochemicals and biopolymers from agricultural or forest wastes[56].

Internet of Things (IoT)

The Internet of Things is a dynamic global network infrastructure with self-configuring capabilities based on standard and interoperable communication protocols, where physical and virtual 'things' have identities, physical attributes and virtual personalities and use intelligent interfaces and are seamlessly integrated into the information network[57]. The Internet of Things (IoT) refers to the network of smart, interconnected devices and services that are capable of sensing or even listening to requests. IoT is an aggregation of endpoints that are uniquely identifiable and that communicate bi-directionally over a network using some form of automated connectivity. Objects become interconnected, make themselves recognisable and acquire intelligence in the sense that they can communicate information about themselves and access information that has been provided by another source. The Internet of Things relies on networked sensors to remotely connect, track and manage products, systems and grids. The Industrial Internet of Things (IIoT) – a subset of the larger Internet of Things – focuses on the specialised requirements of industrial applications, such as manufacturing, oil and gas, and utilities. IIoT systems connect non-consumer devices, used by companies, governments and utility providers in their service delivery[58].

[53] Borbon-Galvez, et. Al. (2020) Secured by Blockchain. Deliverable WP1 (DR1_2020_01_20). Accessed 12/10/2022 https://www.liucbs.it/ricerca-applicata-e-advisory/progetti/secured-by-blockchain/

[54] EC (2022). Cloud and Edge Computing: a different way of using IT — Brochure. Accessed 12/10/2022. https://digital-strategy.ec.europa.eu/en/library/cloud-and-edge-computing-different-way-using-it-brochure#Future

[55] Nielsen, J., Tillegreen, C.B. and Petranovic, D., 2022. Innovation trends in industrial biotechnology. Trends in Biotechnology. https://doi.org/10.1016/j.tibtech.2022.03.007

[56] EC EISMEA/GROW (2021) Advanced Technologies for Industries – Methodological Report. Indicator Framework and Data Calculations. ISBN 978-92-9202-952-4. doi:10.2826/911991.

[57] European Commission, Directorate-General for Communications Networks, Content and Technology, Cross-cutting business models for IoT : final report, Publications Office, 2018,

[58] EC EISMEA/GROW (2021) Advanced Technologies for Industries – Methodological Report. Indicator Framework and Data Calculations. ISBN 978-92-9202-952-4. doi:10.2826/911991.

Micro- and Nanoelectronics

Micro- and Nanoelectronics deal with semiconductor components and highly miniaturised electronic subsystems and their integration in larger products and systems. They include the fabrication, the design, the packaging and testing from nano-scale transistors to micro-scale systems integrating multiple functions on a chip[59].

Nanotechnology

Nanotechnology is the term given to those areas of science and engineering where phenomena that take place at dimensions in the nanometre scale are utilised in the design, characterisation, production and application of materials, structures, devices and systems. It has only been in the last quarter of a century that it has been possible to actively and intentionally modify molecules and structures within this size range. It is this control at the nanometre scale that distinguishes nanotechnology from other areas of technology[60]. Nanotechnology holds the promise of leading to the development of smart nano and micro devices and systems and to radical breakthroughs in vital fields such as healthcare, energy, environment and manufacturing.

Photonics

Photonics includes the sciences and techniques that generate, emit, detect, collect, transmit, modulate, amplify photon beams, from the terahertz band (min: 200 Gigahertz) to X-rays. Photonic based projects target the development of photonics core technologies as well as the development of whole products and systems based on photonic components. These photonic technologies are applied in multiple areas, among the most important ones are: personalised healthcare, industry 4.0, smart cities, homes, grid and digital infrastructures, secure digital society, environment and sustainability, frontier research equipment, connected mobility, space and defence, smart farming and food production, knowledge transfer and smart learning, etc[61].

Robotics

Robotics, a domain of technology that produces programmable machines. It is a technology that encompasses the design, building, implementation and operation of robots. Robotics is often organised into three categories: 1) Application specific. This includes Robotics designed to conduct a specific task or series of tasks for commercial purposes. These robots may be stationary or mobile but are limited in function as defined by the intended application. 2) Multipurpose. Multipurpose robots are capable of performing a variety of functions and movements determined by a user that programs the robot for tasks, movement, range and other functions and that may change the effector based on the required task. These robots function autonomously within the parameters of their programming to conduct tasks for commercial applications and may be fixed, 'moveable' or mobile. 3) Cognitive. Cognitive robots are capable of decision making and reason, which allows them to function within a complex environment. These robots can learn and make decisions to support optimal function and performance and are designed for commercial applications. When measuring production and uptake of Robotics, industrial applications were taken into account[62].

Digital tech for Security/ Cybersecurity

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[59] Idem.
[60] Allan J., Ferreri A., Grande S., Giannantonio R., Matteucci F., Technology Transfer in Nanotechnology, EUR 29686 EN, Publication Office of the European Union, Luxembourg, 2019, ISBN 978-92-76-00671-8, doi:10.2760/183529, JRC115968
[61] Photonics21 (2017) Photonics – a critical Key Enabling Technology for Europe. Access 13/10/2022.
[62] EC EISMEA/GROW (2021) Advanced Technologies for Industries – Methodological Report. Indicator Framework and Data Calculations. ISBN 978-92-9202-952-4. doi:10.2826/911991.

'Cybersecurity' are activities necessary to protect network and information systems, the users of such systems, and other persons affected by cyber threats, whilst 'cybersecurity products and solutions' means ICT products, services or process with the specific purpose of protecting network and information systems, their users and affected persons from cyber threats[63]. Cybersecurity products are tools designed using a wide variety of technologies to enhance the security of an organisation's networking infrastructure — including computers, information systems, internet communications, networks, transactions, personal devices, mainframe and the cloud — as well as help provide advanced value-added services and capabilities. Cybersecurity products are utilised to provide confidentiality, integrity, privacy and assurance. Through the use of security applications, organisations are able to provide security management, access control, authentication, malware protection, encryption, data loss prevention (DLP), intrusion detection and prevention (IDP), vulnerability assessment (VA) and perimeter defense, among other capabilities[64].

Energy saving technologies

Energy-saving technologies at industrial level are systems, machinery, drives, thermal systems, combustion or electrical systems, or industrial design features of the production processes or operations that increase the energy efficiency of buildings, transport and production processes[65].

Renewable energy technologies

Renewable energy technologies are converters of Earth's ecosystem energy into energy products. Examples of energy technologies included are biomass, wind, solar, hydropower, geothermal, marine energies converters. Energy products include electricity, heat, hydrocarbons, steam, methanol, bio-oils, biodiesel, charcoal, cold, light, movement (power), ventilation, etc. [66]

Clean production technologies

The UN[67] defines clean production as the continuous application of an integrated preventive environmental strategy applied to processes, products, and services to increase overall efficiency and reduce risks to humans and the environment. Clean production technologies create products with less environmental impact and focus on the reduction of the use of natural resources. In this project, technologies that aim at reducing the creation of waste, or the use of water and raw materials have been taken into account.

Recycling and waste management technologies

Recycling technology means a specific combination of physical and chemical concepts, principles, and practices to recycle a waste stream of a certain type and collected in a certain way into recycled plastic materials and articles of a specific type and with a specific intended use and includes a decontamination technology[68].

Circular business models

As defined by the OECD (2019)[69] circular business models serve to reduce the extraction and use of natural resources and the generation of industrial and consumer wastes. They

[63] European Commission (2019). Proposal for a Regulation of the European Parliament and of the Council Establishing the European Cybersecurity Industrial, Technology and Research Competence Centre and the Network of National Coordination Centres, COM(2018) 630 Final, 9 December 2018c.
[64] EC EISMEA/GROW (2021) Advanced Technologies for Industries – Methodological Report. Indicator Framework and Data Calculations. ISBN 978-92-9202-952-4. doi:10.2826/911991.
[65] Löschel, A., Lutz, B.J. and Massier, P., 2017. Credit constraints, energy management practices, and investments in energy saving technologies: German manufacturing in close-up. ZEW, Zentrum für Europäische Wirtschaftsforschung GmbH.
[66] Turkenburg, et. Al. (2015) Renewable Energy Technologies. In UNPD, UNDESA, and WEC. World Energy Assessment. Energy and the challenges of sustainability. UNPD. Accessed 14/10/2022
[67] https://www.unep.org/resources/report/environmental-agreements-and-cleaner-production
[68] https://www.lawinsider.com/dictionary/recycling-technology
[69] OECD (2019). Business Models for the Circular Economy Opportunities and Challenges from a Policy Perspective

represent the key activities required to transition to a more resource efficient and circular economy. Key circular business models that are monitored in this project include:

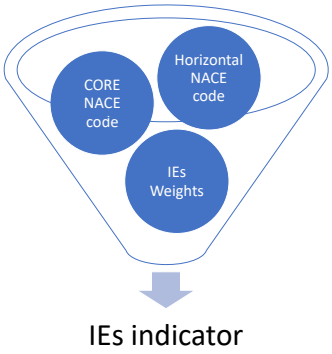
- Remanufacturing
- Renting, leasing and related service models
- Repair and maintenance services
- Resell, reuse
- Circular design (products that can be disassembled and recycled)
- Design for durability (products that can last longer)

10 Appendix B: Industrial ecosystem calculations

The estimation of the industrial ecosystem (IE) data followed the definition of the 2021 Annual Single Market report. Each IE has different NACE core divisions, and horizontal divisions. Core divisions are unique to each IE, and horizontal are Divisions with contributions to all IEs. Each Nace division contribute to each IEs in different degrees, due to the importance of the division for the IEs in terms of value added, employment generation, and overall business activities.

An example of IE's core divisions, in the case of the Aerospace and Defece (ASD), indicates there are nine NACE rev 2 core divisions (see table below), and other set of horizontal divisions contributing to ASD as well as other IEs (see below).

Figure 20 Industrial Ecosystems indicators estimation process



Source: Consortium

The estimation of the IEs indicators implied aggregating each IEs' division weighted value as follows.

Eq1)

$$\sum_{IE}(Core\ division\ value * IEs'core\ division\ weight) + (Horizontal\ division\ value * horisonal\ division\ weight)$$

As an example, the ASD indicators were estimated as follows,

Eq2)

$$ASD\ IE\ Indicator = \sum_{ASD} (C25\ value * 0.03 + C26\ value * 0.44 + C27\ value * 0.23 + C30\ value * 0.68 + C33\ value * 0.09 + H51\ value * 0.09 + H52\ value * 0.18 + J61\ value * 0.07 + N80\ value * 1) + (C25 * 0.0674 + C28\ 0.079 + C33 * 0.0776 + E36 * 0.0174 + ((E37 + E38 + E39) * 0.0274) + ((M69 + M70) * 0.025) + M71 * 0.0337 + M72 * 0.0565 + ((N77 + N78) * 0.271))$$

Figure 21: Contribution of NACE Rev 2 divisions core to the ASD

Division NACE Code	Division name	Weight for the ASD
C25	Manufacture of fabricated metal products, except machinery and equipment	0.03
C26	Manufacture of computer, electronic and optical products	0.44
C27	Manufacture of electrical equipment	0.23
C30	Manufacture of other transport equipment	0.68
C33	Repair and installation of machinery and equipment	0.09
H51	Air transport	0.09
H52	Warehousing and support activities for transportation	0.18
J61	Telecommunications	0.07
N80	Security and investigation activities	1

Source: Consortium

Figure 22: Contribution of NACE Rev 2 horizontal divisions to the ASD

NACE rev 2 division	Wieght for the ASD
C25	6.74%
C28	6.79%
C33	7.76%
E36	1.74%
E37-E39	2.74%
M69_M70	2.50%
M71	3.37%
M72	5.65%
N77_N78	2.71%

Source: Consortium

Estimating IEs indicators requires data disaggregated either at NACE division or more disaggregated data (group level) with complete information for the division. This aggregation was possible for a set of indicators, whilst for other indicators such as LinkedIn data, this is not possible. The table below lists the indicators with IEs level estimates applying the weighted approach.

Figure 23: Industrial Ecosystem Indicators level estimates

EMI Data Set	IEs estimate weighted	IEs estimate unweighted	Excluded IEs
Enviornmental data	✓		
Prodcom	✓		
Performance: Trade	✓		
Investment Startup		✓	
Investment venture capital		✓	

EMI Data Set	IEs estimate weighted	IEs estimate unweighted	Excluded IEs
Investment FDI		✓	
Imvestment Procurement (TED)		✓	
Investment and funding (Corda)		✓	
Skills – LinkedIn		✓	
Skills - OVATE - CEDEFOP		✓	
Patent data		✓	CCI, PSE, Retail,Tourism
Big Data	✓	✓	
Survey		✓	Digital, RES

Source: Consortium

11 Appendix C: Industrial Ecosystem coverage by source

This appendix includes tables indicating the coverage of each industrial ecosystem by data source (i.e. Patent, Crunchbase/Netzero, LinkedIn, CORDA, TED, FDI, UNComtrade, SkillsOvate).

Figure 24 IE - Cruncbase & Netzero

IE	NACE_rev2	Description	Scope
Aerospace & Defence	C25	Manufacture of fabricated metal products, except machinery and equipment	
	C26	Manufacture of computer, electronic and optical products	x
	C27*	Manufacture of electrical equipment	
	C30	Manufacture of other transport equipment	x
	C33	Repair and installation of machinery and equipment	
	H51	Air transport	x
	H52*	Warehousing and support activities for transportation	
	J61	Telecommunications	x
	N80	Security and investigation activities	x
Agri-food	A	Agriculture, forestry and fishing	x
	C10	Manufacture of food products	x
	C11	Manufacture of beverages	x
	C12	Manufacture of tobacco products	x
Construction	C31	Manufacture of furniture	
	F	Construction	x
	M71	Architectural and engineering activities; technical testing and analysis	x
	N81	Services to buildings and landscape activities	x
Cultural and Creative Industries	C18	Printing and reproduction of recorded media	x
	C32	Other manufacturing	
	G47*	Retail trade, except of motor vehicles and motorcycles	
	J58	Publishing activities	x
	J59	Motion picture, video and television programme production, sound recording and music publishing activities	x
	J60	Programming and broadcasting activities	x
	J62_63	Computer programming, consultancy and related activities;	x
	M71	Architectural and engineering activities; technical testing and analysis	x
	M73	Advertising and market research	
	M74_M75	Other professional, scientific and technical activities and veterinary activities	x
	N77	Rental and leasing activities	
	P85	Education	
	R90-R92	Creative, arts and entertainment activities; libraries, archives, museums and other cultural activities; gambling and betting activities	x

IE	NACE_rev2	Description	Scope
	S94	Activities of membership organisations	
	S95	Repair of computers and personal and household goods	
Digital	C26*	Manufacture of computer, electronic and optical products	
	J58	Publishing activities	
	J61	Telecommunications	
	J62	Computer programming, consultancy and related activities	
	J63	Information service activities	
	S95	Repair of computers and personal and household goods	
Electronics	C26	Manufacture of computer, electronic and optical products	x
	C28	Manufacture of machinery and equipment n.e.c.	
Energy - Renewables	C27*	Manufacture of electrical equipment	
	D35	Electricity, gas, steam and air conditioning supply	x
Energy Intensive Industries	C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	x
	C17	Manufacture of paper and paper products	x
	C19	Manufacture of coke and refined petroleum products	
	C20	Manufacture of chemicals and chemical products	x
	C22	Manufacture of rubber and plastic products	x
	C23	Manufacture of other non-metallic mineral products	x
	C24	Manufacture of basic metals	x
Health	C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	x
	C33	Manufacture of medical and surgical equipment and orthopaedic appliances	x
	C32	Other manufacturing	
	Q86	Human health activities	x
	Q87_Q88	Residential care activities and social work activities without accommodation	x
Mobility - Transport - Automotive	C27	Manufacture of electrical equipment	
	C29	Manufacture of motor vehicles, trailers and semi-trailers	x
	C30	Manufacture of other transport equipment	x
	G45	Wholesale and retail trade and repair of motor vehicles and motorcycles	
	H49	Land transport and transport via pipelines	x
	H50	Water transport	
	H52	Warehousing and support activities for transportation	
Proximity, Social Economy and Civil Security	G47*	Retail trade, except of motor vehicles and motorcycles	
	I	Accommodation and food service activities	
	L	Real estate activities	
	N81	Services to buildings and landscape activities	
	N82	Office administrative, office support and other business support activities	
	Q87_Q88	Residential care activities and social work activities without accommodation	
	S95	Repair of computers and personal and household goods	
	S96	Other personal service activities	
	T	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use	
Retail	G46	Wholesale trade, except of motor vehicles and motorcycles	x
	G47	Retail trade, except of motor vehicles and motorcycles	x
	H53	Postal and courier activities	x
Textile	C13	Manufacture of textiles	x
	C14	Manufacture of wearing apparel	x
	C15	Manufacture of leather and related products	x
Tourism	H49	Land transport and transport via pipeline	
	H50	Water transport	
	H51	Air transport	x
	I	Accommodation and food service activities	x
Tourism	N79	Travel agency, tour operator and other reservation service and related activitieS	x
	N82	Office administrative, office support and other business support activities	
	R90-R92	Creative, arts and entertainment activities; libraries, archives, museums and other cultural activities; gambling and betting activities	x
	R93	Sports activities and amusement and recreation activities	x

Source: Consortium

As explained in section 4.1, Crunchbase and NetZero Insights classify their data through a tagging taxonomy that includes industry tags as well as tags related to technologies (AI, Blockchain, etc). Figure 22 below provides an overview of the matching that has been done between the studied industrial ecosystems and the tags available in Crunchbase and Net Zero Insights, in collaboration with the experts of each industrial ecosystem. To overcome the limitations of the tagging taxonomy, and in order to capture all industrial segments of each ecosystem, the project team also used keywords to further scrape relevant companies.

Figure 25 Tags and keywords matched by industrial ecosystem in Crunchbase and Net Zero Insights

IE	Industry tags in Crunchbase	Industry tags in Net Zero Insights	Keywords used to text-mine in companies' description
Aerospace & Defence	Aerospace, Space Travel, Satellite communication, Military, National Security, Geospatial, GPS, Location Based Services, Mapping Services, Navigation, Drones	*Through keywords*	Aerospace, Space Travel, Satellite communication, Military, National Security, Drones, Geospatial, GPS, Location Based Services, Mapping Services, Navigation, defence, aeronautic, navigation, air traffic, space traffic, earth observation, Launchers, Space Industry, Defence Industry, Aeronautics, Chemical Biological Radiological Nuclear, Unmanned Air Systems, Space Situational Awareness, Space Command and Control, Geostationary Equatorial Orbit, Low Earth Orbit, ballistic missile, Maritime surveillance, radars, strike capabilities, Ground combat, Air combat, Defence capabilities, Defence technologies, space intelligence, Space Assets, Avionics, spacecraft, orbit sensors, EGNOS, Copernicus & Galileo, Geostationary Orbit, Orbit Data Centres, flight management, airframe, airline operations, hybrid-elecric turboprop.
Agri-Food	Agriculture and Farming: Agriculture, AgTech, Animal Feed, Aquaculture, Farming, Horticulture, Hydroponics, Livestock, Food and Beverage: Bakery, Brewing, Catering, Coffee, Confectionery, Craft Beer, Dietary Supplements, Distillery, Farmers Market, Food and Beverage, Food Delivery, Food Processing, Food Trucks, Fruit, Grocery, Nutrition, Organic Food, Seafood, Snack Food, Tea, Tobacco, Wine And Spirits, Winery, Restaurants	Precision Agriculture, Food and Beverage, Vertical Farming, Agriculture	N/A
Construction	Architecture, Building Maintenance, Construction, Green Building, Smart Building, Civil Engineering,	Construction, Green building, Built environment	N/A

IE	Industry tags in Crunchbase	Industry tags in Net Zero Insights	Keywords used to text-mine in companies' description
	facility management, home renovation, interior design, landscaping, home improvement, home services, janitorial service, electrical distribution		
Creative & Cultural Industries	Architecture, Advertising, Video Games, Music, Internet radio, News, Journalism, Printing, Publishing, Audiobooks, E-books, Photography, Performing arts, Theatre, Arts, Design, Film, Film production, Film distribution, Museums and historical sites, Independent music, Music label, Music streaming, Music venues, Musical instruments, Gamification, TV, TV production	*Not used*	N/A
Digital	Artificial Intelligence, Big Data, Internet of Things, Robotics, Blockchain, Augmented Reality, Virtual Reality, Cloud technologies	*Not used*	N/A
Electronics	Semiconductor, Electronics, Electronic design automation	Sensor + keywords	Semiconductor, semiconductor material, organic electronic, biobased electronic, print electronic, nanochip, microchip, chip tech, silicon chip, Lidar,
Energy Intensive Industries	Chemicals, Paper Manufacturing, Plastics and Rubber Manufacturing, Mineral, Mining, Mining Technology, Wood Processing, Building material	Chemical, Steel, Manufacture of Iron and steel	Steel, Iron, Alluminium, Metal
Healthcare	Health Care, Pharmaceuticals, Medical devices, Alternative Medicine, Assisted Living, Assistive Technology, Biopharma, Clinical Trials, Cosmetic Surgery, Dental, Diabetes, Dietary Supplements, Electronic Health Record (EHR), Emergency Medicine, Fertility, First Aid, Genetics, Health Care, Health Diagnostics, Home Health Care, Hospital, Medical, Medical Device, mHealth, Nursing and Residential Care, Nutraceutical, Outpatient Care, Personal Health, Pharmaceutical, Psychology, Rehabilitation, Therapeutics	*Not used*	N/A
Mobility, Transport & Automotive	Automotive, Autonomous Vehicles, Car Sharing, Electric Vehicle, Recreational Vehicles, Ride Sharing, Transportation	Electric vehicle Autonomous vehicle Shared mobility Mobility	
Proximity & Social Economy	Green consumer goods, Charity, collaborative consumption, homeless shelter, non profit, Sharing economy, social bookmarking, social impact, social recruiting, Recycling, Pollution control, Social, Social Entrepreneurship, Social Shopping	*Not used*	N/A
Renewable Energy	Renewable Energy, Solar, Wind Energy, Clean Energy, Energy Storage, Energy Management, Biofuel, Biomass Energy, Cleantech,	Maritime, Fuels, Electricity, Heating, Bioeconomy, Sustainable Aviation Fuels (SAFs), Ocean	N/A

IE	Industry tags in Crunchbase	Industry tags in Net Zero Insights	Keywords used to text-mine in companies' description
		energy, Offshore energy	
Retail	Retail, Retail Technology, E-commerce, E-commerce Platforms, Marketplace, Shopping, Point of Sale, Personalisation, Wholesale, Warehousing and Mobile Payments (including retail, customer, business and payment within their description)	*Through keywords*	B2C, B2B Clothing, commerce platform, e-commerce, ecommerce, fashion, food, furniture, grocer, Marketplace, online payment, online retailer, pay later, payment enabler, recommerce, retail, shopping, supermarket
Textiles	Textiles, Fashion, Lingerie, Shoes	Textile and Fashion, Logistics	Textile, Apparel, Clothing, Cotton, yarn, fabric, leather, linens, garment, Fiber, Biofiber, Fiber, weaving, bioopolymer, dyeing, filament, polyester, knitting, enzymes
Tourism	Hotel, Travel Accommodations, Hospitality, Vacation Rental, Restaurants Travel arrangement and reservation services Travel Agency, Adventure Travel, Business Travel, Hospitality, Tour Operator, Sports, Amusement Park Museums and Historical Sites, Parks, Resorts, Casino Public Transportation, Railroad, Marine Transportation, Air Transportation	sustainable aviation, food waste + keywords	hospitality provider, hospitality industry, hotel, vacation rental, Business travel, tourism, museum, accommodation marketplace, casino, travel agency, travel agent, tour operator, Resorts, Adventure travel, travel industry, Amusement Park, theme park air transportation, aviation company and airline Restaurant, food service, bar, food delivery.

Source: Consortium

Figure 26 IE – LinkedIn

IE	NACE_rev2	NACE_rev2_labels	LinkedIn
Aerospace & Defence	C25	Manufacture of fabricated metal products, except machinery and equipment	Aviation and Aerospace, Defense and Space
Aerospace & Defence	C26	Manufacture of computer, electronic and optical products	Aviation and Aerospace, Defense and Space
Aerospace & Defence	C27*	Manufacture of electrical equipment	Aviation and Aerospace, Defense and Space
Aerospace & Defence	C30	Manufacture of other transport equipment	Aviation and Aerospace, Defense and Space
Aerospace & Defence	C33.1	Repair and installation of machinery and equipment	
Aerospace & Defence	H51	Air transport	Aviation and Aerospace, Defense and Space
Aerospace & Defence	H52*	Warehousing and support activities for transportation	
Aerospace & Defence	J61	Telecommunications	
Aerospace & Defence	N80	Security and investigation activities	Defense and Space
Agri-food	A	Agriculture, forestry and fishing	Ranching, Fishery, Farming
Agri-food	C10	Manufacture of food products	Food & Beverages, Food Production, Dairy
Agri-food	C11	Manufacture of beverages	Food & Beverages, Wine & Spirits
Agri-food	C12	Manufacture of tobacco products	
Construction	C31	Manufacture of furniture	
Construction	F	Construction	Construction
Construction	M71	Architectural and engineering activities; technical testing and analysis	Architecture & Planning,
Construction	N81	Services to buildings and landscape activities	Civil engineering
Cultural and Creative Industries	C18	Printing and reproduction of recorded media	Music, Design, Computer Games
Cultural and Creative Industries	C32	Other manufacturing	
Cultural and Creative Industries	G47*	Retail trade, except of motor vehicles and motorcycles	
Cultural and Creative Industries	J58	Publishing activities	Publishing, Writing & Editing, Online Media, Newspaper
Cultural and Creative Industries	J59	Motion picture, video and television programme production, sound recording and music publishing activities	Motion Pictures & Film
Cultural and Creative Industries	J60	Programming and broadcasting activities	Broadcast Media,
Cultural and Creative Industries	J62_63	Computer programming, consultancy and related activities;	
Cultural and Creative Industries	M71	Architectural and engineering activities; technical testing and analysis	Architecture & Planning,
Cultural and Creative Industries	M73	Advertising and market research	Marketing & Advertising,
Cultural and Creative Industries	M74_M75	Other professional, scientific and technical activities and veterinary activities	
Cultural and Creative Industries	N77	Rental and leasing activities	

IE	NACE_rev2	NACE_rev2_labels	LinkedIn
Cultural and Creative Industries	P85	Education	
Cultural and Creative Industries	R90-R92	Creative, arts and entertainment activities; libraries, archives, museums and other cultural activities; gambling and betting activities	Museums, Performing Arts, Fine Art, Arts & Crafts
Cultural and Creative Industries	S94	Activities of membership organisations	
Cultural and Creative Industries	S95	Repair of computers and personal and household goods	
Digital	C26*	Manufacture of computer, electronic and optical products	
Digital	J58	Publishing activities	
Digital	J61	Telecommunications	
Digital	J62	Computer programming, consultancy and related activities	
Digital	J63	Information service activities	
Digital	S95	Repair of computers and personal and household goods	
Electronics	C26	Manufacture of computer, electronic and optical products	Electronics, Semiconductors
Electronics	C28	Manufacture of machinery and equipment n.e.c.	
Energy - Renewables	C27*	Manufacture of electrical equipment	
Energy - Renewables	D35	Electricity, gas, steam and air conditioning supply	
Energy Intensive Industries	C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	Paper & Forest Products
Energy Intensive Industries	C17	Manufacture of paper and paper products	Paper & Forest Products
Energy Intensive Industries	C19	Manufacture of coke and refined petroleum products	
Energy Intensive Industries	C20	Manufacture of chemicals and chemical products	Chemicals
Energy Intensive Industries	C22	Manufacture of rubber and plastic products	Plastics
Energy Intensive Industries	C23	Manufacture of other non-metallic mineral products	Mining & Metals, Glass, Ceramics & Concrete
Energy Intensive Industries	C24	Manufacture of basic metals	Mining & Metals
Health	C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	Pharmaceuticals
Health	C33	Manufacture of medical and surgical equipment and orthopaedic appliances	Medical devices
Health	C32	Other manufacturing	
Health	Q86	Human health activities	Hospital and Healthcare
Health	Q87_Q88	Residential care activities and social work activities without accommodation	Hospital and Healthcare
Mobility - Transport - Automotive	C27	Manufacture of electrical equipment	
Mobility - Transport - Automotive	C29	Manufacture of motor vehicles, trailers and semi-trailers	Automotive

IE	NACE_rev2	NACE_rev2_labels	LinkedIn
Mobility - Transport - Automotive	C30	Manufacture of other transport equipment	Shipbuilding
Mobility - Transport - Automotive	G45	Wholesale and retail trade and repair of motor vehicles and motorcycles	
Mobility - Transport - Automotive	H49	Land transport and transport via pipelines	Transportation/Trucking/Railroad
Mobility - Transport - Automotive	H50	Water transport	Transportation/Trucking/Railroad
Mobility - Transport - Automotive	H52	Warehousing and support activities for transportation	
Proximity, Social Economy and Civil Security	G47*	Retail trade, except of motor vehicles and motorcycles	
Proximity, Social Economy and Civil Security	I	Accommodation and food service activities	
Proximity, Social Economy and Civil Security	L	Real estate activities	
Proximity, Social Economy and Civil Security	N81	Services to buildings and landscape activities	
Proximity, Social Economy and Civil Security	N82	Office administrative, office support and other business support activities	
Proximity, Social Economy and Civil Security	Q87_Q88	Residential care activities and social work activities without accommodation	Civic & Social Organisation, Environmental Services, Non-profit Organisation Management
Proximity, Social Economy and Civil Security	S95	Repair of computers and personal and household goods	
Proximity, Social Economy and Civil Security	S96	Other personal service activities	
Proximity, Social Economy and Civil Security	T	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use	
Retail	G46	Wholesale trade, except of motor vehicles and motorcycles	Wholesale
Retail	G47	Retail trade, except of motor vehicles and motorcycles	Retail
Retail	H53	Postal and courier activities	
Textile	C13	Manufacture of textiles	Textiles
Textile	C14	Manufacture of wearing apparel	Apparel & Fashion

IE	NACE_rev2	NACE_rev2_labels	LinkedIn
Textile	C15	Manufacture of leather and related products	
Tourism	H49	Land transport and transport via pipeline	Transportation
Tourism	H50	Water transport	Transportation
Tourism	H51	Air transport	Transportation
Tourism	I	Accommodation and food service activities	Hospitality, Restaurants,
Tourism	N79	Travel agency, tour operator and other reservation service and related activitieS	Leisure, Travel & Tourism,
Tourism	N82	Office administrative, office support and other business support activities	
Tourism	R90-R92	Creative, arts and entertainment activities; libraries, archives, museums and other cultural activities; gambling and betting activities	Museums & Institutions, Gambling & Casinos, Leisure, Travel & Tourism,
Tourism	R93	Sports activities and amusement and recreation activities	Recreational Facilities & Services

Source: Consortium

Figure 27 IE - Corda

IE	Keywords
Tourism	vacation, hospitality, air transport & tourism, restaurants, wheelchair access*, disabled guest*, culture, transport & tourism, tourism
Aerospace & Defence	aerospace, military, defence, aeronautic, navigation, air traffic, space traffic, earth observation, Launchers, Space Industry, Defence Industry, Aeronautics, Chemical Biological Radiological Nuclear, Unmanned Air Systems, Space Situational Awareness, Space Command and Control, Geostationary Equatorial Orbit, Low Earth Orbit, ballistic missile, Maritime surveillance, radars, strike capabilities, Ground combat, Air combat, Defence capabilities, Defence technologies, space intelligence, Space Assets, Avionics, spacecraft, orbit sensors, EGNOS, Copernicus & Galileo, Geostationary Orbit, Orbit Data Centres, flight management, airframe, airline operations, hybrid-elecric turboprop
Agri-food	fisheries, food safety, animal husbandry, plant protection, fruit growing, nutrition, vegetable growing, horticulture, agriculture, legumes, cereals, animal feed, viticulture, food technology, food packaging, oilseeds
Construction	architecture, building, building maintenance, construction, green building, smart building, civil engineering, facility management, home renovation, interior design, landscaping, home improvement, home services, janitorial service, electrical distribution
Cultural and Creative Industries	video games, Music cinematography, Journalism, arts, radio and television
Electronics	Semicondutivity, electrical engineering, electromagnetism and electronics, lab on a chip, organ on a chip
Energy - Renewables	Renewable Energy, Solar power, solar energy, Wind power, electric batteries, electric power, fuel cells, hydrogen energy, electric energy, Biofuel, Biomass, photovolatics
Energy Intensive Industries	Chemicals, Paper Manufacturing, Plastics and Rubber Manufacturing, Mineral, Mining, Mining Technology, Wood Processing, Building material, Mining and mineral processing, metalurgy, ceramics, woodworking, industrial crops
Health	Health care services, vaccines, virology, mortality, infectious disease, immunisation, organ on a chip, public health, cancer, nanomedicine, surgery, alzheimer, drug discovery, disease, physiotherapy, Pharmaceutical, personalized medicine, eHealth, diabetes, allergy, radiology, parkinsons, stroke, surgical procedures, orthopaedics, fetal medicine, hematology, cardiovascular diseases, pharmacokinetics, toxicology, antibiotic resistance, bone, muscular, glaucoma
Mobility - Transport - Automotive	Public Transport, intelligent transport systems, autonomous vehicles, electric vehicles, freight transport, automotice engineering
Proximity, Social Economy and Civil Security	n.a.
Retail	
Textile	textile , apparel, clothing, cotton, yarn, leather, textile machinery, shoe, embroidery, Fiber, Biofiber, weaving, polymer, biopolymer, dyeing, filament, polyester, knitting, enzymes, textile, apparel, clothing, cotton, yarn, leather, textile machinery, shoe, embroidery

Source: Consortium

Notes: Blank cells represent industrial ecosystems for which the analysis was not conducted.

Figure 28 IE - Tenders Electronic Daily

IE	CPV Codes
Tourism	55100000-1, 55110000-4, 55120000-7, 55130000-0, 55200000-2, 55210000-5, 55220000-8, 55221000-5, 55240000-4, 55241000-1, 55242000-8, 55243000-5, 55250000-7, 55260000-0, 55270000-3, 55300000-3, 55310000-6, 55311000-3, 55312000-0, 55320000-9, 55321000-6, 55322000-3, 55330000-2, 55400000-4, 55410000-7, 55500000-5, 55510000-8, 55511000-5, 55512000-2, 55520000-1, 55521000-8, 55521100-9, 55521200-0, 55522000-5, 55523000-2, 55523100-3, 55524000-9, 63510000-7, 63511000-4, 63512000-1, 63513000-8, 63514000-5, 63515000-2, 63516000-9, 79995000-5, 79995100-6, 79995200-7, 92300000-4, 92310000-7, 92311000-4, 92312000-1, 92312100-2, 92312110-5, 92312120-8, 92312130-1, 92312140-4, 92312200-3, 92312210-6, 92312211-3, 92312212-0, 92312213-7, 92312220-9, 92312230-2, 92312240-5, 92312250-8, 92312251-5, 92320000-0, 92330000-3, 92331000-0, 92331100-1, 92331200-2, 92331210-5, 92332000-7, 92340000-6, 92341000-3, 92342000-0, 92342100-1, 92342200-2, 92350000-9, 92351000-6, 92351100-7, 92351200-8, 92352000-3, 92352100-4, 92352200-5, 92360000-2, 92370000-5, 92500000-6, 92510000-9, 92511000-6, 92512000-3, 92512100-4, 92520000-2, 92521000-9, 92521100-0, 92521200-1, 92521210-4, 92521220-7, 92522000-6, 92522100-7, 92522200-8, 92530000-5, 92531000-2, 92532000-9, 92533000-6, 92534000-3, 92600000-7, 92610000-0, 92620000-3, 92621000-0, 92622000-7, 98340000-8, 98341000-5, 98341100-6, 98341110-9, 98341120-2, 98341130-5, 98341140-8, 98342000-2
Aerospace & Defence	09131000-6, 09131100-7, 34700000-4, 34700000-4, 34710000-7, 34711000-4, 34711100-5, 34711200-6, 34711300-7, 34711400-8, 34711500-9, 34712000-1, 34712100-2, 34712200-3, 34712300-4, 34720000-0, 34721000-7, 34721100-8, 34722000-4, 34722100-5, 34722200-6, 34730000-3, 34731000-0, 34731100-1, 34731200-2, 34731300-3, 34731400-4, 34731500-5, 34731600-6, 34731700-7, 34731800-8, 34740000-6, 34741000-3, 34741100-4, 34741200-5, 34741300-6, 34741400-7, 34741500-8, 34741600-9, 34960000-4, 34960000-4, 34961000-1, 34961100-2, 34962000-8, 34962100-9, 34962200-0, 34962210-3, 34962220-6, 34962230-9, 34963000-5, 34964000-2, 34965000-9, 34966000-6, 34966100-7, 34966200-8, 34967000-3, 34968000-0, 34968100-1, 34968200-2, 34969000-7, 34969100-8, 34969200-9, 34995000-8, 34997100-3, 34997200-4, 34999200-8, 34999300-9, 34999400-0, 34999410-3, 35000000-4, 35100000-5, 35110000-8, 35111000-5, 35111100-6, 35111200-7, 35111300-8, 35111310-1, 35111320-4, 35111400-9, 35111500-0, 35111510-3, 35111520-6, 35112000-2, 35112100-3, 35112200-4, 35112300-5, 35113000-9, 35113100-0, 35113110-0, 35113200-1, 35113210-4, 35113300-2, 35113400-3, 35113410-6, 35113420-9, 35113430-2, 35113440-5, 35113450-8, 35113460-1, 35113470-4, 35113480-7, 35113490-0, 35120000-1, 35121000-8, 35121100-9, 35121200-0, 35121300-1, 35121400-2, 35121500-3, 35121600-4, 35121700-5, 35121800-6, 35121900-7, 35123000-2, 35123100-3, 35123200-4, 35123300-5, 35123400-6, 35123500-7, 35124000-9, 35125000-6, 35125100-7, 35125110-0, 35125200-8, 35125300-2, 35126000-3, 35200000-6, 35210000-9, 35220000-2, 35221000-9, 35230000-5, 35240000-8, 35250000-1, 35260000-4, 35261000-1, 35261100-2, 35262000-8, 35300000-7, 35310000-0, 35311000-7, 35311100-8, 35311200-9, 35311300-0, 35311400-1, 35312000-4, 35320000-3, 35321000-0, 35321100-1, 35321200-2, 35321300-3, 35322000-7, 35322100-8, 35322200-9, 35322300-0, 35322400-1, 35322500-2, 35330000-6, 35331000-3, 35331100-4, 35331200-5, 35331300-3, 35331400-7, 35331500-8, 35332000-0, 35332100-1, 35332200-2, 35333000-7, 35333100-8, 35333200-9, 35340000-9, 35341000-6, 35341100-7, 35342000-3, 35343000-0, 35400000-8, 35410000-1, 35411000-8, 35411100-9, 35411200-0, 35412000-5, 35412100-6, 35412200-7, 35412300-8, 35412400-9, 35412500-0, 35420000-4, 35421000-1, 35421100-2, 35422000-8, 35500000-9, 35510000-2, 35511000-9, 35511100-0, 35511200-1, 35511300-2, 35511400-3, 35512000-6, 35512100-7, 35512200-8, 35512300-9, 35512400-0, 35513000-3, 35513100-4, 35513200-5, 35513300-6, 35513400-7, 35520000-5, 35521000-2, 35521100-3, 35522000-9, 35600000-0, 35600000-0, 35610000-3, 35611000-0, 35611100-1, 35611200-2, 35611300-3, 35611400-4, 35611500-5, 35611600-6, 35611700-7, 35611800-8, 35612100-8, 35612200-9, 35612300-0, 35612400-1, 35612500-2, 35613000-4, 35613100-5, 35620000-6, 35621000-3, 35621100-4, 35621200-5, 35621300-6, 35621400-7, 35622000-0, 35622100-1, 35622200-2, 35622300-3, 35622400-4, 35622500-5, 35622600-6, 35622700-7, 35623000-7, 35623100-8, 35630000-9, 35631000-6, 35631100-7, 35631200-8, 35631300-9, 35640000-2, 35641000-9, 35641100-0, 35642000-7, 35700000-1, 35710000-4, 35711000-1, 35712000-8, 35720000-7, 35721000-4, 35722000-1, 35723000-8, 35730000-0, 35740000-3, 35800000-2, 35810000-5, 35811100-3, 35811200-4, 35811300-5, 35812000-9,

IE	CPV Codes
	35812100-0, 35812200-1, 35812300-2, 35813000-6, 35813100-7, 35814000-3, 35815000-0, 35815100-1, 35820000-8, 35821000-5, 35821100-6, 45112740-4, 45213330-5, 45235000-3, 45235100-4, 45235110-7, 45235111-4, 45235200-5, 45235210-8, 45235300-6, 45235310-9, 45235311-6, 45235320-2, 45316220-3, 48121000-2, 48130000-8, 48131000-5, 50210000-0, 50211000-7, 50211100-8, 50211200-9, 50211210-2, 50211211-9, 50211212-6, 50211300-0, 50211310-3, 50212000-4, 50600000-1, 50610000-4, 50620000-7, 50630000-0, 50640000-3, 50650000-6, 50660000-9, 51146000-7, 51221000-7, 51611110-2, 60400000-2, 60410000-5, 60411000-2, 60420000-8, 60421000-5, 60423000-9, 60424000-6, 60424100-7, 60424110-0, 60424120-3, 60440000-4, 60441000-1, 60442000-8, 60443000-5, 60443100-6, 60444000-2, 60444100-3, 60445000-9, 60500000-3, 60510000-6, 60520000-9, 63730000-5, 63731000-2, 63731100-3, 63732000-9, 63733000-6, 63734000-3, 71311240-5, 72212120-6, 72212121-3, 72212130-9, 72212131-6, 72212132-3, 73400000-6, 73410000-9, 73420000-2, 73421000-9, 73422000-6, 73423000-3, 73424000-0, 73425000-7, 73426000-4, 73430000-5, 73431000-2, 73432000-9, 73433000-6, 73434000-3, 73435000-0, 73436000-7, 75220000-4, 75221000-1, 75222000-8, 75230000-7, 75231000-4, 75231100-5, 75231200-6, 75231210-9, 75231220-2, 75231230-5, 75231240-8, 75240000-0, 75241000-7, 75241100-8, 75242000-4, 75242100-5, 75242110-8, 75250000-3, 75251000-0, 75251100-1, 75251110-4, 75251120-7, 75252000-7, 80600000-0, 80610000-3, 80620000-6, 80630000-9, 80640000-2, 80650000-5, 80660000-8
Agri-food	
Construction	71313000, 45000000-7, 71322000-1, 71500000-3, 50700000-2, 71221000-3, 71223000-7, 98341130-5, 45112700-2, 31200000-8, 51112000-0, 65300000-6, 65310000-9, 71313400-9, 90712500-6, 45261215-4, 45262640-9
Cultural & Creative Industries	
Energy & Renewables	
Energy Intensive Industries	
Health	85000000-9, 85100000-0, 85110000-3, 85111000-0, 85111100-1, 85111200-2, 85111300-3, 85111310-6, 85111320-9, 85111400-4, 85111500-5, 85111600-6, 85111700-7, 85111800-8, 85111810-1, 85111820-4, 85111900-9, 85112000-7, 85112100-8, 85112200-9, 85120000-6, 85121000-3, 85121100-4, 85121200-5, 85121210-8, 85121220-1, 85121230-4, 85121231-1, 85121232-8, 85121240-7, 85121250-0, 85121251-7, 85121252-4, 85121270-6, 85121271-3, 85121280-9, 85121281-6, 85121282-3, 85121283-0, 85121290-2, 85121291-9, 85121292-6, 85121300-6, 85130000-9, 85131000-6, 85131100-7, 85131110-0, 85140000-2, 85141000-9, 85141100-0, 85141200-1, 85141210-4, 85141211-1, 85141220-7, 85142000-6, 85142100-7, 85142200-8, 85142300-9, 85142400-0, 85143000-3, 85144000-0, 85144100-1, 85145000-7, 85146000-4, 85146100-5, 85146200-6, 85147000-1, 85148000-8, 85149000-5, 85150000-5, 85160000-8, 85170000-1, 85171000-8, 85172000-5, 33157000-5, 33195100-4, 33115100-0, 33123200-0, 33168100-6, 39330000-4, 33181100-3, 33161000-6, 33152000-0, 33194110-0, 33157400-9, 33169100-3, 33111610-0, 39711120-6, 31524110-9, 33191110-9, 33160000-9, 33162000-3, 33112200-0, 33191000-5, 33111000-1, 33111650-2,
Mobility, transport & automotive	34000000-7, 34100000-8, 34110000-1, 34111000-8, 34111100-9, 34111200-0, 34113000-2, 34113100-3, 34113200-4, 34113300-5, 34114000-9, 34114100-0, 34114110-3, 34114120-6, 34114121-3, 34114122-0, 34114200-1, 34114210-4, 34114300-2, 34114400-3, 34115000-6, 34115200-8, 34115300-9, 34120000-4, 34121000-1, 34121100-2, 34121200-3, 34121300-4, 34121400-5, 34121500-6, 34130000-7, 34131000-4, 34132000-1, 34133000-8, 34133100-9, 34133110-2, 34134000-5, 34134100-6, 34134200-7, 34136000-9, 34136100-0, 34136200-1, 34137000-6, 34138000-3, 34139000-0, 34139100-1, 34139200-2, 34139300-3, 34140000-0, 34142000-4, 34142100-5, 34142200-6, 34142300-7, 34143000-1, 34144000-8, 34144100-9, 34144200-0, 34144210-3, 34144211-0, 34144212-7, 34144213-4, 34144220-6, 34144300-1, 34144400-2, 34144410-5, 34144420-8, 34144430-1, 34144431-8, 34144440-4, 34144450-7, 34144500-3, 34144510-6, 34144511-3, 34144512-0, 34144520-9, 34144700-5, 34144710-8, 34144750-0, 34144751-7, 34144760-3, 34144800-6, 34144900-7, 34144910-0, 34150000-3, 34151000-0, 34152000-7, 34200000-9, 34210000-2, 34211000-9, 34211100-9, 34211200-9, 34211300-9, 34220000-5, 34221000-2, 34221100-3, 34221200-4, 34221300-5, 34223000-6, 34223100-7, 34223200-8, 34223300-9, 34223310-2,

IE	CPV Codes
	34223320-5, 34223330-8, 34223340-1, 34223350-4, 34223360-7, 34223370-0, 34223400-0, 34224000-3, 34224100-4, 34224200-5, 34300000-0, 34310000-3, 34311000-0, 34311100-1, 34311110-4, 34311120-7, 34312000-7, 34312100-8, 34312200-9, 34312300-0, 34312400-1, 34312500-2, 34312600-3, 34312700-4, 34320000-6, 34321100-4, 34321200-5, 34322000-0, 34322100-1, 34322200-2, 34322300-3, 34322400-4, 34322500-5, 34324000-4, 34324100-5, 34325000-1, 34325100-2, 34325200-3, 34326100-9, 34326200-0, 34327000-5, 34327100-6, 34327200-7, 34328000-2, 34328100-3, 34328200-4, 34328300-5, 34330000-9, 34350000-5, 34351000-2, 34351100-3, 34352000-9, 34352100-0, 34352200-1, 34352300-2, 34360000-8, 34370000-1, 34390000-7, 34400000-1, 34410000-4, 34411000-1, 34411100-2, 34411110-5, 34411200-3, 34420000-7, 34421000-7, 34422000-7, 34430000-0, 34431000-7, 34432000-4, 34432100-5, 34500000-2, 34510000-5, 34511100-3, 34512000-9, 34512100-0, 34512200-1, 34512300-2, 34512400-3, 34512500-4, 34512600-5, 34512700-6, 34512800-7, 34512900-8, 34512950-3, 34513000-6, 34513100-7, 34513150-2, 34513200-8, 34513250-3, 34513300-9, 34513300-9, 34513350-4, 34513400-0, 34513400-0, 34513450-5, 34513500-1, 34513500-1, 34513550-6, 34513600-2, 34513600-2, 34513650-7, 34513700-3, 34513750-8, 34514000-3, 34514000-3, 34514100-4, 34514200-5, 34514300-6, 34514400-7, 34514500-8, 34514600-9, 34514700-0, 34514800-1, 34514900-2, 34515000-0, 34515100-1, 34515200-2, 34516000-7, 34520000-8, 34521000-5, 34521100-6, 34521200-7, 34521300-8, 34521400-9, 34522000-2, 34522100-3, 34522150-8, 34522200-4, 34522250-9, 34522300-5, 34522350-0, 34522400-6, 34522450-1, 34522500-7, 34522550-2, 34522600-8, 34522700-9, 34600000-3, 34610000-6, 34611000-3, 34612000-0, 34612100-1, 34612200-2, 34620000-9, 34621000-6, 34621100-7, 34621200-8, 34622000-3, 34622100-4, 34622200-5, 34622300-6, 34622400-7, 34622500-8, 34630000-2, 34631000-9, 34631100-0, 34631200-1, 34631300-2, 34631400-3, 34632000-6, 34632100-7, 34632200-8, 34632300-9, 34640000-5, 34900000-6, 34910000-9, 34911000-6, 34911100-7, 34912000-3, 34912100-4, 34913000-0, 34913100-1, 34913200-2, 34913300-3, 34913400-4, 34913500-5, 34913510-8, 34913600-6, 34913700-7, 34913800-8, 34920000-2, 34921000-9, 34921100-0, 34921200-1, 34922000-6, 34922100-7, 34922110-0, 34923000-3, 34924000-0, 34926000-4, 34927000-1, 34927100-2, 34928000-8, 34928100-9, 34928110-2, 34928120-5, 34928200-0, 34928210-3, 34928220-6, 34928230-9, 34928300-1, 34928310-4, 34928320-7, 34928330-0, 34928340-3, 34928400-2, 34928410-5, 34928420-8, 34928430-1, 34928440-4, 34928450-7, 34928460-0, 34928470-3, 34928471-0, 34928472-7, 34928480-6, 34928500-3, 34928510-6, 34928520-9, 34928530-2, 34929000-5, 34930000-5, 34931000-2, 34931100-3, 34931200-4, 34931300-5, 34931400-6, 34931500-7, 34932000-9, 34933000-6, 34934000-3, 34940000-8, 34941000-5, 34941100-6, 34941200-7, 34941300-8, 34941500-0, 34941600-1, 34941800-3, 34942000-2, 34942100-3, 34942200-4, 34943000-9, 34944000-6, 34945000-3, 34946000-0, 34946100-1, 34946110-4, 34946120-7, 34946121-4, 34946122-1, 34947100-8, 34946210-5, 34946220-8, 34946221-5, 34946222-2, 34946223-9, 34946224-6, 34946230-1, 34946231-8, 34946232-5, 34946240-4, 34947000-7, 34947100-8, 34947200-9, 34950000-1, 34951000-8, 34951200-0, 34951300-1, 34952000-5, 34953000-2, 34953100-3, 34953300-5, 34954000-9, 34955000-6, 34955100-7, 34961000-1, 34961100-2, 34963000-5, 34964000-2, 34965000-9, 34966000-6, 34966100-7, 34966200-8, 34970000-7, 34971000-4, 34972000-1, 34980000-0, 34990000-3, 34991000-0, 34992000-7, 34992100-8, 34992200-9, 34992300-0, 34993000-4, 34993100-5, 34994000-1, 34994100-2, 34996000-5, 34996100-6, 34996200-7, 34996300-8, 34998000-9, 34999000-6, 34999100-7, 34999300-9, 34999400-0, 34999420-6
Proximity, Social Economy and Civil Security	
Retail	
Textile	03115100-1, 18224000-5, 18814000-8, 18936000-9, 114000000-6, 3416000-8, 19400000-0, 19410000-3, 19420000-6, 19430000-9, 19436000-1, 19513000-5, 19513200-7, 39192000-4, 39516100-7, 39510000-0, 39515420-5, 39520000-3, 39522500-2, 39525000-8, 39541200-8, 39525000-5, 39561120-9, 39561130-2, 39561131-9, 39561132-6, 39563000-6, 39563100-7, 39563400-0, 39563500-1, 39563510-4, 50800000-7, 39563600-2, 42700000-3, 42710000-6, 42711000-3, 42712000-0, 42718000-2, 42720000-9, 50830000-2, 51543000-0, 51543100-1, 98312000-3, 98312100-4

Source: Consortium

Notes: Blank cells represent industrial ecosystems for which the analysis was not conducted.

Figure 29 IE – FDI[70]

IE	NACE_rev 2	Description	NAICS sector
Aerospace & Defence	C25	Manufacture of fabricated metal products, except machinery and equipment	
	C26	Manufacture of computer, electronic and optical products	Navigational instruments
	C27*	Manufacture of electrical equipment	
	C30	Manufacture of other transport equipment	Aircraft engines, other parts & auxiliary equipment; Aircraft Military armoured vehicle, tank, & components; Guided missile & space vehicles; Other (Space & defence) Engines & Turbines; Other (Engines & turbines); Other (Aerospace)
	C33	Repair and installation of machinery and equipment	
	H51	Air transport	
	H52*	Warehousing and support activities for transportation	
	J61	Telecommunications	Satellite telecommunications
	N80	Security and investigation activities	
Agri-food	A	Agriculture, forestry and fishing	Fishing, hunting & trapping
	C10	Manufacture of food products	Dairy products; Bakeries & tortillas Seasoning & dressing; Crop production; Animal production Fruits & vegetables & specialist foods; Animal slaughtering & processing; Seafood products Other (Food & Beverages); Snack food; Animal food; Sugar & confectionary products
	C11	Manufacture of beverages	Soft drinks & ice; Breweries & distilleries; Wineries; Coffee & tea
	C12	Manufacture of tobacco products	Tobacco
Construction	C31	Manufacture of furniture	
	F	Construction	Industrial building construction; Commercial & institutional building construction; Residential building construction
	M71	Architectural and engineering activities; technical testing and analysis	
	N81	Services to buildings and landscape activities	
Cultural and Creative Industries	C18	Printing and reproduction of recorded media	Newspaper, periodical, book, & directory publishers
	C32	Other manufacturing	
	G47*	Retail trade, except of motor vehicles and motorcycles	
	J58	Publishing activities	Newspaper, periodical, book, & directory publishers; Video games, applications and digital content
	J59	Motion picture, video and television programme production, sound recording and music publishing activities	Motion picture & sound recording industries

[70] Blank spaces in the table means that the subsector was not covered through NAICS sector code available in the fdI insights database. N/A means that FDI was not analysed for that IE.

IE	NACE_rev 2	Description	NAICS sector
	J60	Programming and broadcasting activities	Radio & TV broadcasting
	J62_63	Computer programming, consultancy and related activities;	
	M71	Architectural and engineering activities; technical testing and analysis	Architectural, engineering, & related services
	M73	Advertising and market research	Advertising, PR, & related
	M74_M75	Other professional, scientific and technical activities and veterinary activities	
	N77	Rental and leasing activities	
	P85	Education	
	R90-R92	Creative, arts and entertainment activities; libraries, archives, museums and other cultural activities; gambling and betting activities Museums, historical sites, & similar	Performing arts, spectator sports, & related; Museum, historical sites, & similar
	S94	Activities of membership organisations	
	S95	Repair of computers and personal and household goods	
Digital	C26*	Manufacture of computer, electronic and optical products	N/A
	J58	Publishing activities	
	J61	Telecommunications	
	J62	Computer programming, consultancy and related activities	
	J63	Information service activities	
	S95	Repair of computers and personal and household goods	
Electronics	C26	Manufacture of computer, electronic and optical products	Magnetic & optical media; Batteries; Semiconductors & other electronic components; Other (Semiconductors)
	C28	Manufacture of machinery and equipment n.e.c.	
Energy - Renewables	C27*	Manufacture of electrical equipment	
	D35	Electricity, gas, steam and air conditioning supply	Other electric power generation (Renewable Energy); Solar electric power; Wind electric power; Biomass power; Hydroelectric power; Geothermal electric power;Marine electric power
Energy Intensive Industries	C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	Wood products
	C17	Manufacture of paper and paper products	Pulp, paper & paperboard
	C19	Manufacture of coke and refined petroleum products	
	C20	Manufacture of chemicals and chemical products	Basic chemicals Pesticide, fertilisers & other agricultural chemicals Soap, cleaning compounds, & toilet preparation Paints, coatings, additives & adhesives Other chemical products & preparation Resin & artificial synthetic fibres & filaments
	C22	Manufacture of rubber and plastic products	Tyres Other rubber products Rubber hoses & belting Laminated plastics plates, sheets & shapes Plastic pipes, pipe fitting & unlaminated

IE	NACE_rev 2	Description	NAICS sector
			profile shapes Artificial & synthetic fibres Other plastics products Plastics packaging materials & unlaminated film & sheets Plastic bottles
	C23	Manufacture of other non-metallic mineral products	Other non-metallic mineral products Nonmetallic mineral mining & quarrying
	C24	Manufacture of basic metals	Steel products Iron & steel mills & ferroalloy Nonferrous metal production & processing Alumina & aluminium production and processing Architectural & structured metals Copper, nickel, lead, & zinc mining
Health	C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	Medicinal & botanical Other (Pharmaceuticals) Pharmaceutical preparations
	C33	Manufacture of medical and surgical equipment and orthopaedic appliances	Electromedical and Electrotherapeutic Apparatus Medical equipment & supplies Other (Medical devices)
	C32	Other manufacturing	
	Q86	Human health activities	
	Q87_Q88	Residential care activities and social work activities without accommodation	General medical & surgical hospitals Home healthcare & all other ambulatory health care services Nursing & residential care facilities Offices of physicians, dentists, & other healthcare practitioners Other (Healthcare) Outpatient care centres & medical & diagnostic laboratories Psychiatric & speciality hospitals Social assistance
Mobility - Transport - Automotive	C27	Manufacture of electrical equipment	
	C29	Manufacture of motor vehicles, trailers and semi-trailers	Motor vehicle transmission & power train parts Motor vehicle stamping Other motor vehicle parts Motor vehicle electrical & electronic equipment Motor vehicle steering & suspension components Motor vehicle & parts dealers (Automotive Components) Motor vehicle gasoline engines & engine parts Motor vehicle seating & interior trim Motor vehicle brake systems Motor vehicle body & trailers Automobiles Heavy duty trucks Light trucks & utility vehicles Motor vehicle & parts dealers (Automotive OEM) All other transportation (Automotive OEM)
	C30	Manufacture of other transport equipment	
	G45	Wholesale and retail trade and repair of motor vehicles and motorcycles	

IE	NACE_rev 2	Description	NAICS sector
	H49	Land transport and transport via pipelines	
	H50	Water transport	
	H52	Warehousing and support activities for transportation	
Proximity, Social Economy and Civil Security	G47*	Retail trade, except of motor vehicles and motorcycles	N/A
	I	Accommodation and food service activities	
	L	Real estate activities	
	N81	Services to buildings and landscape activities	
	N82	Office administrative, office support and other business support activities	
	Q87_Q88	Residential care activities and social work activities without accommodation	
	S95	Repair of computers and personal and household goods	
	S96	Other personal service activities	
	T	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use	
Retail	G46	Wholesale trade, except of motor vehicles and motorcycles	N/A
	G47	Retail trade, except of motor vehicles and motorcycles	
	H53	Postal and courier activities	
Textile	C13	Manufacture of textiles	Other (Textiles) Textiles & Textile Mills Textile machinery
	C14	Manufacture of wearing apparel	Clothing & clothing accessories Apparel accessories & other apparel Cut & sew apparel Footwear Apparel knitting
	C15	Manufacture of leather and related products	Leather & hide tanning and finishing Other leather & allied products
Tourism	H49	Land transport and transport via pipeline	
	H50	Water transport	
	H51	Air transport	Air transportation
	I	Accommodation and food service activities	Accommodation Other (Hotels & tourism)
	N79	Travel agency, tour operator and other reservation service and related activitieS	Travel arrangement & reservation services
	N82	Office administrative, office support and other business support activities	
	R90-R92	Creative, arts and entertainment activities; libraries, archives, museums and other cultural activities; gambling and betting activities	
	R93	Sports activities and amusement and recreation activities	

Source: Consortium

Notes: Blank cells in the table means that the subsector was not covered through NAICS sector code available in the fdI insights database. N/A represent industrial ecosystems for which the analysis was not conducted.

Figure 30 IE - Patents

IE	Codes
Tourism	
Aerospace & Defence	B63H21/16%, B64G1/%,(B64D7/%, B64D10/%, B64D17/%, B64D19/%, B64D21/%, B64D23/%), F02C, F02K, F23R, B64B, B64C, F42B12/38%, F42B12/42%,F42B15/08%, F41B11/%, F41B15/%, F41H5/%, F41H7/%, F41H9/%, F42B4/%, F42B3/0%, F42B3/1%, F41A, F41C, F41F, F41G, F42C, B63G
Agri-food	A01B**,** A01C, A01D, A01F, A01G, A01L, A01M, B02B, B29C, B29D, B29K, B29L, B99Z, C03B, C08J, C12L, A01P , C05B , C05C , C05D , C05F , C05G, C13B5/%, C13B15/%, C13B25/%, C13B45/%, D21C, D21D, D21H, B31B , B31C , B31D, B31F, B41B, B41C, B41D, B41F, B41G, B41J, B41K, B41L, B41M, B41N, C14B, D01B, D01C, D01D, D01F, D01G, D01H, D02G, D02H, D02J, D03C, D03D, D03J, D04B, D04C, D04G, D04H, D05B, D05C, D06G, D06H, D06J, D06M, D06P, D06Q, D21B, D21C, D21F, D21G, D21J, D99Z), A01G23/00, A01G25/00, E02D3/00, A01H1/06, C12N15/00, C12N7/00, E02B3/%, E02D, E02F, C13B10/%, C13B20/%, C13B25/%, C13B30/%, C13B35/%, C13B40/%, C13B50/%, C13B99/%, A01J , A01H , A21D , A23B , A23C , A23D , A23F ,A23G , A23J, A23K , A23L , C12C , C12F , C12G,C12H, C12J , C13D, C13F , C13J , C13K ,A21B , A21C, A22B, A22C, A23N, A23P, C07K, C10L5/40%, C10L5/42%, C10L5/44%, C10L5/46%, C10L5/48%, C10B53/02%, A01C3/02%, C02F11/04%, C05F17/02%, B01D53/84%, F23G7/10%, C08B, C08C, C08H, C09F, C11B, C11C, C13B, A01N, D21H, C08L1/%, C08L3/%, C08L5/%, C08L7/%, C09J101/%, C09J103/%, C09J105/%, C09J107/%, C09K17/%, A61K36/02, A61K36/03, A61K36/04, A61K36/05, A01H15/%, A01H1/00, A01H4/00, A61K38/00, A61K39/00, A61K48/00, C02F3/00, C07G11/00, C07G13/00, C07G15/00, C07K4/00, C07K14/00, C07K16/00, C07K17/00, C07K19/00, G01N33/53, G01N33/54, G01N33/55', G01N33/57, G01N33/68, G01N33/74%, G01N33/76%, G01N33/78%, G01N33/88%, G01N33/92%**,** (G01N27/327%, C12M, C12N, C12P, C12Q, C12S)**,** C07C29/%, C07D475/%, C07K2/%, C08B3/%, C08B7/%, C08H1/%, C08L89/%, C09D11/%, C09D189/%, C09J189/%, A01K, A01M, A22B, A61D, A23N17/%,F25D, A21B, A47J
Construction	E01B, E01C, E01D, E01H, E02B, E02C, E02D, E02F, E03B, E03C, E03D, E03F, E04B, E04C, E04D, E04F, E04G, E04H, E05B, E05C, E05D, E05F, E05G, E06B, E06C, E21B, E21C, E21D, E21F, E99Z, E01F1/%, E01F3/%, E01F5/%, E01F7/%, E01F9/%, E01F11/%, E01F13/%, E01F15/%
Cultural and Creative Industries	
Digital	H04L, H04W, H04N21/%, G06C, G06D, G06E, G06F, G06G, G06J, G06K, G06M, G06N, G06T, G10L, G11C, G06Q
Electronics	H01B, H01C, H01F, H01G, H01H, H01J, H01K, H01M, H01R, H01T, F21H, F21K, F21L, F21S, F21V, F21W, F21Y, H02B, H02G, H02H, H02J, H02K, H02M, H02N, H02P, H05B, H05C, H05F, H99Z, G09F, G09G, G11B, H04N3/%, H04N5/%, H04N7/%, H04N9/%, H04N11/%, H04N13/%, H04N15/%, H04N17/%, H04N101/%, H04R, H04S, H05K, G08C, H01P, H01Q, H04B, H04H, H04J, H04K, H04M,H04Q, H04N1/%, H03B, H03C, H03D, H03F, H03G, H03H, H03J, H03K, H03L, H03M, H01L
Energy - Renewables	Y02E10/7%, Y02E10/2%, Y02E10/4%, Y02E10/5%, Y02E50/17%, Y02E10/1%, A01C3/02%, B01D53/84%, C02F11/04%, C05F17/02%, F23G7/10%, F24D3/18%, F24D11/02%, F24D15/04%, F24D17/02%, F24H4/%, F25B30/%, F25B30/02%, F25B30/04%, F25B30/06%, F24D5/12%, C10L5/46%, C10L5/48%
Energy Intensive Industries	Y02P, Y02D10/%, Y02E20/%
Health	A61B, A61C, A61F, A61G, A61H, A61J, A61L, A61M, A61N, H05G, A61P, G06Q50/22%, G06Q50/24%, H04R25/%, A61N1/39%, A61B5/%, A61K6/%, A61K9/%, A61K31/%, A61K33/%, A61K35/%, A61K36/%, A61K38/%, A61K39/%, A61K41/%, A61K45/%, A61K47/%, A61K48/%, A61K49/%, A61K50/%, A61K51/%, A61K101/%, A61K103/%, A61K125/%, A61K127/%, A61K129/%, A61K131/%, A61K133/%, A61K135/%, A01H1/00, A01H4/00, A61K38/00, A61K39/00, A61K48/00, C02F3/34, C07G11/00, C07G13/00, C07G15/00, C07K4/00, C07K14/00, C07K16/00, C07K17/00, C07K19/00, G01N33/53%, G01N33/54%, G01N33/55%, G01N33/57%, G01N33/68%, G01N33/74%, G01N33/76%, G01N33/78%, G01N33/88%, G01N33/92%, ((G01N27/327,C12M, C12N, C12P, C12Q, C12S)

IE	Codes
Mobility - Transport - Automotive	F02B, F02F, F02P, F02D, F02M, B60K6/%, B60K7/%, B60W20/%, F02N11/04%, B60T1/10%, B60L7/10%, B60L7/22%, ((B60K17/356, B60L11/%, B60L15/%, B60L3/%, B60L1/%, H02K) NOT (H04%, G06F3/%, G03G, B60J)), ((B60R16/04, H01M10/%'), H01M2/%, H01M4/%, H01M6/%) NOT (H04%, G03G, B60J, G06F3/%)), B60W10/08%, B60W10/24%, B60W10/26%, B60W10/28%, (H01M8/% AND B60L11/18%), H01M8/02%, H01M8/10%, H01M8/22%, H01M8/24%, B60W10/28%, ((lightweight%, C01F7/00, C07F5/06%, C01F5/00, C04B9/00, D01F9/12%, C08K3/04%, C10M103/02%, C10M113/02%, C10M125/02%, C21C5/00, C07C19/041%, C01B31/00, C04B35/52%, C01B31/18%, C01B31/20%, C03B37/012%', C03B37/075%', C03C13/00, B82Y30/00, B82Y40/00, B29C65/44%, B29C65/64%, C08J5/12%, B29C65/02%, B29C65/72%, B29C65/74%, D01G13/00, C01B, C01C, C01F, C01G, C01B, C01C, C01F, C01G, C09C, C10B) AND (B60%, B61%, B62%, B63%, B64%)), C02F11/04%, B01D53/84%, C07C29/%, C11C3/%, C11L1/18%', C11G3/%, C11G1/%, B09B3/%, C10G2/%, C10G3/%, (alga%(W5)fuel%), algaeoleum, B62D35/%, B62D37/%, B62D39/%, B60B3/%, B60B11/%, B60B15/%, B60C1/%, B60C3/%, B60C5/%, B60C7/%, B60C9/%, B60C11/%, B60C19/%, B61J, B61F, B61G, B60L, B61B3/%, B61B5/%, B61B13/08%, B61B13/10%, B61B13/15%, B61C3/%, B61C5/%, B61C7/%, B61C9/%, B61C11/%, B61C15/%, B61H1/%, B61H3/%, B61H5/%, B61H7/%, B61H9/%, B61H11/%, B61H9/06%, B63H1/%, B63H3/%, B63H5/%, B63H7/%, B63H9/%, B63H11/%, B63H13/%, B63H15/%, B63H19/%, B63H20/%, B63H21/%, B63H23/%, B63J, B64B1/0%, B64B1/1%, B64B1/2%, B64B1/3%, B64C1/06%, B64C1/08%, B64C1/10%, B64C1/12%, B64C1/14%, B64C1/16%, B64C3/%, B64C5/%, B64C7/%, B64C9/%, B64C11/%, B64C15/%, B64C19/%, B64C21/%, B64C23/%, B64C25/%, B64C27/%, B64C31/%, B64C33/%, B64C39/%, F02K1/%, F02K3/%, F02K5/%, F02K7/%, F02K11/%, F02C, E01C1/%, E01C3/%, E01C5/%, E01C7/%, E01C9/%, E01C11/%, E01C23/%, E01F, E01D1/%, E01D2/%, E01D4/%, E01D6/%, E01D11/%, E01D12/%, E01D19/%, E01B1/%, E01B2/%, E01B3/%, E01B5/%, E01B7/%, E01B9/%, E01B11/%, E01B21/%, G06Q10/02%, G06Q10/08%, G06Q20/%, G07F7/08%, G07F19/00, G07G1/12%, G06Q50/14%, G06Q50/28%, G06Q50/30%
Proximity, Social Economy and Civil Security	
Retail	
Textile	D01%, D02%, D03%, D04%, D05%, D06%, D07%, A41%, A42%

Source: Consortium

Notes: Blank cells represent industrial ecosystems for which the analysis was not conducted.

Figure 31 IE - Trade

IE	HS codes
Aerospace & Defence	(890391, 890310, 890392,890399,860110,860210,860120,860310, 860400, 860500, 860610,860711,860800,840710,841111, 841210, 880521, 840910, 841191, 880100, 880211, 880220, 880230, 880240, 880260,940110,880310,880320,880330, 871110, 871120, 871160,871410,840731,840734,871200, 871310, 871390, 871491, 871420, 871500, 871680) + (0.68) (854011, 854071, 854110, 854121, 854130, 854140, 854150, 854160, 854231, 854232, 854233, 854239, 852210, 854091, 854190, 854290, 853400, 847180, 852352, 847130, 847141, 847149, 847150, 844332, 847160, 852842, 844331, 847170, 852321, 847330, 851770, 852560, 852550, 852580, 851711, 851712, 851761, 851762, 851718, 851769, 852910, 852990, 853110, 852719, 852721, 852729, 852871, 852872, 851920, 851981, 852110, 852849, 851810, 851821, 851822, 851829, 851830, 851840, 851850, 851890, 950450, 903020, 903032, 903039, 903082, 903084, 903089, 901410, 901420, 901480, 852691, 901580, 852610, 852692, 901600, 901710, 901730, 903010, 903020, 903031, 903040, 902511, 902519, 902580, 902610, 902620, 902680, 902710, 902720, 902730, 902780, 901210, 902410, 902810, 902820, 902830, 902910, 902920, 903281, 903120, 903180, 903210, 903220, 903289, 901590, 901290, 902890, 902990, 903190, 903290, 901490, 910111, 910211, 910400, 910310, 910811, 911110, 911410, 910610, 910690, 910700, 902212, 902219, 902221, 902230, 902290, 901811, 901812, 901820, 902140, 902190, 902150, 900630, 900640, 900651, 900652, 900653, 900659, 900211, 900630, 900640, 900710, 900720, 900661, 900691, 900190, 900290, 900219, 900120, 900510, 900580, 901120, 901310, 901320, 901380, 901510, 902750, 900590, 901110, 901390, 852329, 852341, 852359, 847180, 847190, 901390, 901590, 901790, 902590, 902690, 902790, 903090, 903300) + (0.44) (850110, 850131, 850132, 850133, 850134, 850120, 850140, 850151, 850152, 850153, 850161, 850162, 850163, 850164, 850211, 850212, 850213, 850220, 850231, 850240, 850421, 850422, 850423, 850431, 850432, 850433, 850434, 850410, 850440, 850450, 850300, 850490, 853510, 853521, 853530, 853540, 853590, 853610, 853620, 853630, 853641, 853649, 853710, 853720, 853810, 853890, 850610, 850630, 850640, 850650, 850660, 850680, 850690, 850710, 850720, 850730, 850740, 850750, 850760, 850780, 850790, 854470, 900110, 854411, 854420, 854449, 854460, 853650, 853661, 853669, 853690, 853670, 392590, 854720, 853910, 853921, 853922, 853929, 853931, 853932, 853941, 851310, 940520, 940550, 940560, 940510, 940540, 851220, 853950, 853990, 851390, 940599, 841810, 841821, 841830, 841840, 842211, 845011, 630110, 841451, 841460, 850811, 850819, 850940, 850980, 851010, 851631, 851632, 851633, 851640, 850860, 851671, 851672, 851679, 851610, 851621, 851629, 851650, 851660, 851680, 850870, 850990, 851090, 851690, 732111, 732112, 732181, 732182, 732189, 732290, 841911, 732190, 854370, 854690, 854790, 854511, 854519, 854520, 854590, 853120, 853180, 851511, 851519, 851521, 851531, 851539, 851580, 851590, 853090, 853190, 854390, 854890, 854442, 854310, 854320, 850520, 850590, 853210, 853221, 853223, 853230, 853321, 853329, 853331, 853339, 853310, 853010, 853080, 853290, 853390) + (0.23) (940690, 730810, 730820, 730840, 730890, 761090, 730830, 761010, 732211, 840310, 840390, 730900, 761100, 731100, 840211, 840219, 840220, 840410, 840420, 840290, 840490, 840110, 840140, 930200, 930310, 930390, 930400, 930621, 930510, 821191, 821192, 821193, 821194, 821300, 821210, 821220, 821410, 821420, 821490, 821520, 821510, 930700, 830110, 830120, 830130, 830140, 830150, 830170, 830160, 830210, 830220, 830230, 830241, 830242, 830249, 830260, 830250, 820110, 820130, 820140, 820150, 820190, 820160, 820210, 820220, 820231, 820239, 820291, 820240, 820310, 820320, 820330, 820340, 820411, 820412, 820420, 820510, 820520, 820530, 820540, 820551, 820559, 820560, 820570, 820590, 820740, 820750, 820760, 820770, 820780, 820790, 848010, 848030, 848041, 848049, 848050, 848060, 848071, 848079, 820713, 820719, 820720, 820730, 820810, 820820, 820830, 820840, 820890, 820900, 731010, 731029, 731021, 761210, 761290, 830910, 830990, 731210, 731290, 731300, 741300, 761410, 731412, 731414, 731420, 731431, 731441, 731442, 731450, 741999, 731700, 831110, 831120, 831130, 831190, 732010, 732020, 732090, 731581, 731582, 731520, 731589, 741910, 731590, 731940, 731815, 731811, 731813, 731814, 731816, 731819, 731821, 731822, 731823, 731824, 741521, 741533, 741539, 732410, 732421, 732490, 741820, 761520, 732391, 732393, 732394, 732399, 741810, 761510, 821000, 732310, 830300, 830400, 830510, 830520, 830590, 830621, 830810, 830820, 830890, 848710, 860800, 731600, 732510, 732591, 732611, 732620, 961590, 961519, 732690, 761691, 741991, 800700, 790700, 780600, 750810, 830610, 830710, 830790, 831000, 850511) + (0.03)

IE	HS codes
Agri-food	160100, 160220, 160231, 160232, 160239, 160241, 160242, 160249, 160250, 160290, 200210, 200310, 200390, 200490, 200540, 200551, 200559, 200560, 200570, 200580, 200590, 200599, 30611, 30612, 30614, 30615, 30616, 30617, 30619, 30691, 30692, 30693, 30694, 30695, 30699, 30712, 30719, 30722, 30729, 30732, 30739, 30743, 30749, 30752, 30759, 30760, 30772, 30779, 30783, 30784, 30787, 30788, 30792, 30799, 30812, 30819, 30822, 30829, 30830, 30890, 160411, 160412, 160413, 160414, 160415, 160416, 160417, 160418, 160419, 160420, 160510, 160521, 160529, 160530, 160540, 160551, 160552, 160553, 160554, 160555, 160556, 160557, 160558, 160559, 160561, 160562, 160563, 160569, 201100, 201209, 203111, 203121, 203191, 204100, 204501, 205002, 206101, 202100, 203211, 203221, 203291, 204300, 204505, 205008, 206210, 208101, 510119, 410120, 410190, 410210, 410390, 209101, 150110, 150210, 504000, 502100, 20741, 20742, 20751, 20752, 20760, 20744, 20745, 20754, 20755, 20760, 207111, 207241, 207412, 207131, 207261, 207441, 207121, 207251, 207423, 207141, 207271, 207451, 209900, 207139, 670100, 210111, 210121, 210191, 210201, 210910, 160100, 160220, 160231, 160232, 160241, 160242, 160249, 160250, 160290, 230110, 302920, 302910, 303110, 303230, 304610, 304910, 304931, 303911, 305310, 305100, 305511, 305410, 305420, 305430, 305441, 160411, 160412, 160413, 160414, 160415, 160416, 160419, 160417, 160420, 160431, 160432, 306111, 307120, 307721, 230120, 511911, 710100, 200410, 712900, 110510, 200520, 200950, 200911, 200912, 200921, 200941, 200961, 200971, 200990, 200931, 200981, 200939, 710210, 711201, 712200, 712310, 712901, 200551, 200540, 200210, 200290, 200310, 200490, 200599, 200560, 200570, 200580, 200591, 200110, 811101, 200791, 200799, 200811, 200819, 814000, 812100, 801220, 806201, 803109, 200820, 230800, 150300, 150410, 150600, 150810, 150910, 151000, 151211, 151411, 151110, 150710, 140420, 230400, 230630, 230641, 230500, 120810, 150790, 150890, 150990, 151219, 151229, 151419, 151190, 151319, 151329, 151610, 151620, 152110, 152200, 151710, 151790, 401101, 401109, 401201, 401401, 401409, 401503, 402101, 402211, 405101, 405109, 405201, 406103, 406200, 406301, 402911, 402991, 403101, 403109, 403901, 403905, 350110, 170211, 404100, 404104, 404902, 210500, 100620, 100630, 100640, 110100, 110220, 110610, 190120, 110311, 110313, 110320, 110412, 110430, 190420, 190410, 190430, 230210, 230240, 230230, 110811, 110812, 110813, 110814, 110820, 110900, 350510, 190300, 170230, 170250, 170290, 151521, 151529, 230310, 190590, 190510, 190540, 190520, 190531, 190532, 190211, 190219, 190240, 170112, 170199, 170191, 170310, 170390, 230320, 180310, 180400, 180500, 180610, 180620, 180631, 180632, 180690, 170410, 170490, 200600, 901120, 901210, 901220, 901909, 210130, 902100, 210120, 121190, 220900, 210310, 210320, 210330, 210390, 250100, 190220, 190230, 210690, 160210, 200510, 200710, 210420, 190110, 210410, 408112, 350211, 210210, 210220, 210230, 160300, 190190, 210610, 230990, 121410, 230910, 230690, 220820, 220830, 220840, 220850, 220860, 220890, 220410, 220421, 220430, 220421, 220422, 220429, 220600, 220510, 220300, 220291, 230330, 110710, 110720, 220110, 220190, 220210, 220299, 240210, 240220, 240290, 240120, 240311, 240391
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IE	HS codes
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Electronics	(840721, 840729, 840820, 840810, 840890, 840610, 841011, 841181, 850231, 840690, 841090, 841199, 840991, 840999, 841221, 841231, 841229, 841350, 841360, 848110, 848120, 841290, 841311, 841319, 841320, 841330, 841340, 841370, 841381, 841410, 841420, 841430, 841440, 841480, 841391, 841490, 848130, 848180, 848140, 848190, 848210, 848220, 848230, 848250, 848240, 848280, 731511, 731512, 848310, 848320, 848330, 848340, 848350, 848360, 848291, 848299, 731519, 848390, 841610, 841620, 841630, 841710, 841780, 851410, 851420, 841690, 841790, 851490, 842511, 842519, 842531, 842541, 842542, 842549, 842611, 842612, 842619, 842620, 842641, 842691, 842699, 842710, 842720, 842790, 870911, 842810, 842840, 842820, 842832, 842833, 842839, 842860, 842890, 843110, 843131, 870990, 843141, 847010, 844312, 844399, 846721, 846729, 846722, 846711, 846781, 846789, 846791, 846792, 841950, 841960, 841510, 841520, 841581, 841583, 841850, 841861, 841869, 842139, 841459, 841590, 841891, 841899, 841990, 840510, 842121, 842122, 842129, 842123, 842131, 842220, 842230, 842240, 842410, 842420, 842430, 842489, 848410, 842320, 842330, 842310, 842381, 901530, 901780, 842119, 842010, 847621, 847629, 842219, 841989, 846810, 846820, 840590, 842191, 842199, 842091, 842099, 842390, 842490, 847690, 842290, 846890, 870110, 870191, 870193, 843210, 843229, 843221, 843231, 843242, 843241, 843280, 843311, 843319, 843320, 843330, 843340, 843353, 843351, 843352, 843359, 842482, 842441, 842449, 871620, 843360, 843410, 843610, 843621, 843629, 843680, 843390, 843290, 843691, 843699, 843490, 870193, 870194, 870195, 845611, 845620, 845630, 845650, 845710, 845720, 845730, 845811, 845819, 845891, 845951, 845961, 845910, 845931, 845939, 845959, 845970, 846012, 846130, 846140, 846150, 846120, 846221, 846229, 846241, 846239, 846249, 846210, 846291, 846299, 846310, 846320, 846330, 846390, 846693, 846694, 846410, 846420, 846490, 846510, 846520, 854330, 847930, 845921, 845929, 846190, 846231, 846610, 846620, 846630, 846691, 846692, 845410, 845510, 845522, 845490, 845530, 845590, 842831, 843031, 843039, 843041, 843049, 842911, 842919, 842920, 842940, 842951, 842952, 842959, 843050, 843142, 870410, 843010, 843020, 843061, 843069, 847910, 847410, 847431, 847432, 870130, 843143, 843149, 847490, 842111, 843420, 843780, 843510, 841720, 841981, 841931, 843810, 843820, 843830, 843840, 843850, 843860, 843880, 847920, 847810, 843710, 843590, 843890, 847890, 843790, 844400, 844520, 844610, 844711, 844720, 844790, 844811, 844319, 844900, 845130, 845140, 845150, 845180, 845020, 845110, 845129, 842112, 845221, 845229, 845310, 845320, 845380, 845210, 844820, 844833, 844842, 844851, 845090, 845190, 845230, 845290, 845390, 843910, 843920, 843930, 844110, 844120, 844130, 844140, 844180, 843991, 843999, 844190, 847710, 847720, 847730, 847740, 847751, 847759, 847780, 847790, 946120, 846190, 844010, 844230, 844311, 844313, 844314, 844316, 844317, 844315, 848610, 848620, 848630, 841932, 841939, 950810, 847981, 840120, 847982, 847510, 847989, 847521, 847950, 848640, 847940, 847480, 847960, 880510, 903110, 844090, 848690, 847590) + (0.1) (854011, 854071, 854110, 854121, 854130, 854140, 854150, 854160, 854231, 854232, 854233, 854239, 852210, 854091, 854190, 854290, 853400, 847180, 852352, 847130, 847141, 847149, 847150, 844332, 847160, 852842, 844331, 847170, 852321, 847330, 851770, 852560, 852550, 852580, 851711, 851712, 851761, 851762, 851718, 851769, 852910, 852990, 853110, 852719, 852721, 852729, 852871, 852872, 851920, 851981, 852110, 852849, 851810, 851821, 851822, 851829, 851830, 851840, 851850, 851890, 950450, 903020, 903032, 903039, 903082, 903084, 903089, 901410, 901420, 901480, 852691, 901580, 852610, 852692, 901600, 901710, 901730, 903010, 903020, 903031, 903040, 902511, 902519, 902580, 902610, 902620, 902680, 902710, 902720, 902730, 902780, 901210, 902410, 902810, 902820, 902830, 902910, 902920, 903281, 903120, 903180, 903210, 903220, 903289, 901590, 901290, 902890, 902990, 903190, 903290, 901490, 910111, 910211, 910400, 910310, 910811, 911110, 911410, 910610, 910690, 910700, 902212, 902219, 902221, 902230, 902290, 901811, 901812, 901820, 902140, 902190, 902150, 900630, 900640, 900651, 900652, 900653, 900659, 900211, 900630, 900640, 900710, 900720, 900661, 900691, 900190, 900290, 900219, 900120, 900510, 900580, 901120, 901310, 901320, 901380, 901510, 902750, 900590, 901110, 901390,

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Renewable Energies	(850110, 850131, 850132, 850133, 850134, 850120, 850140, 850151, 850152, 850153, 850161, 850162, 850163, 850164, 850211, 850212, 850213, 850220, 850231, 850240, 850421, 850422, 850423, 850431, 850432, 850433, 850434, 850410, 850440, 850450, 850300, 850490, 853510, 853521, 853530, 853540, 853590, 853610, 853620, 853630, 853641, 853649, 853710, 853720, 853810, 853890, 850610, 850630, 850640, 850650, 850660, 850680, 850690, 850710, 850720, 850730, 850740, 850750, 850760, 850780, 850790, 854470, 900110, 854411, 854420, 854449, 854460, 853650, 853661, 853669, 853690, 853670, 392590, 854720, 853910, 853921, 853922, 853929, 853931, 853932, 853941, 851310, 940520, 940550, 940560, 940510, 940540, 851220, 853950, 853990, 851390, 940599, 841810, 841821, 841830, 841840, 842211, 845011, 630110, 841451, 841460, 850811, 850819, 850940, 850980, 851010, 851631, 851632, 851633, 851640, 850860, 851671, 851672, 851679, 851610, 851621, 851629, 851650, 851660, 851680, 850870, 850990, 851090, 851690, 732111, 732112, 732181, 732182, 732189, 732290, 841911, 732190, 854370, 854690, 854790, 854511, 854519, 854520, 854590, 853120, 853180, 851511, 851519, 851521, 851531, 851539, 851580, 851590, 853090, 853190, 854390, 854890, 854442, 854310, 854320, 850520, 850590, 853210, 853221, 853223, 853230, 853321, 853329, 853331, 853339, 853310, 853010, 853080, 853290, 853390) + (0.22)
Health	291821, 291822, 291823, 292241, 292242, 292310, 292411, 292423, 293220, 293311, 293321, 293352, 293355, 293369, 293430, 293510, 294000, 293621, 293711, 293810, 294110, 300120, 300190, 300290, 300310, 300320, 300410, 300420, 300331, 300339, 300431, 300432, 300341, 300360, 300441, 300450, 300460, 300211, 300220, 300230, 300660, 300620, 300630, 300510, 300610, 300590, 300650, 711810, 710122, 710229, 711311, 711411, 711419, 711420, 711590, 711711, 920110, 920120, 920190, 920210, 920590, 920510, 920710, 920600, 920810, 920930, 920991, 950611, 950612, 950670, 640212, 950621, 950691, 420321, 950631, 950640, 950651, 950661, 950699, 950710, 950300, 950440, 950420, 950430, 950490, 901841, 901849, 841920, 901831, 901832, 901839, 901850, 901890, 902511, 842119, 901910, 901920, 902131, 902110, 902121, 902129, 902139, 902190, 940210, 940290, 900130, 900140, 900410, 900490, 900311, 900319, 900390, 300640, 300670, 300691, 960310, 960390, 960321, 960329, 960330, 960340, 960350, 420329, 650610, 960810, 960820, 960840, 960830, 960850, 960860, 960891, 960910, 960920, 960990, 961000, 961100, 961220, 961210, 660110, 660200, 660320, 960610, 960630, 960720, 670300, 961310, 961400, 360690, 961390, 360610, 950510, 950590, 961610, 902300, 340600, 670210, 902000, 420600, 960110, 960200, 960400, 961700, 961800, 490510, 442199
Mobility - Transport - Automotive	(850110, 850131, 850132, 850133, 850134, 850120, 850140, 850151, 850152, 850153, 850161, 850162, 850163, 850164, 850211, 850212, 850213, 850220, 850231, 850240, 850421, 850422, 850423, 850431, 850432, 850433, 850434, 850410, 850440, 850450, 850300, 850490, 853510, 853521, 853530, 853540, 853590, 853610, 853620, 853630, 853641, 853649, 853710, 853720, 853810, 853890, 850610, 850630, 850640, 850650, 850660, 850680, 850690, 850710, 850720, 850730, 850740, 850750, 850760, 850780, 850790, 854470, 900110, 854411, 854420, 854449, 854460, 853650, 853661, 853669, 853690, 853670, 392590, 854720, 853910, 853921, 853922, 853929, 853931, 853932, 853941, 851310, 940520, 940550, 940560, 940510, 940540, 851220, 853950, 853990, 851390, 940599, 841810, 841821, 841830, 841840, 842211, 845011, 630110, 841451, 841460, 850811, 850819, 850940, 850980, 851010, 851631, 851632, 851633, 851640, 850860, 851671, 851672, 851679, 851610, 851621, 851629, 851650, 851660, 851680, 850870, 850990, 851090, 851690, 732111, 732112, 732181, 732182, 732189, 732290, 841911, 732190, 854370, 854690, 854790, 854511, 854519, 854520, 854590, 853120, 853180, 851511, 851519, 851521, 851531, 851539, 851580, 851590, 853090, 853190, 854390, 854890, 854442, 854310, 854320, 850520, 850590, 853210, 853221, 853223, 853230, 853321, 853329, 853331, 853339, 853310, 853010, 853080, 853290, 853390) + (0.03) (890391, 890310, 890392, 890399, 860110, 860210, 860120, 860310, 860400, 860500, 860610, 860711, 860800, 840710, 841111, 841210, 880521, 840910, 841191, 880100, 880211, 880220, 880230, 880240, 880260, 940110, 880310, 880320, 880330, 871110, 871120, 871160, 871410, 840731, 840734, 871200, 871310, 871390, 871491, 871420) + (0.32) (840731, 840734, 840820, 870321, 870323, 870331, 870332, 870333, 870340, 870360, 870380, 870390, 870210, 870421, 870422, 870423, 870431, 870120, 870600, 870510, 870310, 870530, 870540, 870520, 870710, 870790, 860900, 871610, 871631, 871690, 854430, 851110, 851120, 851130, 851140, 851150, 851180, 851210, 851230, 851240,

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Source: Consortium

Figure 32 Online Job Advertisements – IE

IE	NACE_rev2	Description	Scope
Tourism	H49	Land transport and transport via pipeline	
Tourism	H50	Water transport	
Tourism	H51	Air transport	
Tourism	I	Accommodation and food service activities	x
Tourism	N79	Travel agency, tour operator and other reservation service and related activities	x
Tourism	N82	Office administrative, office support and other business support activities	
Tourism	R90-R92	Creative, arts and entertainment activities; libraries, archives, museums and other cultural activities; gambling and betting activities	x
Tourism	R93	Sports activities and amusement and recreation activities	x
Aerospace & Defence	C25	Manufacture of fabricated metal products, except machinery and equipment	
Aerospace & Defence	C26_ad	Manufacture of computer, electronic and optical products	x
Aerospace & Defence	C27*	Manufacture of electrical equipment	x
Aerospace & Defence	C30	Manufacture of other transport equipment	x
Aerospace & Defence	C33.1	Repair and installation of machinery and equipment	
Aerospace & Defence	H51	Air transport	
Aerospace & Defence	H52*	Warehousing and support activities for transportation	
Aerospace & Defence	J61	Telecommunications	
Aerospace & Defence	N80	Security and investigation activities	x
Agri-food	A	Agriculture, forestry and fishing	x
Agri-food	C10	Manufacture of food products	x
Agri-food	C11	Manufacture of beverages	x
Agri-food	C12	Manufacture of tobacco products	x
Construction	C31	Manufacture of furniture	x
Construction	F	Construction	x
Construction	M71	Architectural and engineering activities; technical testing and analysis	x
Construction	N81	Services to buildings and landscape activities	x
Cultural and Creative Industries	C18	Printing and reproduction of recorded media	x
Cultural and Creative Industries	C32	Other manufacturing	
Cultural and Creative Industries	G47*	Retail trade, except of motor vehicles and motorcycles	
Cultural and Creative Industries	J58	Publishing activities	x
Cultural and Creative Industries	J59	Motion picture, video and television programme production, sound recording and music publishing activities	x
Cultural and Creative Industries	J60	Programming and broadcasting activities	x
Cultural and Creative Industries	J62_63	Computer programming, consultancy and related activities;	
Cultural and Creative Industries	M71	Architectural and engineering activities; technical testing and analysis	
Cultural and Creative Industries	M73	Advertising and market research	x
Cultural and Creative Industries	M74_M75	Other professional, scientific and technical activities and veterinary activities	
Cultural and Creative Industries	N77	Rental and leasing activities	
Cultural and Creative Industries	P85	Education	
Cultural and Creative Industries	R90-R92	Creative, arts and entertainment activities; libraries, archives, museums and other cultural activities; gambling and betting activities	x
Cultural and Creative Industries	S94	Activities of membership organisations	

IE	NACE_rev2	Description	Scope
Cultural and Creative Industries	S95	Repair of computers and personal and household goods	
Digital	C26*	Manufacture of computer, electronic and optical products	x
Digital	J58	Publishing activities	x
Digital	J61	Telecommunications	x
Digital	J62	Computer programming, consultancy and related activities	x
Digital	J63	Information service activities	x
Digital	S95	Repair of computers and personal and household goods	x
Electronics	C26	Manufacture of computer, electronic and optical products	x
Electronics	C28	Manufacture of machinery and equipment n.e.c.	
Energy - Renewables	C27*	Manufacture of electrical equipment	x
Energy - Renewables	D35	Electricity, gas, steam and air conditioning supply	x
Energy Intensive Industries	C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	x
Energy Intensive Industries	C17	Manufacture of paper and paper products	x
Energy Intensive Industries	C19	Manufacture of coke and refined petroleum products	x
Energy Intensive Industries	C20	Manufacture of chemicals and chemical products	x
Energy Intensive Industries	C22	Manufacture of rubber and plastic products	x
Energy Intensive Industries	C23	Manufacture of other non-metallic mineral products	x
Energy Intensive Industries	C24	Manufacture of basic metals	x
Health	C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	x
Health	C33	Manufacture of medical and surgical equipment and orthopaedic appliances	x
Health	C32	Other manufacturing	
Health	Q86	Human health activities	x
Health	Q87_Q88	Residential care activities and social work activities without accommodation	x
Mobility - Transport - Automotive	C27	Manufacture of electrical equipment	
Mobility - Transport - Automotive	C29	Manufacture of motor vehicles, trailers and semi-trailers	x
Mobility - Transport - Automotive	C30	Manufacture of other transport equipment	x
Mobility - Transport - Automotive	G45	Wholesale and retail trade and repair of motor vehicles and motorcycles	x
Mobility - Transport - Automotive	H49	Land transport and transport via pipelines	x
Mobility - Transport - Automotive	H50	Water transport	x
Mobility - Transport - Automotive	H52	Warehousing and support activities for transportation	
Proximity, Social Economy and Civil Security	G47*	Retail trade, except of motor vehicles and motorcycles	
Proximity, Social Economy and Civil Security	I	Accommodation and food service activities	
Proximity, Social Economy and Civil Security	L	Real estate activities	
Proximity, Social Economy and Civil Security	N81	Services to buildings and landscape activities	

IE	NACE_rev2	Description	Scope
Proximity, Social Economy and Civil Security	N82	Office administrative, office support and other business support activities	
Proximity, Social Economy and Civil Security	Q87_Q88	Residential care activities and social work activities without accommodation	x
Proximity, Social Economy and Civil Security	S95	Repair of computers and personal and household goods	x
Proximity, Social Economy and Civil Security	S96	Other personal service activities	x
Proximity, Social Economy and Civil Security	T	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use	x
Retail	G46	Wholesale trade, except of motor vehicles and motorcycles	x
Retail	G47	Retail trade, except of motor vehicles and motorcycles	x
Retail	H53	Postal and courier activities	x
Textile	C13	Manufacture of textiles	x
Textile	C14	Manufacture of wearing apparel	x
Textile	C15	Manufacture of leather and related products	x

Source: Consortium

Notes: Blank cells represent divisions of industrial ecosystems which were excluded from the analysis for ease of interpretation in the context of the industrial ecosystem report.

Figure 33 Industrial ecosystem coverage – Survey

Industrial ecosystem	NACE_rev2	Description	Scope
Tourism	H49	Land transport and transport via pipeline	
Tourism	H50	Water transport	
Tourism	H51	Air transport	
Tourism	I	Accommodation and food service activities	x
Tourism	N79	Travel agency, tour operator and other reservation service and related activitieS	x
Tourism	N82	Office administrative, office support and other business support activities	
Tourism	R93	Sports activities and amusement and recreation activities	x
Aerospace & Defence	C25	Manufacture of fabricated metal products, except machinery and equipment	
Aerospace & Defence	C26	Manufacture of computer, electronic and optical products	x
Aerospace & Defence	C27*	Manufacture of electrical equipment	
Aerospace & Defence	C30	Manufacture of other transport equipment	x
Aerospace & Defence	C33	Repair and installation of machinery and equipment	
Aerospace & Defence	H51	Air transport	x
Aerospace & Defence	H52*	Warehousing and support activities for transportation	
Aerospace & Defence	J61	Telecommunications	x
Aerospace & Defence	N80	Security and investigation activities	
Agri-food	A	Agriculture, forestry and fishing	x
Agri-food	C10	Manufacture of food products	x
Agri-food	C11	Manufacture of beverages	x
Agri-food	C12	Manufacture of tobacco products	
Construction	F	Construction	x
Construction	M71	Architectural and engineering activities; technical testing and analysis	x
Construction	N81	Services to buildings and landscape activities	x
Cultural and Creative Industries	C18	Printing and reproduction of recorded media	x
Cultural and Creative Industries	C18	Printing and reproduction of recorded media	
Cultural and Creative Industries	C32	Other manufacturing	
Cultural and Creative Industries	G47*	Retail trade, except of motor vehicles and motorcycles	
Cultural and Creative Industries	J58	Publishing activities	x
Cultural and Creative Industries	J59	Motion picture, video and television programme production, sound recording and music publishing activities	x
Cultural and Creative Industries	J60	Programming and broadcasting activities	
Cultural and Creative Industries	J62_63	Computer programming, consultancy and related activities;	
Cultural and Creative Industries	M71	Architectural and engineering activities; technical testing and analysis	
Cultural and Creative Industries	M73	Advertising and market research	x
Cultural and Creative Industries	M74_M75	Other professional, scientific and technical activities and veterinary activities	
Cultural and Creative Industries	N77	Rental and leasing activities	
Cultural and Creative Industries	P85	Education	
Cultural and Creative Industries	R90-R92	Creative, arts and entertainment activities; libraries, archives, museums and other cultural activities; gambling and betting activities	x
Cultural and Creative Industries	S94	Activities of membership organisations	
Cultural and Creative Industries	S95	Repair of computers and personal and household goods	

Industrial ecosystem	NACE_rev2	Description	Scope
Electronics	C26	Manufacture of computer, electronic and optical products	x
Electronics	C28	Manufacture of machinery and equipment n.e.c.	
Energy Intensive Industries	C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	x
Energy Intensive Industries	C17	Manufacture of paper and paper products	x
Energy Intensive Industries	C19	Manufacture of coke and refined petroleum products	x
Energy Intensive Industries	C20	Manufacture of chemicals and chemical products	x
Energy Intensive Industries	C22	Manufacture of rubber and plastic products	x
Energy Intensive Industries	C23	Manufacture of other non-metallic mineral products	x
Energy Intensive Industries	C24	Manufacture of basic metals	x
Health	C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	x
Health	C33	Manufacture of medical and surgical equipment and orthopaedic appliances	x
Health	C32	Other manufacturing	
Health	Q86	Human health activities	
Health	Q87_Q88	Residential care activities and social work activities without accommodation	
Mobility - Transport - Automotive	C27	Manufacture of electrical equipment	x
Mobility - Transport - Automotive	C29	Manufacture of motor vehicles, trailers and semi-trailers	x
Mobility - Transport - Automotive	C30	Manufacture of other transport equipment	x
Mobility - Transport - Automotive	G45	Wholesale and retail trade and repair of motor vehicles and motorcycles	
Mobility - Transport - Automotive	H49	Land transport and transport via pipelines	x
Mobility - Transport - Automotive	H50	Water transport	
Mobility - Transport - Automotive	H52	Warehousing and support activities for transportation	
Proximity, Social Economy and Civil Security	G47*	Retail trade, except of motor vehicles and motorcycles	
Proximity, Social Economy and Civil Security	I	Accommodation and food service activities	
Proximity, Social Economy and Civil Security	L	Real estate activities	
Proximity, Social Economy and Civil Security	N81	Services to buildings and landscape activities	
Proximity, Social Economy and Civil Security	N82	Office administrative, office support and other business support activities	
Proximity, Social Economy and Civil Security	Q87_Q88	Residential care activities and social work activities without accommodation	x
Proximity, Social Economy and Civil Security	S95	Repair of computers and personal and household goods	
Proximity, Social Economy and Civil Security	S96	Other personal service activities	
Proximity, Social Economy and Civil Security	T	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use	
Proximity, Social Economy and Civil Security	G47*	Retail trade, except of motor vehicles and motorcycles	
Proximity, Social Economy and Civil Security	I	Accommodation and food service activities	
Retail	G46	Wholesale trade, except of motor vehicles and motorcycles	x

Industrial ecosystem	NACE_rev2	Description	Scope
Retail	G47	Retail trade, except of motor vehicles and motorcycles	x
Textile	C13	Manufacture of textiles	x
Textile	C14	Manufacture of wearing apparel	x
Textile	C15	Manufacture of leather and related products	x

Source: Consortium

Notes: Blank cells represent divisions of industrial ecosystems which were excluded from the analysis to avoid

12 Appendix D: Technology coverage by patent, prodcom and trade data

Figure 34 Technologies - Patents

Technology	Approach
Green transition	
Micro- and Nanoelectronics	B82Y25/%, G01R31/26%, G01R31/27%, G01R31/28%, G01R31/303%, G01R31/304%, G01R31/317%, G01R31/327%, G09G3/14%, G09G3/32%, H01F1/40%, H01F10/193%, H01G9/028%, H01G9/032%, H01H47/32%, H01H57/%, H01L, H05K3/%, H03B5/32%, H03C3/22%, H03F3/04%, H03F3/06%, H03F3/08%, H03F3/10%, H03F3/12%, H03F3/14%, H03F3/16%, H03F3/183%, H03F3/21%, H03F3/343%, H03F3/387%, H03F3/55%, H03K17/72%, H05K1/%
Photonics	F21K, F21V, F21Y, G01J, G06E, H02S, G01D15/14%, G01D5/26%, G01D5/58%, G01G23/32%, G01L1/24%, G01L11/02%, G01L23/06%, G01L3/08%, G01M/11%, G01P3/36%, G01P3/38%, G01P3/68%, G01P5/26%, G01Q20/02%, G01Q30/02%, G01Q60/06%, G01Q60/18%, G01R15/22%, G01R15/24%, G01R23/17%, G01R31/308%, G01R33/032%, G01R33/26%, G01S7/481%, G01V8/%, G02B13/14%, G02B5/%, G03B/42%, G03G21/08%, G06F3/042%, G06K9/58%, G06K9/74%, G06N3/067%, G08B13/186%, G08C19/36%, G08C23/04%, G08C23/06%, G08G1/04%, G11B11/03%, G11B11/12%, G11B11/18%, G11B7/12%, G11B7/125%, G11B7/13%, G11B7/135%, G11C11/42%, G11C13/04%, G11C19/30%, H01J29/46%, H01J29/82%, H01J29/89%, H01J3/%, H01J31/50%, H01J37/04%, H01J37/05%, H01J49/04%, H01J49/06%, H01J5/16%, H01L31/052%, H01L31/055%, H01L31/10%, H01L33/06%, H01L33/08%, H01L33/10%, H01L33/18%, H01L51/50%, H01L51/52%, H01S3%, H01S5%, H02N6/%, H05B33/%, (G02B6/% NOT (G02B6/36%, G02B6/38%, G02B6/40%, G02B6/44%, G02B6/46%))
Advanced Manufacturing Technologies	B03C,B07C,B23H,B23K,B23P,B23Q,B25J,G01D,G01H,G01L,G01M,G01P,G01Q,G0B,G05D,G05F,G05G,G06M,G07C, B06B 1/6%, B06B 3/00, (G08C NOT (G01D 5/12, G05F 1/10, G07C 9/00, G01P 3/42, H01L 21/02, G05B 19/05, G01D 5/14, F02D 45/00, H01L 29/66, G05F 1/56, G05F 3/24, G07C 5/00, G05D 1/00, B60T 8/17, G05D 1/02, G01M 15/04, G01M 17/007, G07C 5/08, F02D 41/14, G05D 1/06, B60R 16/02, B62D 65/00, B60T 7/04, G01P 21/00, B60R 25/00, B62D 57/00, B60T 8/172, B60T 7/06, B62D 57/032, E05B 49/00, G01P 3/489, G05D 1/08)), (G06% AND (A21C, A22B, A22C, A23N, A24C, A41H, A42C, A43D, B01F, B02B, B02C, B03B, B03D, B05C, B05D, B07B, B08B, B21B, B21D, B21F, B21H, B21J, B22C, B23B, B23C, B23D, B23G, B24B, B24C, B25D, B26D, B26F, B27B, B27C, B27F, B27J, B28D, B30B, B31B, B31C, B31D, B31F, B41B, B41C, B41D, B41F, B41G, B41L, B41N, B42B, B42C, B44B, B65B, B65C, B65H, B67B, B67C, B68F, C13C, C13D, C13G, C13H, C14B, C23C, D01B, D01D, D01G, D01H, D02G, D02H, D02J, D03C, D03D, D03J, D04B, D04C, D05B, D05C, D06B, D06G, D06H, D21B, D21D, D21F, D21G, E01C, E02D, E02F, E21B, E21C, E21D, E21F, F04F, F16N, F26B, G01K, H05H))
Nanotechnology	B82B, B82Y%
Biotechnology	A01H1/00, A01H4/00, A61K38/00, A61K39/00, A61K48/00, C02F3/34%, C07G11/00, C07G13/00, C07G15/00, C07K4/00, C07K14/00, C07K16/00, C07K17/00, C07K19/00, G01N33/53%, G01N33/54%, G01N33/55%, G01N33/57%, G01N33/68%, G01N33/74%, G01N33/76%, G01N33/78%, G01N33/88%, G01N33/92%

Technology	Approach
Energy Saving Technologies	Y02P, Y02E20/%, Y02D10/%
Solar Power	Y02E10/4%, Y02E10/5%
Wind Power	Y02E10/7%
Other (geothermal, hydropower, biomass)	Y02E10/2%, Y02E10/1%, Y02E60/30%, Y02E60/32%, Y02E60/34%, Y02E60/36%, Y02E60/50%, Y02T90/40%, Y02P90/40%, Y02P90/45%, Y02E50/17%, A01C3/02%, B01D53/84%, C02F11/04%, C05F17/02%, F23G7/10%, F24D3/18%, F24D11/02%, F24D15/04%, F24D17/02%, F24H4%, F25B30%, F25B30/02%, F25B30/04%, F25B30/06%, F24D5/12%, C10L5/46%, C10L5/48%
Digital Transition	
Robotics	robot%
Internet of Things Iot	((A61B1/00', A61B5/00', A61B5/02%', A61B5/04%', A61B5/05%', A61B5/103%', G01S13/75%', G01V3/17%', G01V15/00', G05D1/03%', G06K7/00', G06K7/08%', G06K7/10%', G06K19/00', G06K19/06%', G06K19/07%', G06K19/077%', G08B5/22%', G08B6/00', G08B13/14%', G08B13/24%', G08B21/00', G08B25/10%', G08B29/00, G09F3/00', G09F3/03%', H01Q7/00', H01Q9/04%', H02J17/00', H04Q5/22%', H04Q7/00', H04Q9/00', H04B1/48%', H04B1/59%', H04B7/00', H04B7/08%') AND (rfid, nfc, (radio%(5W)frequency%(5W)ident%),(near(5W)field%(5W)communicat%))), H04B5%', G08C17%'
Artificial Intelligence	essentially taken from an OECD study -> https://www.oecd.org/digital/identifying-and-measuring-developments-in-artificial-intelligence-5f65ff7e-en.htm Annex Table C.1. List of AI-related keywords, Annex Table C.2. List of IPC Codes, Annex Table C.3. List of CPC codes
Big Data	((G06F17/30%, G06F19/10%, G06Q30/02%, G06F17/50%, G06N) AND (big\-data, big{-}data, hadoop, yarn, aster, datameer, fico\-blaze, fico{-}blaze, vertica, platfora, splunk ,mapreduce, map\-reduce, map{-}reduce, open\-data, open{-}data, data\-warehous%, data{-}warehous%, informatic%, data\-mine_, data{-}mine_, data\-mining, data{-}mining, simulate%, model%, analy%, artificial\-intelligence, articial{-} intelligence, neural\-network%, neural{-}network%, distributed%'(cluster%(W5)based), (cluster%(W5)comput%), (cluster%(W5)server_), (cluster%(W5)process%),(cluster%(W5)software), (cluster%(W5)application), (cloud%, based),(cloud%, comput%),(cloud%, server_),(cloud%, process%),(cloud%, software),(cloud%, application),(grid_, based),(grid_, comput%),(grid_, server_), (grid_, process%),(grid_, software), (grid_, application), croudsourc%, crowd\-sourc%, crowd{-}sourc%, massively\-parallel\-process%, massively{-}parallel{-}process%, massively\-parallel\-software, massively{-}parallel{-}software, massively\-parallel\-database_, massively{-}parallel{-}database_, distributed\-process%, distributed{-}process%, distributed\-server_, distributed{-}server_, distributed\-quer%, distributed{-}quer%, distributed\-database_, distributed{-}database_, massive\-data, massive{-}data'))
Digital Security	G09C, H04K, G06F12/14%, G06F21/%, G06K19/%, G11C8/20%, H04L9/%, H04M1/66% , H04M1/663%, H04M1/665%, H04M1/667%, H04M1/67%, H04M1/673%, H04M1/675%, H04M1/68%, H04M1/70%, H04M1/727%, H04N7/167%, H04N7/169%, H04N7/171%,H04W12/%
Digital Mobility	G01S, G08G, H04B7/185%, H04B10/105%, G01C11/%, G01C19/%, G01C21/%, G06F17/00, G06F19/00
Advance Materials	C03C, C08F, C08L, C22C, C23C, B32B15/%, B32B17/%, B32B18/%, B32B19/%, B32B25/%, B32B27/%, B32B9/%, B82Y30/%, C01B31/%, C01B32/00, C01B32/05%, C01B32/10%, C01B32/15%, C01B32/152%, C01B32/154%, C01B32/156%, C01B32/158%, C01B32/159%, C01B32/16%, C01B32/162%, C01B32/164%, C01B32/166%, C01B32/168%, C01B32/17%, C01B32/172%, C01B32/174%, C01B32/176%, C01B32/178%, C01B32/18%, C01B32/182%, C01B32/184%, C01B32/186%, C01B32/188%, C01B32/19%, C01B32/192%, C01B32/194%, C01B32/196%, C01B32/198%, C01B32/20%, C01B32/205%, C01B32/21%, C01B32/215%, C01B32/22%, C01B32/225%, C01B32/23%, C01B32/25%, C01B32/26%, C01B32/28%, C01B32/30%, C01B32/306%, C01B32/312%, C01B32/318%, C01B32/324%, C01B32/33%, C01B32/336%, C01B32/354%, C01B32/36%, C01B32/366%, C01B32/372%, C01B32/378%, C01B32/39%, C01B32/342%, C01B32/348%, C01B32/384%, B01J39/24%, B01J41/18%, C01B32/40%, C01B32/50%, C01B32/55%, C01B32/60%, C01B32/70%, C01B32/72%, C01B32/75%, C01B32/77%, C01B32/80%, C01B32/90%, C01B32/907, C01B32/914%, C01B32/921%, C01B32/928%, C01B32/935%, C01B32/942%, C01B32/949%, C01B32/956%, C01B32/963%, C01B32/97%, C01B32/977%, C01B32/984%, C01B32/991%, C01D15/%, C01D17/%,

Technology	Approach
	C01F13/%, C01F15/%, C01F17/%, C04B35/%, C08J5/%, D21H17%, G02B1%, H01B3%, H01F1/0%, H01F1/12%, H01F1/34%, H01F1/42%, H01F1/44%, H01L51/30%, H01L51/46%, H01L51/54%

Source: Consortium

Figure 35 Technologies - Trade

Technology	Approach
Green Transition	
Advanced Materials	281810, 284210, 284610, 284690, 285200, 300510, 300590, 300670, 321590, 340700, 380110, 380120, 380130, 380190, 380210, 381220, 381230, 381800, 382430, 390950, 391400, 400520, 400591, 400599, 540310, 540331, 540332, 540333, 540339, 540500, 550200, 550410, 550490, 690911, 690912, 690919, 700711, 700719, 700721, 700729, 760310, 760320, 850519, 850730, 850740, 850780, 852210, 854590, 900140, 900150
Nanotechnology	320710, 320720, 320730, 320740, 321590, 380110, 380120, 380130, 380190, 850730, 850740, 850780, 854590
Biotechnology	843231, 843239, 210210, 210220, 210210, 290539, 291521, 291814, 291815, 291811, 291816, 291819, 291829, 291830, 291891, 291899, 292221, 292229, 292231, 292239, 292249, 292250, 350700, 350710, 350790, 220710, 380892, 382499, 382491, 382499, 292241, 292242, 293621, 293622, 293623, 293624, 293625, 293626, 293627, 293628, 293629, 293690, 294110, 294120, 294130, 294140, 294150, 294160
Energy Saving Technologies	732211, 840310, 840390, 840211, 840220, 854140, 854190, 852990, 853710, 853932, 853941, 940560, 841911, 853120, 853120, 850440, 850440, 850440, 848180, 841950, 841583, 841861, 853669, 853931
Renewable Energy Technologies	680690, 730431, 730431, 730439, 730490, 730820, 854140, 854190, 900211, 900290, 850300, 850650, 850650, 850650, 850680, 850690, 850720, 850720, 850760, 850440, 850440, 841011, 850231, 841090, 841239, 841290, 841480, 841490, 841950, 841861, 847930, 880310, 854330, 280461, 392099, 722840, 903289, 901390, 850220, 853710, 840790, 940541
Digital Transition	
Micro- and Nanoelectronics	854110, 854121, 854129, 854130, 854140, 854150, 854160, 854231, 854232, 854233, 854239
Photonics	854110, 852340, 853120, 854140, 854190, 854470, 900110, 900120, 900190, 900211, 900219, 900220, 900290, 900510, 900580, 900610, 900630, 900661, 900669, 900720, 900810, 900830, 900840, 901010, 901050, 901060, 901110, 901120, 901310, 901320, 901380, 901820, 902221, 902229, 902730, 902750, 903141, 903149
Advanced Manufacturing	845610, 845620, 845630, 845690, 845710, 845730, 845811, 845921, 845931, 845951, 845961, 846011, 846021, 846031, 846221, 846231, 846241, 847950, 848610, 848620, 848630, 848640, 851531, 902410, 902480, 902730, 902750, 902810, 902820, 903082, 903180, 903281
Robotics	842489, 842890, 847950, 848640, 851580, 852380, 853400, 854231, 902219, 902290, 903210, 903290
Internet of Things (IoT)	844331, 847149, 850610, 850630, 850640, 850650, 850660, 850680, 850690, 851762, 851769, 851950, 852340, 852351, 852352, 852359, 852380, 852610, 852691, 852692, 852713, 852719, 852791, 852799, 852990, 853010, 853080, 853090, 853120, 853400, 854320, 854390, 854470, 900110, 902810, 902830, 903040, 903180
Artificial Intelligence	847010, 847149, 847150, 847170, 847321, 852329, 852351, 852359, 852380, 852841, 852851, 852861, 853180, 854320, 854370, 900711, 900719, 950410
Big Data	847010, 847150, 847170, 852329, 852359, 852380, 854320
Digital Security	852329, 852351, 852352, 852359, 852380, 853110, 853120, 854232, 854233, 854290, 903040
Digital Mobility	852380, 852610, 852691, 852990, 853010, 853080, 853090, 860110, 900580, 901410, 901420, 901480, 901580, 902910

Source: Consortium

Figure 36 Technologies – Prodcom (generation)

Technology	Prodcom code
AI	26201400, 26201700, 26202100, 26201500, 26202200, 26406050, 26403300, 26701300, 26801100, 26801300, 27904530, 27902080, 27901150, 28231000, 28232210
Advanced Materials and Nanotechnology	20135275, 20136270, 20136510, 20136520, 20136550, 20136580, 20136585, 20165670, 20165970, 20302130, 20302150, 20302170, 20593000, 20595230, 20595300, 20595400, 20595640, 20595650, 20595740, 20595940, 20602140, 20602150, 20602200, 20602320, 20602340, 20602390, 20602400, 21202420, 21202430, 21202440, 22192019, 23121210, 23121230, 23121250, 23121270, 23441100, 23441210, 23441230, 23991400, 23991500, 24101240, 24101250, 24101255, 24101265, 24101270, 24101280, 24101285, 24101295, 24422100, 24422450, 26112220, 26112240, 26114010, 26114070, 26702153, 27202310, 27202320, 27202330, 27202340, 27202350, 27202395, 27901390, 32502235, 32502253, 32502255, 32502259, 32502290, 32504153, 32504155, 32504159, 32504170, 32504290, 32505010, 32505020
Advanced Manufacturing & Robotics	26112260, 26115050, 26115020, 26113003, 26121080, 26516500, 26515235, 26518550, 26517015, 26515330, 26515135, 26516350, 26516330, 26515239, 26514500, 26516200, 26515271, 26515175, 26517019, 26515283, 26516690, 26515381, 26601170, 26601119, 26702450, 26801300, 27903154, 27903181, 28152475, 28221840, 28296050, 28292240, 28412220, 28412123, 28412240, 28412300, 28411240, 28411270, 28412217, 28413120, 28412130, 28411220, 28413140, 28413310, 28411140, 28411120, 28413240, 28411150, 28491340, 28491310, 28992020, 28993945, 28993935, 28992040, 28992060
Big Data and Cloud Computing	26201500, 26202100, 26801300, 26801100, 27904530, 28231000
Energy Saving Technologies	25211300, 25211200, 25211100, 25301110, 25301170, 26114070, 26112220, 26304065, 27123150, 27401550, 27401570, 27402400, 27521400, 27902020, 27904155, 27902050, 27904153, 27904140, 28141253, 28251270, 28251380, 28251130
Biotechnology (including Medical Biotechnology)	10891350, 10891339, 10891334, 20143271, 20147400, 20144290, 20142338, 20143473, 20146470, 20143382, 20143475, 20201590, 20595994, 20595957, 21105100, 21105400, 21102020, 21102010
Internet of Things	26121080, 26122000, 26123000, 26201800, 26201400, 26202200, 26203000, 26302320, 26302370, 26304065, 26401100, 26405190, 26512020, 26512060, 26518110, 26512080, 26516370, 26514400, 26516330, 26511190, 26516690, 26801200, 26801300, 27201140, 27201175, 27201155, 27201170, 27201200, 27201110, 27201125, 27201120, 27201130, 27201190, 27201115, 27201150, 27201160, 27311200, 27311100, 27904530, 27903330, 27902050, 27907030, 27903370, 27907010
Micro- and Nanoelectronics & Photonics	26113067, 26113023, 26112220, 26113065, 26112240, 26112180, 26114070, 26113091, 26113034, 26112150, 26113003, 26112120, 26113006, 26113027, 26113080, 26113054, 26112280, 26113094, 26112260, 26202200, 26304065, 26403400, 26405190, 26512020, 26518110, 26515330, 26601130, 26601170, 26601300, 26601115, 26702450, 26702155, 26702270, 26702153, 26702180, 26702250, 26701650, 26701250, 26702310, 26702230, 26702170, 26702390, 26702330, 26702490, 26701910, 26701100, 26801200, 27311200, 27311100, 27403010, 27403030, 27402500, 27902050, 28411120, 32501335
Digital Tech for Mobility	26304065, 26405190, 26518110, 26512020, 26511190, 26512060, 26801300, 27903330, 27907010, 27907030, 30201100
Renewable Energy Technologies (including solar, wind, batteries, geothermal, hydropower, biomass, hydrogen)	23991930, 24201400, 24201350, 24201330, 24201370, 25112200, 26114070, 26112240, 26702155, 26701100, 27116110, 27201200, 27202350, 27201155, 27201190, 27202230, 27201160, 27202240, 27201150, 27904200, 27904153, 27904155, 28112200, 28113200, 28112400, 28121200, 28122000, 28132800, 28133200, 28251380, 28251130, 28491287, 28491283, 30114050, 30305030
Digital Security & Networks	26113054, 26113027, 26113080, 26114090, 26113065, 26113067, 26113034, 26122000, 26123000, 26203000, 26202200, 26305020, 26305080, 26514400, 26801100, 26801300, 27902050

Source: Consortium

Figure 37 Technologies – Prodcom (diffusion)

Technology	Prodcom code
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Advanced Materials and Nanotechnology	18121620, 20301250, 20301170, 20301150, 20302470, 20301230, 21202340, 21201160, 21201250, 21201230, 23121350, 23121190, 23121150, 23121330, 23121390, 23141220, 23141240, 23991950, 24322030, 25302200, 25301330, 25301250, 25401250, 25401230, 25401270, 25612290, 25612250, 25611250, 25611170, 25611150, 25612270, 25612230, 25611190, 25611130, 25612100, 25611230, 25734061, 25734023, 25734048, 25734069, 25734087, 25734079, 25734014, 25734037, 25734016, 25734074, 25734019, 25734085, 25734025, 25734044, 25734045, 25734031, 25734089, 25734066, 25734083, 25734081, 25734071, 25734035, 25734050, 25734033, 25734027, 26115020, 26112280, 26113067, 26112120, 26113080, 26113023, 26113034, 26115050, 26113006, 26113054, 26113003, 26113027, 26112180, 26114090, 26113094, 26113065, 26112260, 26113091, 26112150, 26123000, 26201100, 26305080, 26302200, 26403400, 26404239, 26403200, 26404270, 26404235, 26601150, 26601300, 26601280, 26601130, 26601170, 26601230, 26601115, 26702270, 26701910, 26702530, 26702180, 26701100, 26701500, 26702155, 26702330, 26701990, 26702510, 26701300, 26702230, 26702250, 26702310, 26701250, 26702610, 26701400, 26702390, 26701650, 26702170, 27202240, 27202410, 27202120, 27202110, 27201120, 27201150, 27202230, 27201155, 27201200, 27201170, 27201115, 27201190, 27201175, 27202420, 27201130, 27201125, 27201140, 27201110, 27201160, 27311100, 27311200, 29202100, 29201030, 29201050, 29322090, 29323040, 29322050, 29323010, 29323067, 30114030, 30119200, 30114050, 30119100, 30121100, 30121930, 30303200, 30303300, 30305010, 30303400, 30304000, 30301300, 30305030, 30301400, 30302000, 30301200, 30301100, 30305050, 30303100, 30913100, 30913200, 30911100, 30911200, 30911300, 30921000, 30923010, 30922030, 30924030, 30922090, 32301150, 32301590, 32301400, 32301580, 32301510, 32301200, 32301530, 32301300, 32301131, 32301550, 32301560, 32301600, 32301137, 32501355, 32501365, 32501130, 32501311, 32502239, 32501317, 32501353, 32501320, 32501315, 32504350, 32501150, 32501380, 32504400, 32501335, 32501340, 32504130, 32505030, 32504250, 32501333, 32503050, 32501313, 32501370, 32502180, 32503030, 32501363, 32502130, 32504390
Advanced Manufacturing & Robotics	24105130, 24102221, 24102321, 24102122, 24105110, 24102322, 24105140, 24102121, 24102110, 24102222, 24202200, 24203110, 24201250, 24202150, 24203150, 24201210, 24201110, 24202110, 24201150, 25301330, 25301250, 25302200, 25301350, 25301230, 25301150, 25302100, 25301110, 25301170, 25401230, 25401270, 25401250, 25734019, 25734066, 25736043, 25734079, 25735050, 25734081, 25735060, 25734016, 25734083, 25734089, 25735030, 25734033, 25736067, 25736013, 25736065, 25734045, 25736039, 25735080, 25734085, 25735070, 25736063, 25734074, 25734014, 25736090, 25734061, 25736033, 25735015, 25735013, 25736018, 25734025, 25734027, 25734071, 25734048, 25734087, 25734031, 25736050, 25734037, 25736045, 25734035, 25734069, 25734044, 25734050, 25736023, 25734023, 25736024, 25735020, 25991270, 26114090, 26112280, 26112240, 26113065, 26112180, 26113027, 26114070, 26113080, 26113023, 26113091, 26113054, 26113067, 26112150, 26113034, 26112120, 26113006, 26112220, 26113094, 26122000, 26123000, 26201660, 26201400, 26203000, 26201100, 26201610, 26201620, 26201500, 26201650, 26202200, 26202100, 26201800, 26201700, 26201300, 26201200, 26301200, 26301100, 26302320, 26305080, 26305020, 26302100, 26301300, 26302310, 26302200, 26304060, 26302330, 26304010, 26304039, 26303000, 26302370, 26406050, 26402090, 26403300, 26404355, 26403400, 26404270, 26404400, 26401100, 26404359, 26401270, 26401290, 26404370, 26511150, 26515313, 26511120, 26511200, 26516100, 26511190, 26515139, 26513300, 26517090, 26513100, 26515395, 26516453, 26517030, 26514300, 26512060, 26515383, 26515320, 26516430, 26514100, 26514400, 26515319, 26515150, 26512020, 26511180, 26516455, 26512080, 26516370, 26601150, 26601300, 26601433, 26601115, 26601130, 26601280, 26601230, 26601450, 26601439, 26702270, 26702330, 26702420, 26702530, 26702180, 26701100, 26702250, 26702390, 26701250, 26702155, 26702510, 26702170, 26701300, 26701990, 26701500, 26702230, 26702610, 26701650, 26701910, 26701400, 26702153, 26702490, 26702310, 26801200, 26801400, 27114240, 27114330, 27114180, 27116205, 27115080, 27114260, 27116208, 27114120, 27114220, 27115050, 27114380, 27116110, 27116203, 27114150, 27123170, 27123203, 27123205, 27124030, 27201150, 27201175, 27202330, 27201170, 27201160, 27201115, 27201155, 27201125, 27202410, 27201120, 27202340, 27201140, 27201200, 27202310, 27202320, 27202350, 27202420, 27201190, 27201130, 27201110, 27202395, 27311100, 27311200, 27402400, 27403030, 27401100, 27402200, 27402500, 27904140, 27907030, 27905240, 27906037, 27902020, 27904130, 27904155, 27902080, 27904200, 27904170, 27905220, 27905100, 27901390, 27902050, 27903118, 27904530, 27903145, 27901150, 27903191, 27904510, 27904190, 27904153, 27905300, 27907010, 28112400, 28122000, 28121420, 28121180, 28121480, 28131220, 28131250, 28141180, 28141313, 28152434, 28152432, 28152433, 28151030, 28151057, 28151055, 28151090, 28153130, 28151070, 28151053, 28152440, 28152473, 28221450, 28232110, 28231000, 28241113, 28241185,

Technology	Prodcom code
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Big Data and Cloud Computing	18201070, 18202070, 18203050, 18203070, 18203030, 26201300, 26204000, 26202200, 26201660, 26201100, 26203000, 26201400, 26302370, 26302320, 26304010, 26304060, 26403100, 26404359, 26401290, 26404370, 26402090, 26404400, 26403200, 26401100, 26404270, 26401270, 26801200, 27116208, 27123130, 27904140, 27903350, 27902080, 28252010
Energy Saving Technologies	23121330, 23192100, 23192500, 23192400, 23431050, 23431030, 23491230, 23991930, 24104150, 24104130, 24105310, 24512000, 25291120, 25301150, 25301330, 25301350, 25301230, 26115020, 26115050, 26114090, 26202100, 26201700, 26203000, 26201500, 26403400, 26517019, 26517015, 27115013, 27121090, 27121020, 27122330, 27122350, 27122230, 27123130, 27122250, 27122370, 27201150, 27201190, 27201155, 27201200, 27201160, 27331100, 27331360, 27331330, 27331350, 27331380, 27331310, 27401300, 27402200, 27512900, 27512560, 27512123, 27512450, 27511400, 27512890, 27512870, 27512310, 27512125, 27512170, 27512330, 27512410, 27512370, 27512690, 27512530, 27513030, 27512430, 27512490, 27512810, 27512650, 27513070, 27512200, 27513050, 27511133, 27511530, 27512850, 27512630, 27512350, 27512830, 27521270, 27521113, 27521234, 27521115, 27521300, 27521250, 27521190, 27522000, 27901230, 27901280, 27905100, 28131417, 28141313, 28211351, 28211354, 28211470, 28211270, 28211230, 28253010, 28251333, 28253080, 28253070, 28251360, 28251250, 28251220, 28251335, 28251240, 28296090, 28294330, 28296030
Biotechnology (including Medical Biotechnology)	24202110, 24201150, 25301330, 25301250, 25302200, 25301350, 25301230, 25301150, 25302100, 25301110, 25301170, 25401230, 25401270, 25401250, 25734019, 25734066, 25736043, 25734079, 25735050, 25734081, 25735060, 25734016, 25734083, 25734089, 25735030, 25734033, 25736067, 25736013, 25736065, 25734045, 25736039, 25735080, 25734085, 25735070, 25736063, 25734074, 25734014, 25736090, 25734061, 25736033, 25735015, 25735013, 25736018, 25734025, 25734027, 25734071, 25734048, 25734087, 25734031, 25736050, 25734037, 25736045, 25734035, 25734069, 25734044, 25734050, 25736023, 25734023, 25736024, 25735020, 25991270, 26114090, 26112280, 26112240, 26113065, 26112180, 26113027, 26114070, 26113080, 26113023, 26113091, 26113054, 26113067, 26112150, 26113034, 26112120, 26113006, 26112220, 26113094, 26122000, 26123000, 26201660, 26201400, 26203000, 26201100, 26201610, 26201620, 26201500, 26201650, 26202200, 26202100, 26201800, 26201700, 26201300, 26201200, 26301200, 26301100, 26302320, 26305080, 26305020, 26302100, 26301300, 26302310, 26302200, 26304060, 26302330, 26304010, 26304039, 26303000, 26302370, 26406050, 26402090, 26403300, 26404355, 26403400, 26404270, 26404400, 26401100, 26404359, 26401270, 26401290, 26404370, 26511150, 26515313, 26511120, 26511200, 26516100, 26511190, 26515139, 26513300, 26517090, 26513100, 26515395, 26516453, 26517030, 26514300, 26512060, 26515383, 26515320, 26516430, 26514100, 26514400, 26515319, 26515150, 26512020, 26511180, 26516455, 26512080, 26516370, 26601150, 26601300, 26601433, 26601115, 26601130, 26601280, 26601230, 26601450, 26601439, 26702270, 26702330, 26702420, 26702530, 26702180, 26701100, 26702250, 26702390, 26701250, 26702155, 26702510, 26702170, 26701300, 26701990, 26701500, 26702230, 26702610, 26701650, 26701910, 26701400, 26702153, 26702490, 26702310, 26801200, 26801400, 27114240, 27114330, 27114180, 27116205, 27115080, 27114260, 27116208, 27114120, 27114220, 27115050, 27114380, 27116110, 27116203, 27114150, 27123170, 27123203, 27123205, 27124030, 27201150, 27201175, 27202330, 27201170, 27201160, 27201115, 27201155, 27201125, 27202410, 27201120, 27202340, 27201140, 27201200, 27202310, 27202320, 27202350, 27202420, 27201190, 27201130, 27201110, 27202395, 27311100, 27311200, 27402400, 27403030, 27401100, 27402200, 27402500, 27904140, 27907030, 27905240, 27906037, 27902020, 27904130, 27904155, 27902080, 27904200, 27904170, 27905220, 27905100, 27901390, 27902050, 27903118, 27904530, 27903145, 27901150, 27903191, 27904510, 27904190, 27904153, 27905300, 27907010, 28112400, 28122000, 28121420, 28121180, 28121480, 28131220, 28131250, 28141180, 28141313, 28152434, 28152432, 28152433, 28151030, 28151057, 28151055, 28151090, 28153130, 28151070, 28151053, 28152440, 28152473, 28221450, 28232110, 28231000, 28241113, 28241185, 28251450, 28253010, 28253050, 28251440, 28252070, 28251430, 28251250, 28253030, 28252010,

Technology	Prodcom code
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Internet of Things	18203070, 18203050, 18203030, 22299197, 26113067, 26113091, 26113080, 26115050, 26112120, 26114070, 26113023, 26113094, 26113034, 26112180, 26112240, 26112220, 26112150, 26113006, 26115020, 26113054, 26112280, 26113027, 26112260, 26113003, 26114090, 26113065, 26201200, 26201700, 26201610, 26201650, 26204000, 26201300, 26201500, 26201620, 26201100, 26304035, 26302100, 26304060, 26302340, 26303000, 26302330, 26301200, 26304010, 26302200, 26301100, 26304040, 26302310, 26304050, 26304039, 26301300, 26403100, 26401270, 26404400, 26403200, 26402020, 26402090, 26401290, 26402040, 26404355, 26517090, 26511200, 26511180, 26518600, 26511150, 26522440, 26522470, 26601450, 26601280, 26601433, 26601439, 26601130, 26601300, 26601119, 26601115, 27116208, 27124030, 27123150, 27124090, 27123130, 27321200, 27904140, 27903350, 27902080, 28232210, 28232110, 28231000, 28252010, 28308100, 28308200, 28309400, 28309380, 30204060, 30204050, 32501380, 32501363, 32501365, 32501320, 32501370, 32501340, 32501355, 32501353, 32501333, 32501335
Micro- and Nanoelectronics & Photonics	20591150, 20591200, 20591130, 20591170, 25302100, 25302200, 25301150, 26114090, 26115050, 26115020, 26114040, 26111200, 26123000, 26121080, 26122000, 26201100, 26202100, 26201700, 26201500, 26201610, 26201400, 26203000, 26201620, 26201650, 26201300, 26201800, 26201660, 26201200, 26301100, 26302320, 26302330, 26301200, 26304039, 26302310, 26301300, 26302100, 26302370, 26305020, 26302200, 26305080, 26401290, 26404400, 26404370, 26404359, 26404270, 26403300, 26401270, 26401100, 26402090, 26406050, 26404355, 26513300, 26516430, 26516453, 26511120, 26511190, 26514300, 26512080, 26511150, 26515383, 26516455, 26511180, 26517090, 26515139, 26511200, 26512060, 26521300, 26521400, 26522470, 26521100, 26522440, 26522410, 26521200, 26601450, 26601433, 26601230, 26601150, 26601280, 26701400, 26701990, 26702420, 26701300, 26701500, 26801400, 26801300, 27116205, 27115050, 27114260,

Technology	Prodcom code
	27114180, 27114220, 27114150, 27114380, 27116203, 27114330, 27116110, 27114120, 27116208, 27115080, 27114240, 27124030, 27123170, 27123203, 27123205, 27201170, 27201200, 27201160, 27202340, 27201175, 27201150, 27201125, 27201190, 27202330, 27201110, 27202350, 27201115, 27201130, 27201120, 27202310, 27202320, 27202395, 27201155, 27201140, 27403090, 27402400, 27401100, 27401570, 27401293, 27402200, 27401510, 27401530, 27401295, 27402100, 27401250, 27905300, 27904190, 27905240, 27907010, 27904155, 27901150, 27904170, 27905100, 27907030, 27905220, 27906037, 27904510, 27904200, 27904140, 27902020, 27904130, 27904153, 27904530, 28112400, 28141313, 28231000, 28232110, 30304000, 32504250, 32504153, 32504130, 32504159, 32501150, 32504155, 32504290, 32504170, 32501320, 32501200, 32911210
Digital Tech for Mobility	18203070, 18203030, 18203050, 26122000, 26302200, 26302370, 26304010, 26403300, 26401290, 26401270, 26516453, 26512080, 26518450, 26521300, 26702310, 26701300, 27124090, 27124030, 27903350, 27902080, 27902050, 27904530, 27902020, 28252010, 29312330, 29312350, 30204050, 30204060, 30304000
Renewable Energy Technologies (including solar, wind, batteries, geothermal, hydropower, biomass, hydrogen)	25291200, 25291110, 25301350, 25301250, 26515383, 26515283, 26516370, 26515274, 26515289, 26515271, 26515259, 26515381, 26518433, 26518435, 26515395, 26516330, 27114150, 27114180, 27114120, 27114380, 27114330, 27114240, 27114260, 27114220, 27122250, 27123170, 27123203, 27123205, 27121090, 27122230, 27121020, 27202420, 27202395, 27202410, 27321200, 27321400, 27321100, 27321380, 27331360, 27331380, 27905240, 27906035, 27906057, 27906055, 27901350, 27908200, 27905100, 27901330, 27901280, 27906080, 27905220, 27906037, 27908100, 28112300, 28112160, 28113300, 28113100, 28121480, 28121530, 28121450, 28121580, 28131380, 28211430, 28211150, 28251150, 30112270, 30114030
Digital Security & Networks	18203050, 18203070, 18202070, 18203030, 26112220, 26111100, 26112260, 26112150, 26112180, 26112240, 26112280, 26113023, 26112120, 26113003, 26115050, 26113091, 26115020, 26114070, 26113094, 26113006, 26201700, 26201200, 26304010, 26302370, 26301100, 26302340, 26301300, 26303000, 26304060, 26301200, 26304039, 26304050, 26302330, 26302310, 26304035, 26302200, 26302100, 26304040, 26403300, 26404400, 26402020, 26404355, 26403400, 26402090, 26402040, 26521400, 26701300, 29312330

Source: Consortium

13 Appendix E: Survey questionnaire

Digital transformation (A)
Technology selection

A.0 Which of the following technologies is your organisation using or planning to use?

- Already using
- Planning to adopt in the next two years
- Not using and no plans
- Not aware of, or never heard of this technology

Digital Technologies List

- Artificial intelligence (AI) systems
- Big Data and analytics solutions
- Augmented and virtual reality (AR/VR)
- Internet of Things (IoT) solutions
- Robotics
- Blockchain (and other distributed ledger technologies)
- Cloud software and cloud computing
- Edge computing
- Digital software (eg. business intelligence or production software)
- Online platform (to communicate with customers/suppliers, e-commerce)
- Digital twin
- Digital micro-factory
- Others (please record and ask the respondent to explain in detail what other digital technologies they consider as transformative and adopted or planning to adopt)

Artificial Intelligence and Big Data

A1. In which of the following value chain stage and area does your organisation use or plan to use AI and Big Data?

Material sourcing and design:
1.1 Support to material/design selection (predictions)
1.2 Cognitive intelligence embedded in the final product ('smart products')
1.3 Circular, environmentally friendly design

Production:
2.1 Optimisation of production processes
2.2 Automation of production processes
2.3 Quality control/error detection

Business operation:
3.1 Analysis of supply chain data/ automated supply tracking
3.2 Predictions, forecasting, assistance to support decision-making
3.3 Recruitment intelligence
3.4 Accounts payable/accounts receivable automation

Sales:

4.1 Analysis of customer behavior and planning of marketing strategies
4.2 Customer service and new service delivery models (including intelligent assistants, chatbots etc)

End of product lifecycle:
5.1 Recycling

Other:

Augmented and virtual reality

A2. In which of the following areas does your organisation use or plan to use augmented/virtual reality?

Material sourcing and design:
1.1 Virtual material sourcing
1.2 Virtual product development (e.g., simulation, or testing serviceability of new products in the design/engineering phase)
1.3 Circular/environmental friendly design

Production:
2.1 AR/VR based simulation to support/prepare production
2.2 Inventory visualisation and management

Business operation:
3.1 AR/VR-based business meeting and collaboration
3.2 AR/VR based training of personnel
3.3 Workflow management, eg. remote worker management

Sales:
4.1 Augmented/virtual customer data visualisation (e.g., portfolio simulation, asset return, risk management)
4.2 AR/VR-based customer experience

End of product lifecycle:
5.1 Recycling

Other:

Internet of Things

A3. In which of the following areas does your organisation use or plan to use IoT?

Material sourcing and design:
1.1 Support to material/design selection (predictions)
1.2 Cognitive intelligence embedded in the final product ('smart products')

Production:
2.1 Sensor-based production systems
2.2 Remote asset monitoring and management (e.g., preventing physical intrusion, fleet and transportation equipment management)
2.3 Predictive maintenance of productions assets
2.4 Traceability for logistics (automatic track and trace of materials, tools and products inside the organisation (inventory and warehouse)

Business operation:

3.1 Sensor-based staff identification and location (e.g., access control or time reporting)
3.2 Smart lighting/HVAC/elevator for energy saving

Sales:
4.1 Connected products/wearables to enable new consumer services and business models

End of product lifecycle:
5.1 Recycling
5.2 Remote environmental monitoring (CO2 emissions, level of noise, level of dust

Other:

Robotics

A4. In which of the following areas does your organisation use or plan to use robotics?

Material sourcing and design:
1.1 Product quality test, testing during design

Production:
2.1 Robots for production (product assembly)
2.2 Robots and drones for monitoring of production
2.3 Inventory management

Business operation:
3.1 Business administration

Sales:
4.1 Logistics, warehouse management and automated transportation
4.2 Autonomous Street vehicles
4.3 Service robots (to support customers)

End of product lifecycle:
5.1 Waste management

Other:

Blockchain including other Distributed Ledger Technologies

A5. In which of the following areas does your organisation use or plan to use blockchain?

Material sourcing and design:
1.1 Product quality test, testing during design

Production:
2.1 Product/service traceability
2.2 Asset and goods management

Business operation:
3.1 Supply chain transactions

3.2 Payment
3.3 Regulatory compliance/ environmental impact assessment and climate change/ESG reporting

Sales:
4.1 Smart logistics network
4.2 Loyalty programmes and warranty claims

End of product lifecycle:
5.1 Recycling and end of life

Other:

Green transformation (C)

C.1 Which of the following clean/green technologies has your organisation adopted or planning to adopt?

- Renewable energies
- Hydrogen
- Energy-saving technologies
- Advanced materials including organic, bio-based, biodegradable
- Recycled materials
- Clean production technologies (reducing the use of natural resources)
- Recycling technologies and waste management technologies
- Additive manufacturing
- Biotechnology

C.2 Which of the following green business models/non-technological solutions has your organisation adopted or planning to adopt?

- Remanufacturing
- Renting, leasing and related service models (eg. sharing products or sharing equipment)
- Repair and maintenance services (repair workshops and repair cafés)
- Resell, reuse (second-hand operation)
- Circular design (products that can be disassembled and recycled)
- Design for durability (products that can last longer)
- Digital product passport/ transparent supply chains
- Others (please record)

C.3 Is your company certified on any third party verified environmental standards? Which one?

- Yes
- No

C4. What is the share of energy that you source from renewable energies?

- Less than 5%
- Between 5-20%
- Between 20-50%
- Between 50-75%
- More than 75%

C5. What is the share of recycled materials that you use within your products/production?

- Less than 5%
- Between 5-20%
- Between 20-50%
- Between 50-75%
- More than 75%

C6. What is the share of fabric waste that you have repurposed?

- Less than 5%
- Between 5-20%
- Between 20-50%
- Between 50-75%
- More than 75%

C7. What is the share of organic materials that you use within your products/production?

- Less than 5%
- Between 5-20%
- Between 20-50%
- Between 50-75%
- More than 75%

C7. What share of your turnover do service models represent (e.g. services for reuse, remanufacturing, repair, rental etc)?

- Less than 5%
- Between 5-20%
- Between 20-50%
- Between 50-75%
- More than 75%

C8. Is the use of circular service models cost-effective for your business (does it pay off)?

- Yes
- No

Investments (D)

D1. During the last five years has your firm/organisation increased its investments or expenditure that aimed at digital transformation (adopting any of the above discussed technologies)? If yes, for what overall amount?

What percentage of your organisation's revenue/income is invested in digital transformation?

- Less than 5%
- 5%–9%
- 10%–14%
- 15% or more
- Don't know

D.4 During the last five years has your firm increased its investment or expenditure that aimed at green transformation/environmental sustainability strategy (adopting any of the above discussed technologies or non-technological solutions)? If yes, for what overall amount?

What percentage of your organisation's revenue is invested in green transformation on average annually?

- Less than 5%
- 5%–9%
- 10%–14%
- 15% or more
- Don't know

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Thank you for your time and support.
Should you require any further information, you may contact …….
Have a good day. Goodbye.

14 Appendix F: LinkedIn representativeness analysis

Reflections on the suitability of LinkedIn

LinkedIn is the largest professional network platform with rich information like profile summary, job title, job description and field of study, which can be used for the identification of skilled professionals in advanced technologies. **It represents the single most comprehensive source currently available for the construction of technology-specific skills related indicators**.

Compared to highly resource intensive alternatives such as surveys it represents the most cost-effective alternative considering not just the cost of running the analysis once but also the potential to run the analysis at regular intervals and on demand (e.g. during and after the Covid-19 crisis). The use of LinkedIn gives practitioners the flexibility not only to define any combination of skills but to do so at the national, regional or even local level.

To leverage the potential of the database for the purpose of policy making the indicators derived from the data need to be corrected for the under or overrepresented groups in the population which can be done using post stratification techniques. The lack of representativeness for the population characteristics is expected when using Big Data databases and the objective, as in every statistically sound survey analysis, is to apply the right method to derive correct estimates of the population. The weighting approach applied is described in section **Error! Reference source not found.**.

Considerations to be taken into account when using LinkedIn data include the following points:

- LinkedIn is a voluntary professional networking platform for which subscription is voluntary. This implies that registered users have chosen to sign up, leading to self-selection into the sample. Hence, as the selection process is not random but voluntary, the LinkedIn sample is not a random sample. Secondly, the self-selection of LinkedIn users implies that they chose to join based on rational arguments, and only those who find utility in joining will do so. This is likely to create bias as not everyone has the same utility of joining LinkedIn depending on various factors such as geographical location, sector of activity and plausibly level of education. This is supported by the data, as one can easily observe differences in popularity of LinkedIn between countries and sectors. Hence, self-selection of LinkedIn users justifies the expected lack of representativeness of the active population.
- Using the LinkedIn tool to harvest data is very powerful and provides practitioners the flexibility to monitor skills supply in a way that has not been possible using traditional data sources. It is based on the algorithm developed by LinkedIn. Access to the raw data for an extended verification of the results is not possible but it is possible to manually check the profiles returned by queries to assure the good performance of the queries. It should also be noted that for instance when looking for the share of population with specific skills, it is not possible to assess the level of the skill, nor to distinguish between academic knowledge and industry knowledge. However, skills supply in a specific industry are possible to isolate by selecting a sector which results in only professionals currently employed in the sector in focus to be returned by the query. Furthermore, the database is constructed based on the information provided by the users on their profiles. Users basically have the opportunity to claim what they want, although it would be unlikely that someone would claim a skill not at all relevant for the employment profile

he/she is working in. Data is therefore dependent on users' honesty, self-assessment (what skills do I consider having?), willingness to share information and involvement in the network (how exhaustive is my profile?). This characteristic may leave room for non-accuracy of information but that would have been the same in the case of surveys.

Considerations to be taken into account when reading the representativeness analysis include:

- The LinkedIn database suffers from missing data points such as for instance the level of education. This does not compromise the indicators but rather the possibility to run a comprehensive representativeness analysis.
- Another limitation in performing a compreshensive representativeness analysis by comparing the LinkedIn database, with the data retrieved from Eurostat is that the two datasets have different origins and hence there are mismatches in the definition of some categories. For example, the educational attainment categories on LinkedIn (masters' degree; bachelor's degree; high school) are different from Eurostat (tertiary education; upper secondary and post-secondary non tertiary education; lower than primary, primary and lower secondary education). The same kind of mismatch exists for skills and sector. These differences affect the assessment of representativeness as the comparisons between the two datasets have to be made based on criteria that are not identical.

Approach to test the representativeness of LinkedIn

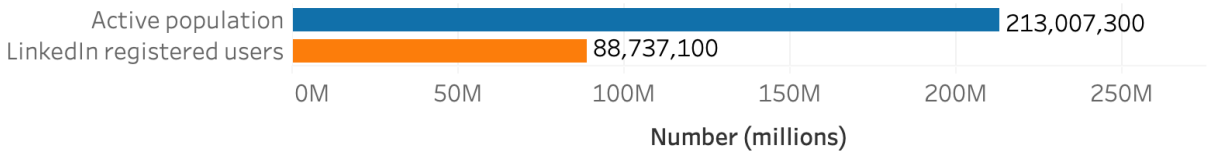
To perform the test of representativeness of LinkedIn we proceeded in two stages. First, the two datasets notably LinkedIn and Eurostat (active population) have been compared based on key statistics. These descriptive statistics show if the two populations behave similarly regarding different key aspects: entire workforce, educational attainment, gender and the science sector. Similar behaviors and figures tend to indicate that the sample represents well the population. Second, the representativeness of LinkedIn has been statistically tested on the same aspects through X-squared tests. These tests allow to check whether the difference in the behavior of the two populations is statistically significant or not, and therefore whether the sample fail to represent the population, or not.

Descriptive statistics comparing Eurostat data and LinkedIn aggregates

Workforce

The comparison of the EU27 workforce and the number of EU27 LinkedIn users in terms of absolute numbers shows that the active population of the EU27 is 213 million while 88.7 million Europeans are registered on LinkedIn. In other words, 41.6% of the active population is registered on the professional networking platform.

Figure 38: EU27 active population vs EU27 LinkedIn registered users

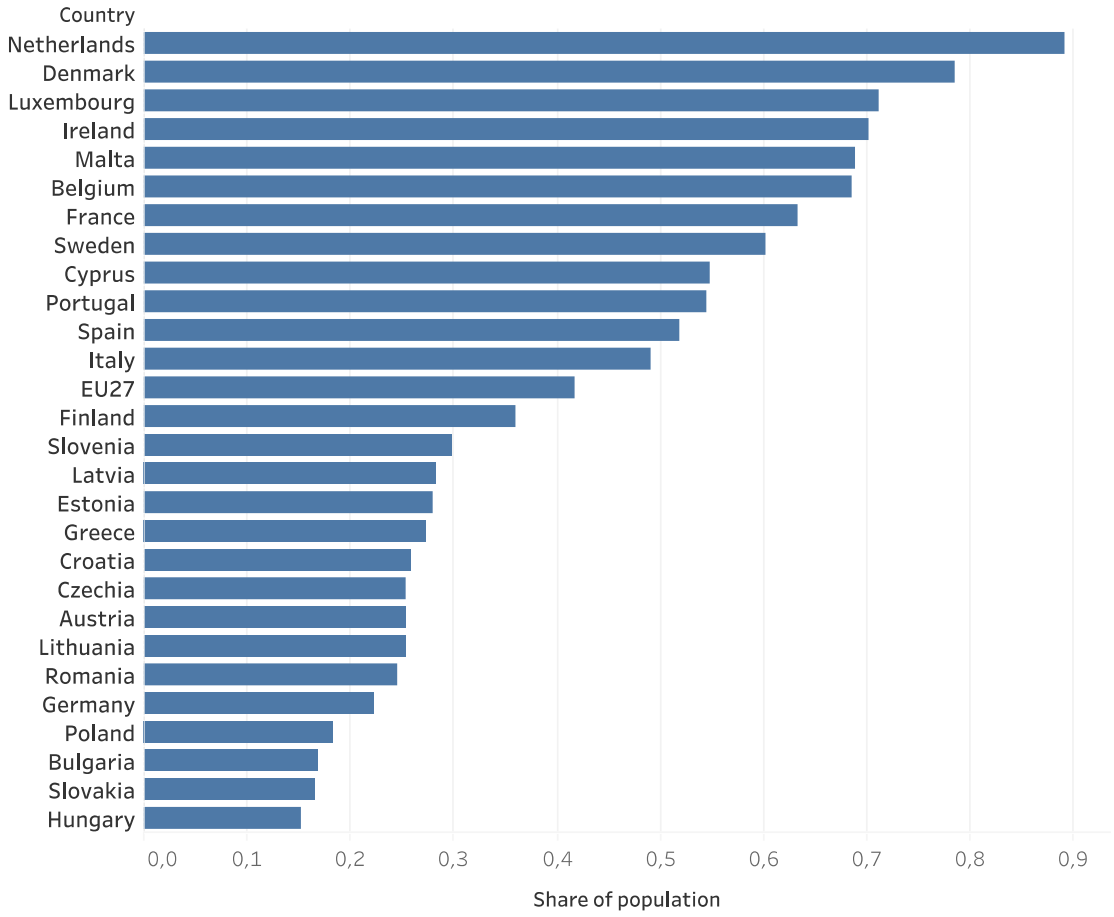


Source: LinkedIn and Eurostat (Active population by sex, age and educational attainment [lfsa_agaed] - All ISCED 2011 levels; 15 to 74 years old; 2018)

Behind the aggregated figure at the EU27 level, there is an important heterogeneity in the national use of LinkedIn among EU Member States, as indicated by the next figure. Indeed, in some EU countries, the number of LinkedIn users is marginal, while it is widely spread in others. In particular, Hungary, Slovakia, Bulgaria and Poland display the lowest use of

LinkedIn, with less than 20% of the population registered on the platform. On the other hand, Netherlands and Denmark are the countries where LinkedIn is the most popular, with more than 75% of the active population registered (see Figure on the next page).

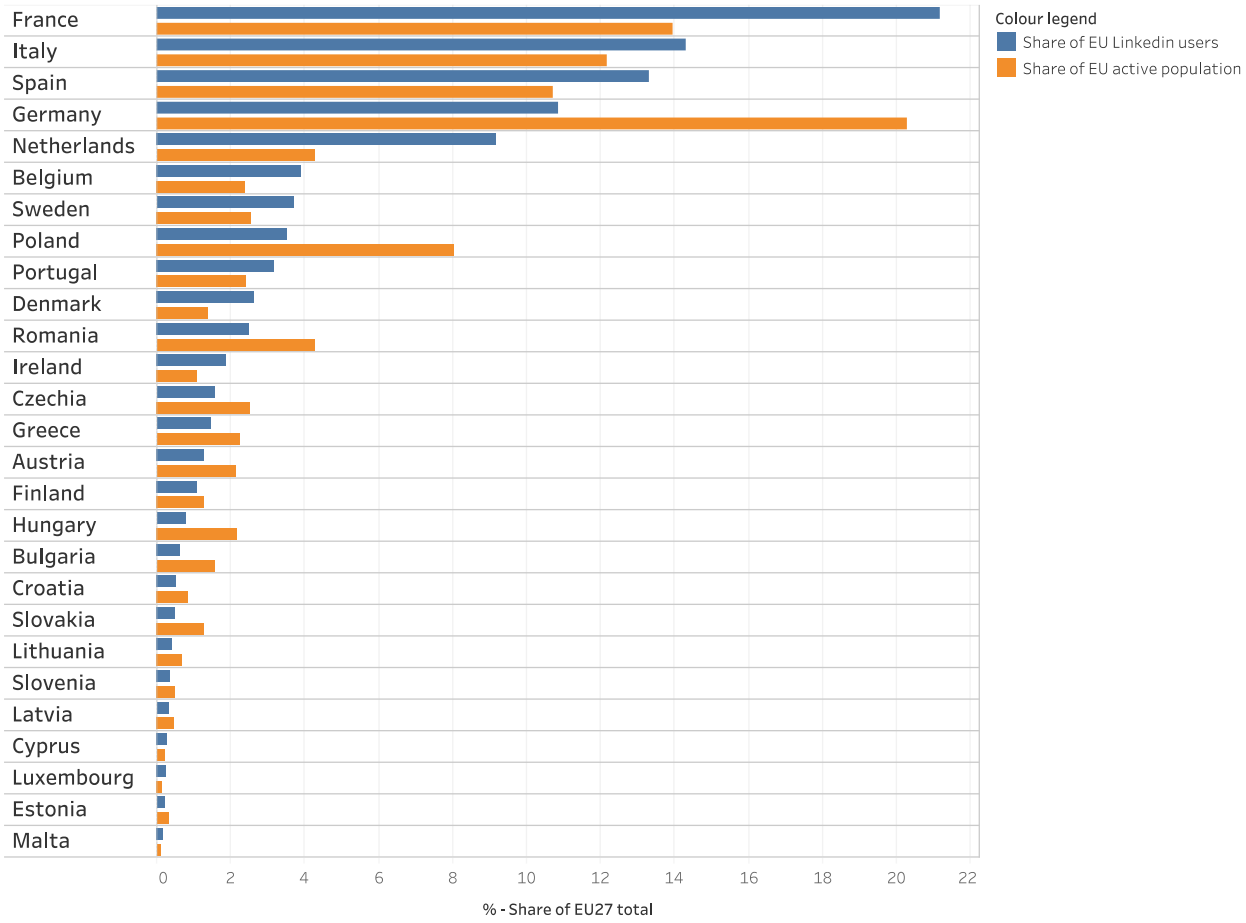
Figure 39: Share of active population registered on LinkedIn by country



Source: LinkedIn and Eurostat (Active population by sex, age and educational attainment [lfsa_agaed] - All ISCED 2011 levels; 15 to 74 years old; 2018)

As a result of the heterogeneity in the use of LinkedIn between EU Member States, the LinkedIn population does not reflect the EU population. Indeed, the countries where the use of LinkedIn is rare are underrepresented on the platform, while the countries where the use of LinkedIn is widespread are overrepresented. Figure 10 compares the share of the EU workforce and of the EU LinkedIn population of each country, and highlights the mismatch between them. For example, while the active population of Poland and Romania accounts for 8.03% and 4.25% of the total EU active population respectively, they only represent 3.53% and 2.5% of the EU LinkedIn users. On the contrary, Netherlands and Denmark represent 9.16% and 2.64% of the LinkedIn users although they only account for 4.28% and 1.4% of the EU active population. In total, 15 countries are underrepresented on LinkedIn (e.g. Germany) and 12 are overrepresented (e.g. France).

Figure 40: Share of total EU 27 active population vs share of total EU LinkedIn users by country



Source: LinkedIn and Eurostat (Active population by sex, age and educational attainment [lfsa_agaed] - All ISCED 2011 levels; 15 to 74 years old; 2018)

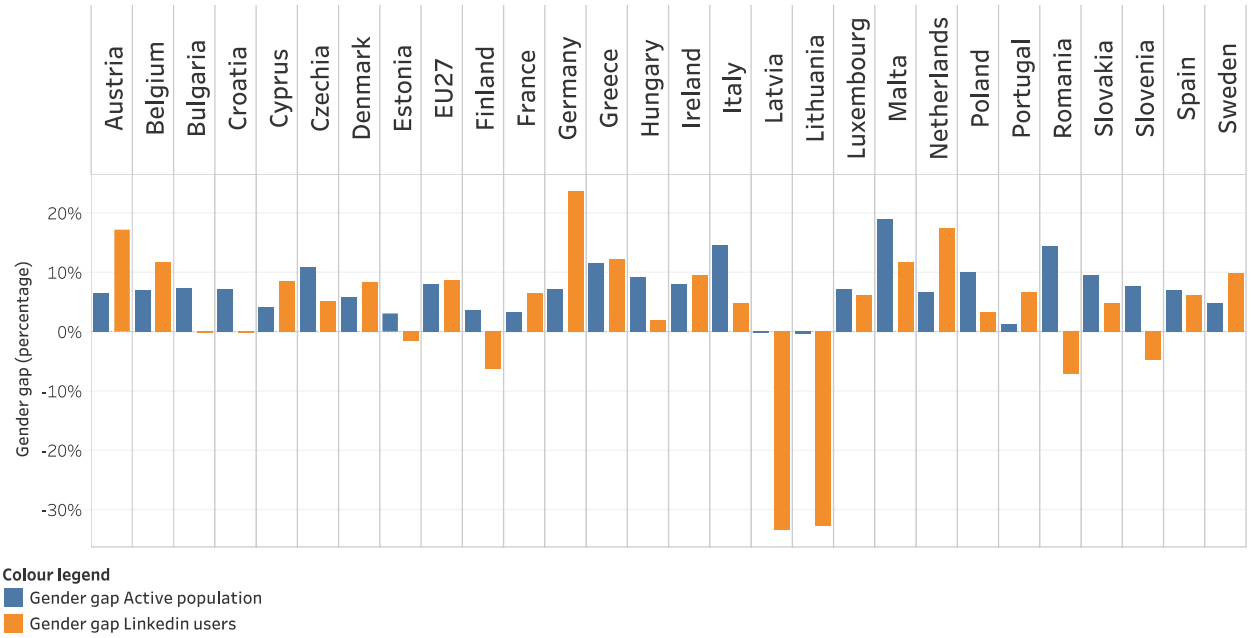
Gender

In order to assess the representativeness of the LinkedIn population in terms of gender proportions, we use the gender gap.[71] Figure 11 illustrates the gender gap that takes place in the active population and among the LinkedIn registered users. At the EU level, the gender gap on LinkedIn is comparable to the gender gap in the active population, with respective values of 8.62% and 7.95%. Regarding gender proportions, the LinkedIn population is therefore representative of the active population at the European level. However, among EU Member States, heterogeneity is observed.

Some countries display higher gender gaps on LinkedIn than in the active population. In particular, Austria, Germany and Netherlands display the most important gender gap on LinkedIn despite a limited gender gap in the active population. On the contrary, there are countries where the gender gap is reduced on LinkedIn compared to the active population, or even of opposite sign. Indeed, Estonia, Finland, Slovenia and Romania have a negative gender gap on LinkedIn (more women than men) but a positive one in the active population. This indicates a high propensity of women to register on LinkedIn. The same trend occurs in Lithuania and Latvia where the gender gap is negative both among the LinkedIn users and the active population, but is more pronounced on LinkedIn.

[71] The gender gap is calculated as the difference between the percentage of the labour market constituted of men and the percentage of the labour market constituted of women. The classification used in the case of the gender gap is therefore the same as the presence of women on the labour market.

Figure 41: Gender gap in active population vs LinkedIn users

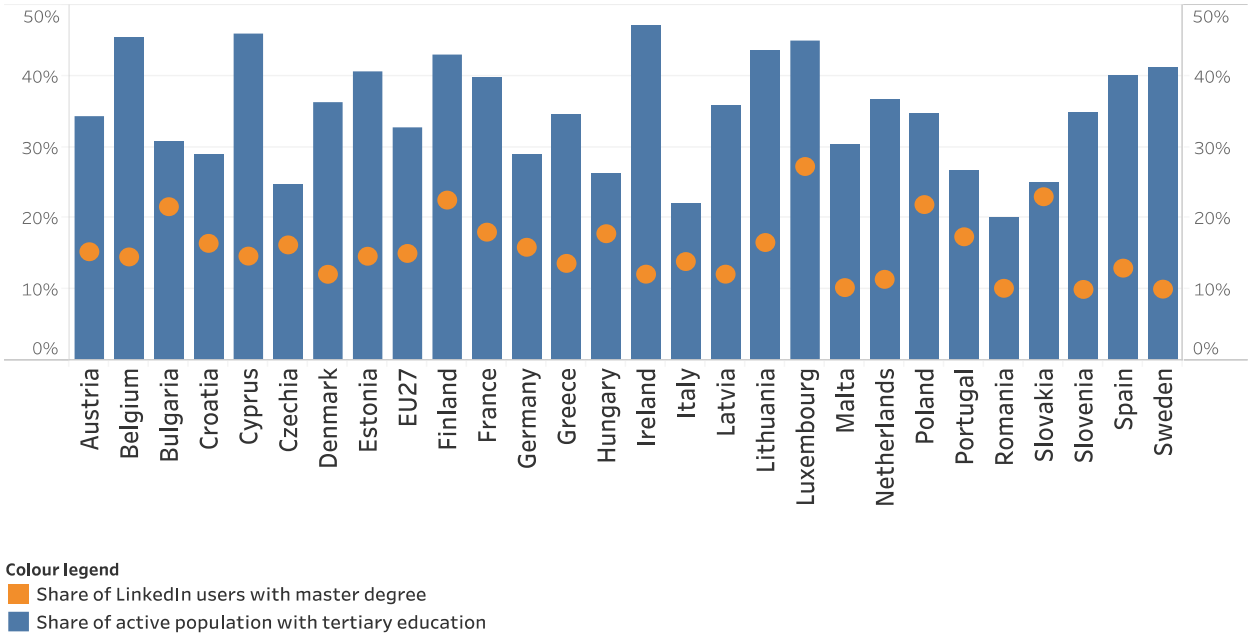


Source: LinkedIn and Eurostat (Active population by sex, age and educational attainment [lfsa_agaed] - All ISCED 2011 levels; Females and Males; 15 to 74 years old; 2018)

Educational attainment

Regarding the educational attainment, we first analysed the highest educated share of population both in LinkedIn and in Eurostat data. When comparing the share of LinkedIn users with master's degree and the share of active population with tertiary education, one can observe that the share of population with tertiary education is smaller for the LinkedIn users than for the active population in all countries. The first straightforward explanation is the underrepresentation of the population with a master's degree among LinkedIn users. However, more plausibly, the low shares of tertiary educated workers on LinkedIn might as well be explained by the non-systematic registration of educational attainment on LinkedIn. Since the information on the educational attainment is missing for 68.7% of the LinkedIn sample, the share of those who are registered as having a master on the total users is low. Additionally, only the LinkedIn users having a master's degree are accounted for in the LinkedIn ratio, while tertiary education includes other forms of higher education in the active population ratio.

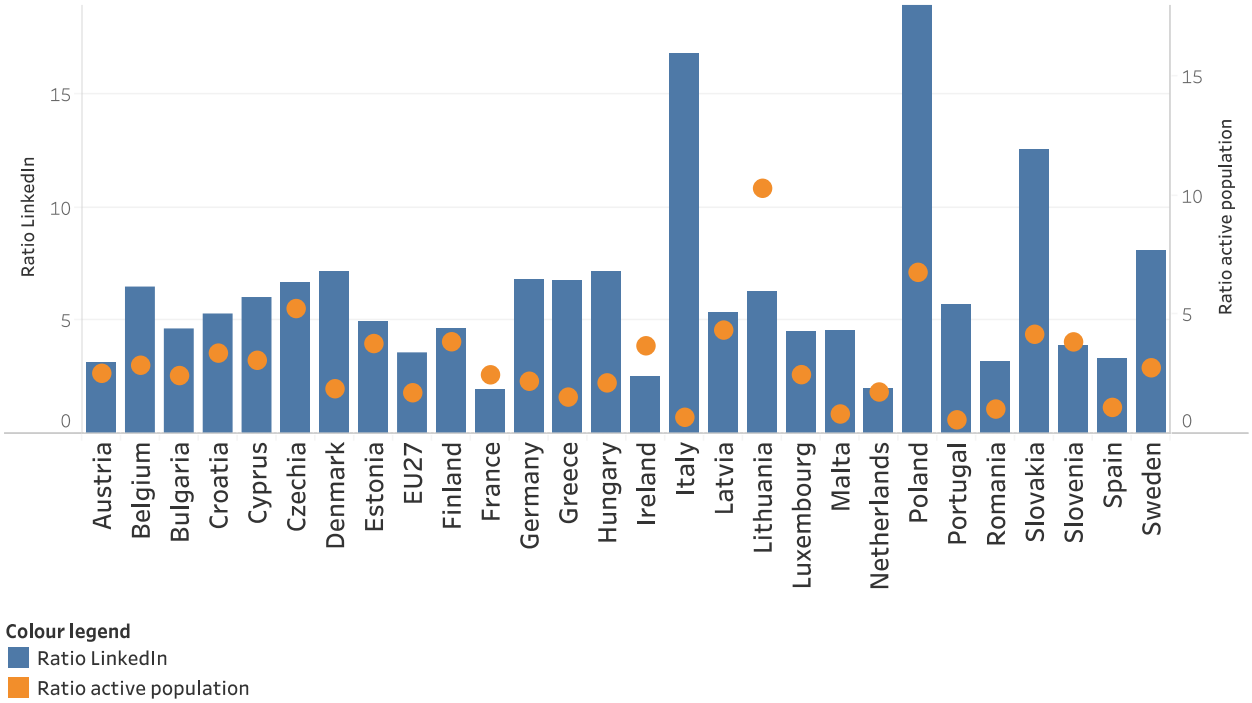
Figure 42: Share of highest educated among LinkedIn users vs active population



Source: LinkedIn and Eurostat (Active population by sex, age and educational attainment [lfsa_agaed] – ISCED 2011 Levels 5-8; 15 to 74 years old; 2018)

In order to avoid the bias caused by the missing information on educational attainment, we use a ratio for the active population and for the LinkedIn population. The structure of the ratio takes into account both extremes of the education distribution and it is constructed in the following way. The share of people with highest educational attainment (master's degree for the LinkedIn users, tertiary education for the active population) on the share of people with the lowest educational attainment (high school for LinkedIn users and less than primary, primary and lower secondary education for active population). Comparing both ratios allows to see if the proportions between highly educated and low educated are similar in the two populations without being distorted by the missing information. From Figure 13 one can observe that in most countries (19 EU Member States and EU27 average), the ratio of the highest educated on the lowest educated is higher among LinkedIn users than in the active population. In other words, among the LinkedIn users for whom the educational attainment is available, the highly educated (master's degree) are overrepresented. This is particularly true for Italy, Portugal and Poland where the difference between the LinkedIn ratio and the active population ratio is the largest. In fact, the ratio for Poland is so high that it is not fully visible on Figure 13 (57.4). It is interesting to note that in the case of Italy and Portugal, the important difference between the two ratios is linked to the large share of the active population with the lowest educational attainment. It can be deducted that while this fringe of population reduces the active population ratio, it does not have the same effect on the LinkedIn ratio because it is not present among LinkedIn users, i.e. underrepresented in the LinkedIn population.

Figure 43: Educational attainment ratio among LinkedIn users vs in active population



Source: LinkedIn and Eurostat (Active population by sex, age and educational attainment [lfsa_agaed] – ISCED 2011 Levels 0-2 & 5-8; 15 to 74 years old; 2018)

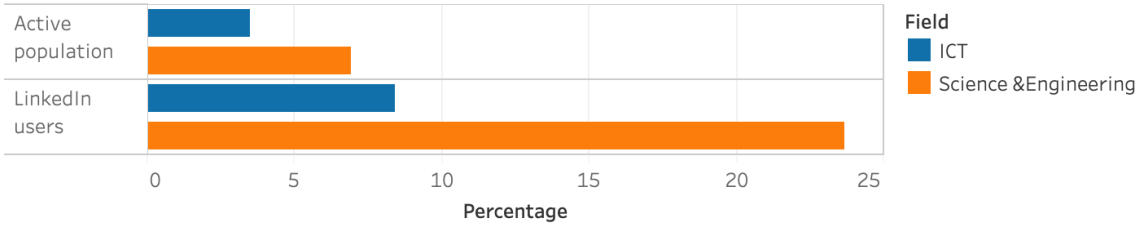
There are few cases where the active population ratio is more important than the LinkedIn ratio, but the difference is generally quite small (<1.5). The only exception is Lithuania, where the difference of ratio therefore indicates that on LinkedIn the lowest educated are overrepresented and/or the highest educated underrepresented.

In general, the lowest educated are underrepresented and/or the highest educated are overrepresented in most of the EU Member States (including EU27 average). In terms of educational attainment, the LinkedIn population is not representative of the active population.

Science & Engineering and ICT

The representativeness of the LinkedIn sample can also be assessed against the importance of different knowledge activities among the population. We compare the relative importance of the Information and Communications Technology population (ICT) and the Science and Engineering population (SE). In Figure 14 the number of people working in ICT and SE is taken as the percentage of the active population and of the LinkedIn users. 6.92% of the active population works in SE[72] and 3.49% in ICT[73], while 23.68% of LinkedIn users are from the SE sector and 8.38% from the ICT sector.

Figure 44: Share of EU active population vs share of EU LinkedIn users in Science & Engineering vs in ICT



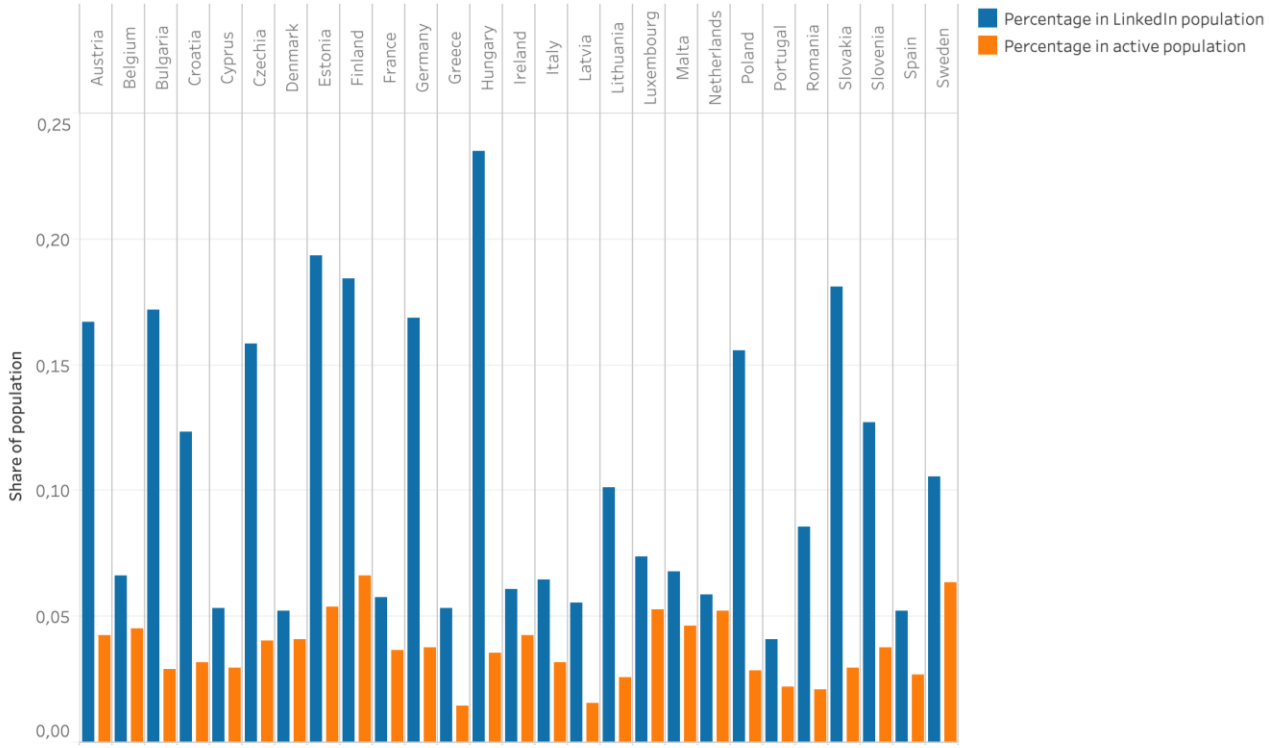
Source: LinkedIn and Eurostat (A. *Active population by sex, age and educational attainment [lfsa_agaed] - All ISCED 2011 levels; 15 to 74 years old; 2018.* B. Employed ICT specialists by sex [isoc_sks_itsps] – Males and Females; 2018. C. HRST by category, sex and age [hrst_st_ncat] – 15-74 years old; Scientists and engineers; 2018)

One can observe that both populations are overrepresented on LinkedIn, as they represent a larger share in the LinkedIn population than in the active population. This trend is even more pronounced for the SE sector: the share of LinkedIn users in SE is more than 3 times more important than the share of active population in SE. For the ICT sector, this figure is around 2.4. The overrepresentation of the ICT and SE sectors on LinkedIn does not only concern the EU27 as a whole, but it is persistent among all EU Member States. Figures 15 and 16 show that in all countries the share of population in ICT and SE is higher among the LinkedIn users than in the active population.

However, this trend occurs to different extents. In particular, Hungary has among the largest gaps for both ICT and SE, along with Finland for SE and Bulgaria, Estonia and Slovakia for ICT. Ireland and Luxembourg are interesting cases because the gaps between the share of LinkedIn population in SE and the share of active population in SE are among the largest; while in ICT this gap is very limited. The best performers in terms of representativeness of the LinkedIn sample, i.e. the EU Member States with the smallest gap between the LinkedIn population and the active population, are Romania, Poland and Sweden for SE, Denmark and Portugal for ICT and Belgium and Netherlands in total.

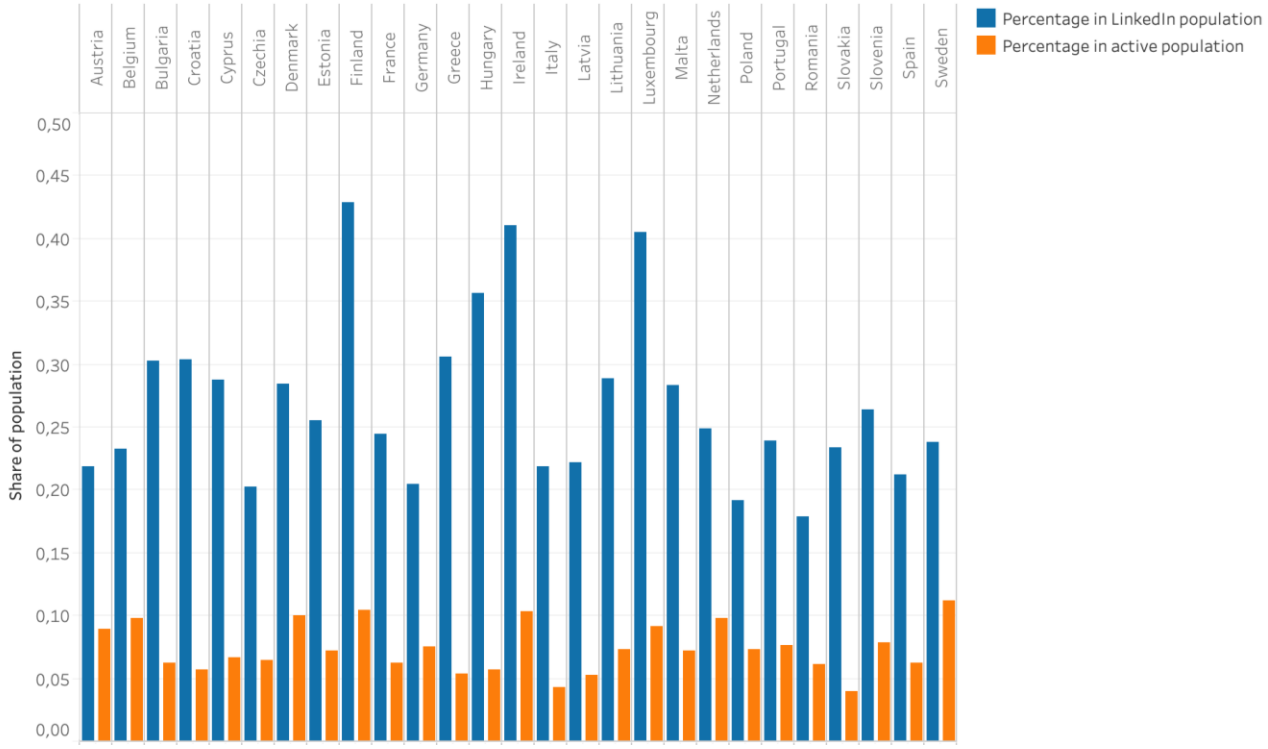
[72] Eurostat: HRST by category, sex and age [hrst_st_ncat]; Active population by sex, age and educational attainment [lfsa_agaed]
[73] Eurostat: Employed ICT specialists by sex [isoc_sks_itsps]; Active population by sex, age and educational attainment [lfsa_agaed]

Figure 45: Share of LinkedIn users in ICT vs share of active population in ICT by country



Source: LinkedIn and Eurostat (A. *Active population by sex, age and educational attainment [lfsa_agaed] - All ISCED 2011 levels; 15 to 74 years old; 2018.* B. Employed ICT specialists by sex [isoc_sks_itsps] – Males and Females; 2018)

Figure 46: Share of LinkedIn users in Science and Engineering population vs share of active population in Science and Engineering population by country



Source: LinkedIn and Eurostat (A. *Active population by sex, age and educational attainment [lfsa_agaed] - All ISCED 2011 levels; 15 to 74 years old; 2018.* B. HRST by category, sex and age [hrst_st_ncat] – 15-74 years old; Scientists and engineers; 2018)

Despite these few exceptions, the population in Science & Engineering and ICT is in general largely overrepresented on LinkedIn. Hence, regarding the knowledge activities, the LinkedIn population is not representative of the active population.

In conclusion, as anticipated, LinkedIn based indicators will need to be corrected to reflect the distribution of the population for the characteristics in focus. This is because LinkedIn's popularity is different from a country to another, causing the EU Member States where it is more widespread to be overrepresented. Moreover, there is a misrepresentation of the educational attainment as the ratio between the highest educated and the lowest educated is considerably more important on LinkedIn than in the active population. Similarly, the prevalence of LinkedIn depends on the knowledge activity. The population in Science & Engineering is overrepresented, as well as the Information & Communication Technology population to a lesser extent. The weighting mechanism to correct for the lack of representativeness is described in section **Error! Reference source not found.**.

Statistical testing

Beyond the comparison of the LinkedIn population and the active population in terms of descriptive statistics, the representativeness of LinkedIn has been also assessed through statistical testing. The X-squared tests compare the observed frequencies (i.e. derived from the LinkedIn population) and the expected frequencies (i.e. derived from the active population) and assess if the difference between them is statistically significant or not. In other words, they test if the frequencies correspond to the same population or if, on the contrary, the LinkedIn sample is not representative of the active population.

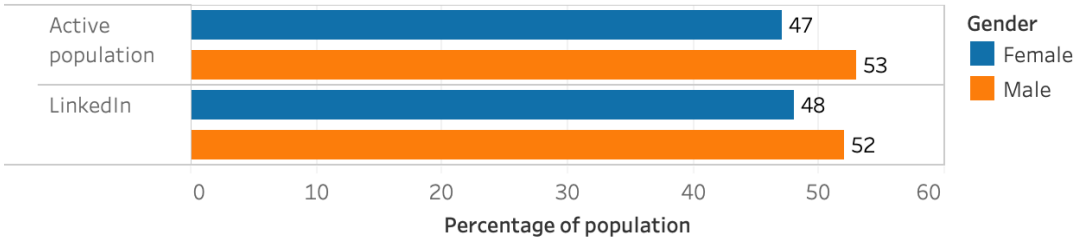
We perform the X-squared tests[74] with regard to the importance of the national workforce, the population's educational attainment, the gender proportions and the prevalence of ICT and SE. Each test has been run for the EU27 and by country (apart from the national workforce which is obviously not tested at the level of EU27). The tests are unequivocal as they all display the same result: the LinkedIn population is not representative of the active population.[75]

Comparison of LinkedIn population in the EU27 and the US

The networking platform LinkedIn is more popular in the United States than in the EU27, as 164.98 million Americans are registered on LinkedIn, i.e. 100.88% of the US active population, against 41.6% in the EU27. In fact, the US even has more nationals registered on LinkedIn than accounted in the active population (as indicated by the percentage greater than 100). This is very likely to be due to the use of LinkedIn among non-active parts of the population, such as students and retirees. Given the prevalence of LinkedIn in the US, it is of interest to assess its representativeness, and to compare it with EU27.

In order to analyse the representativeness in terms of gender, we compare the proportions of males and females in the labour force and in the LinkedIn population. As indicated by the Figure below, the active population in the US is composed of 53% of males and 47% of women, against 52% and 48% on LinkedIn. The figures are therefore similar, even if the gender gap is slightly reduced on LinkedIn, going from 6% in the labour force to 4%.

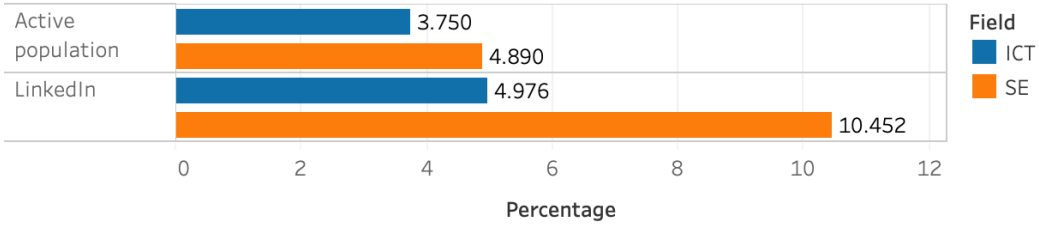
Figure 47: Gender proportions in the US active population vs among the US LinkedIn users



Source: LinkedIn 2020 and OECD 2019 (OECD Data – Labour force)

As it was the case in the EU27, some knowledge activities are overrepresented on LinkedIn. Figure 18 shows that the shares of the LinkedIn population in the ICT and SE sectors are larger than the corresponding shares in the active population. However, this trend occurs to a lesser extent than in the EU27. In particular, the share of the LinkedIn users in the ICT sector is 'only' 33% larger than the share of the active population in ICT. For the SE sector, the LinkedIn share is 2.14 more important than the active population share, indicating a pronounced overrepresentation of the SE population on LinkedIn, although still smaller than for EU27.

Figure 48: Share of US active population vs share of US LinkedIn users in Science & Engineering vs in ICT



Source: LinkedIn 2020, National Science Foundation 2018 (Individuals in S&E occupations as a percentage of all occupations – USA; 2018), OECD 2017 (OECD Digital Outlook 2017 - Share of ICT specialist employment; 2014)

[74] The X-squared tests are run with the statistical software STATA.
[75] The X-squared tests reject the null hypothesis of representativeness.