European Commission

European Cluster and Industrial Transformation Trends Report

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List of Abbreviations

3D	Three Dimensional
AI	Artificial Intelligence
AR	Augmented Reality
BRIC	Brazil, Russia, India, and China
BRICS	Brazil, Russia, India, China, and South Africa
CO2	Carbon Dioxide
ECCP	European Cluster Collaboration Platform
EFTA	European Free Trade Area
EOCIC	European Observatory for Clusters and Industrial Change
ESCA	European Secretariat for Cluster Analysis
GDP	Gross Domestic Product
GPS	Global Positioning System
H2020	Horizon 2020
HR	Human Resources
IaaS	Infrastructure as a Service
ICT	Information and Communications Technologies
IMF	International Monetary Fund
IoT	Internet of Things
IT	Information Technology
JV&A(s)	Joint Venture and Alliance(s)
LED	Light-Emitting Diodes
M&A(s)	Merger(s) and Acquisition(s)
MNE(s)	Multi-National Enterprise(s)
N.a.	Not available
NACE	Statistical Classification of Economic Activities in the European Community (in French "*Nomenclature Générale des Activités Économiques dans les Communautés Européennes*")
NUTS	Nomenclature of Territorial Units for Statistics (in French "*Nomenclature des Units Territoriales Statistiques*")
OECD	Organisation for Economic Co-operation and Development
PaaS	Platform as a Service
PPP	PURCHASING-POWER-PARITY
R&D	Research and Development
SaaS	Software as a Service
SME(s)	Small-Medium Enterprise(s)
UNESCO	United Nations Educational, Scientific and Cultural Organization
VR	Virtual Reality
WB	World Bank

Executive summary

Objective and methodology of analysis

The European Cluster and Industrial Transformation Trends Report (the Trends Report, in brief) identifies and analyses where and how clusters of related industries are transforming themselves and where new specialisation patterns give rise to the emergence or renewal of industries.

The report aims to support policy-makers, cluster practitioners and companies to spot transformation trends at an early stage by examining, in particular, the ten emerging industries previously identified by the European Cluster Observatory (2012), namely:

	Advanced Packaging	Environmental industries	
	Biopharmaceuticals	Experience industries	
	Blue growth industries	Logistical Services	
	Creative industries	Medical Devices	
	Digital industries	Mobility Technologies	

The analysis contributes to facilitating the policy efforts towards establishing favourable framework conditions for the development of emerging industries, which evolve at the borderlines of different competences and hence cut across and reshape traditionally defined sectors. It also helps European regions identify potential collaboration areas where emerging industries cut not only across sectors, but also across borders.

The methodology is a mix of quantitative and qualitative methods, including statistical analysis and social network analysis of patenting and co-patenting, Mergers and Acquisition (M&A) transactions, Joint Ventures, strategic alliances and innovation networks (JV&A) data; extensive literature and documentary review; foresight analysis; Delphi surveys involving international experts on different topics; consultation with regional stakeholders in a sample of European regions in industrial transition; survey of international, national and regional cluster programmes; and data of the European Secretariat of Cluster Analysis (ESCA) on cluster organisations.

The methodology follows the approach adopted in the previous European Cluster Trends Report (European Cluster Observatory, 2015) to ensure consistency of data and comparability of findings over a long time period.

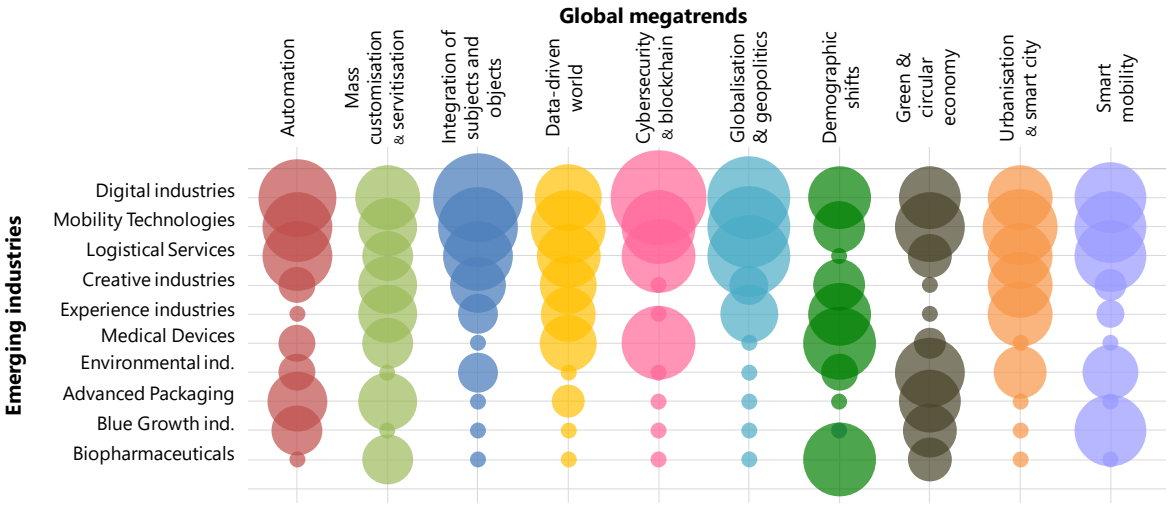
Global megatrends and their impact on emerging industries

Technological, socio-political, environmental and economic megatrends shape the development of emerging industries

The future development of emerging industries is shaped by a number of global megatrends, defined as sustained forces on a global and macro-economic level that influence the developments of business, environment, economy, society, cultures and citizens' lives on a local and global scale.[1]

Ten megatrends, selected on the basis of a comprehensive review of the most recent literature,[2] have been investigated in detail. Some relate to the diffusion of new disruptive technologies (Automation, Mass customisation and servitisation, Integration of subjects and objects, Data-driven world, Cybersecurity and blockchain); others are more closely related to demographic, socio-political, environmental and economic shifts (Globalisation and geopolitics, Demographic shifts, Green and circular economy, Urbanisation and smart city, Smart mobility). The megatrends pose both significant challenges and opportunities for the emerging industries by affecting the business models, creating incentives or deterrents to the development of new markets, altering employment and productivity, causing shifts in skills requirements and disrupting existing value chains.

Figure A - Impact of ten global megatrends on ten emerging industries



Source: EOCIC

Some emerging industries will be impacted the most

The foresight analysis and impact assessment highlight that the **Digital industries**, **Mobility Technologies** and **Logistical Services** are impacted the most by all the identified global megatrends. Conversely, some industries are more decisively influenced by particular megatrends. For instance, population ageing creates opportunities for new products and service development and applications in the Biopharmaceutical industries. Blue Growth industries, and especially the sectors related to maritime

[1] The concept of megatrend emerged in the 1980s, with the seminal work of John Naisbitt, "Megatrends: Ten New Directions Transforming Our Lives" (Naisbitt, 1982).

[2] For the full literature review, see EOCIC, 2019b.

navigation, are affected by the changing mobility paradigm, driven by Automation, Green and circular economy and Smart mobility trends. Cybersecurity and blockchain are expected to impact especially on health-related sectors (Medical Devices), insurance and mobility (Digital industries, Mobility Technologies and Logistical Services).

Cross-sectoral dynamics of industrial transformation

Cross-sectoral linkages favour industry transformation

The global megatrends push for substantial technological transformation at different levels of the value chain, increasing servitisation and product personalisation and attention towards greener and environmentally friendly solutions. Cross-sectoral linkages play a central role in industrial transformation and the development of emerging industries because they favour collaboration between firms and knowledge spill overs and therefore innovation.

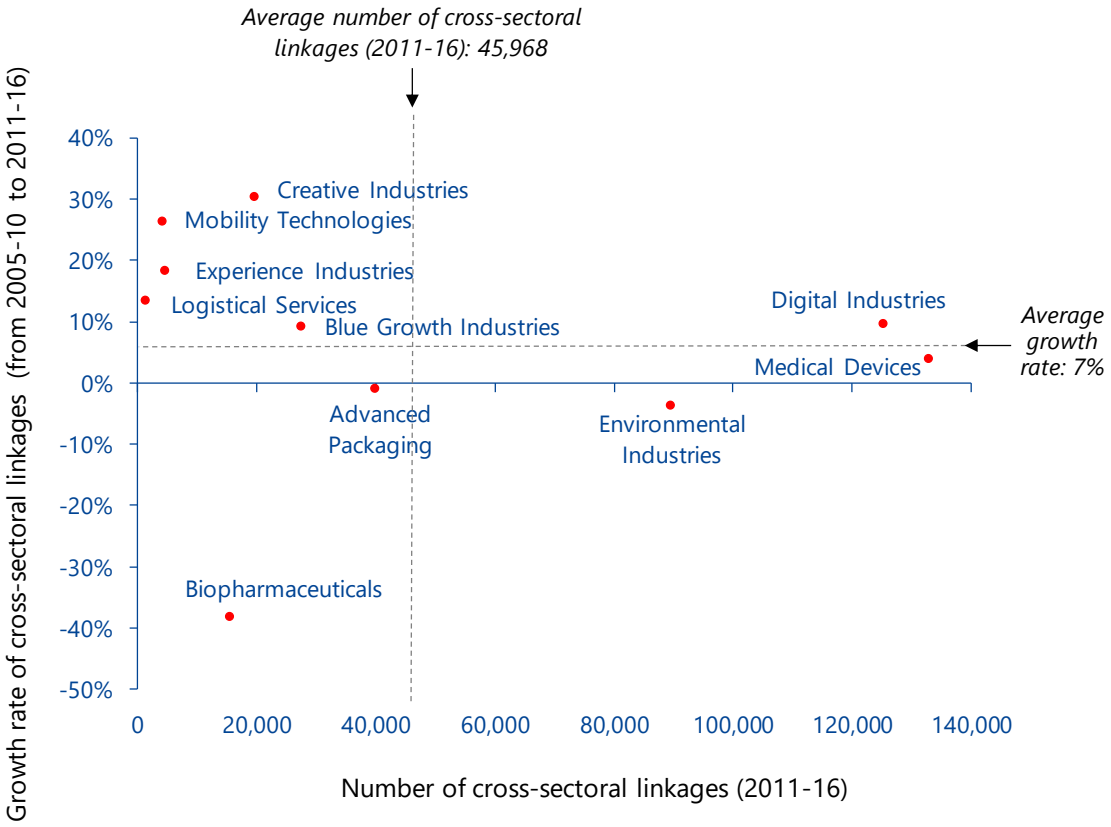
Cross-sectoral linkages are defined as any form of interaction (e.g. supplier-client relationships, R&D activities, strategic alliances and collaborations) in which the two interacting parties belong to different industrial sectors. To study the transformation trends of the ten emerging industries, data on cross-sectoral patents, M&A and J&A since 2000 were analysed.

Cross-sectoral linkages have grown for most of the emerging industries

Elaborations on cross-sectoral patents, M&A and JV&A data indicate that overall, the ten emerging industries keep being highly interconnected with a large number of sectors. Figure B shows the number of cross-sectoral linkages observed in the 2011-2016 period and the growth rate over the previous years (2005-2010) for each emerging industry. The following key findings can be highlighted.

- **Digital industries** are among the most interconnected, providing key enabling technologies to other sectors. They are characterised by the largest number of cross-sectoral patents and also by a high level of cross-sectoral business operations. The data analysed show that the number of these linkages keeps increasing over time.
- **Environmental industries** are also deeply associated with several other industries. Innovations in the fields of pollution management, cleaner technologies and renewable energy sources, products and resource management trigger changes in the value chain of all other industries.
- The **Medical Devices** industries rely to a great extent on technologies developed for other sectors. As an illustrative example, sensor and automation technologies that are applied to the automotive sector are increasingly used also for medical robotics.
- The **Creative industries** recorded top-level numbers in M&A and JV&A operations. Patents are less numerous than for other emerging industries, even if significantly increasing over time. The Creative industries have strong intersections with the medical/health sectors due to the increasing application of game and virtual reality technologies for medical treatment.

Figure B - Number and growth rate of cross-sectoral linkages by emerging industry



Source: EOCIC

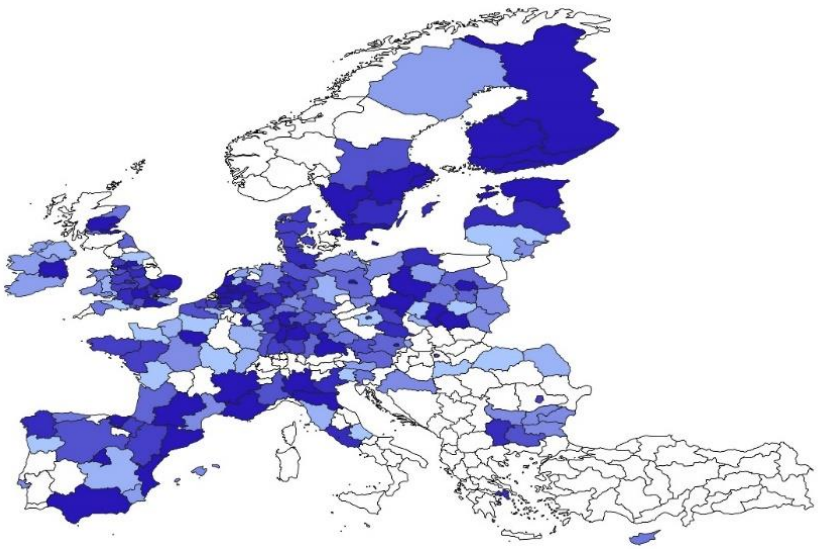
- **Experience industries** are becoming high-tech and high-touch, highly creative and cultural, connecting with media and design sectors as well as digital industries as software and web sites have acquired an increasingly prominent role.
- The **Logistical Services** and **Mobility Technologies** industries, even if not characterised by a high number of cross-sectoral patents, show a remarkable increase in M&A operations. The Smart mobility megatrend is driving deep transformation trends (e.g. smart warehouses, connected trucks, autonomous vehicles, etc.) that are likely to disrupt these industries in the next years.
- The **Blue Growth** industries are undergoing similar transformations (e.g. the development of environmentally friendly ships and autonomous driving boats).
- Traditional cross-sectoral linkages along the value chain of the **Advanced Packaging** industries (e.g. with the food and beverage sectors) have weakened, but stronger linkages are emerging with other sectors, especially in the upstream stages of the value chain, reflecting the introduction of advanced materials (eco-packaging), advanced machinery (digital printing), intelligent manufacturing and smart packaging.
- **Biopharmaceuticals** record a decreasing number of cross-sectoral linkages in terms of patents. As to strategic business operations (M&A

and JV&A), the growth rate in the past years has been positive, even if below the average of the other emerging industries. Some sectors included in the definition of biopharma industries are indeed losing relevance, but other new sectors are gaining importance. For instance, the food and beverage sector is increasingly linked with biopharmaceuticals, which reflects the strong growth of the pharma food market segment.

The ongoing transformation processes call for updating the definition of emerging industries

As a consequence of the dynamism and progressive transformation of emerging industries, the boundaries of emerging industries are changing. Also, some industries are so strongly interconnected one to another that it is becoming challenging to discriminate between them (for instance, the Digital, Experience and Creative industries). In parallel, a new cross-sectoral industry is emerging in the European landscape: the **(smart) construction industry**. Smart materials, eco-building, sustainable hotels, intelligent systems and smart technologies to control building operations (e.g. heating, security, etc.) are trends that are profoundly changing the value chain of the construction industry and increasing the interlinkages between this industry and other manufacturing and service sectors. These developments suggest the need to update the definition of European emerging industries to better reflect more recent transformation trends.

Figure C - Regions (NUTS 2) with a higher degree of cross-sectoral and cross-regional linkages in 2011-2016



Source: *EOCIC*

Cross-sectoral and cross-border linkages are increasing, especially for Eastern European regions

The network analysis reveals that industries are increasingly connected not only across sectors, but also across borders.[3] The number of NUTS 2 regions connected to each other by cross-sectoral linkages is increasing over time. For each industry, **new communities of regions** strongly interconnected via cross-regional and cross-sectoral activities **are emerging in Eastern Europe**. They include, for instance, Wielkopolskie, Dolnośląskie and Pomorskie in Poland, the Nord-Vest region in Romania (especially for the

[3] See Chapter 3.

Digital industries centred in the area of Cluj-Napoca) and the Severozapaden region in Bulgaria (especially for Creative industries and Experience industries). The Spanish regions are also increasingly interconnected with each other and, to a more limited extent, with regions of other Member States.

Figure C provides the full picture of EU regions with a high degree of cross-sectoral linkages (above the EU median in 2011-2016)[4].

EU emerging industries in the global economy

Internationalisation is a key driver of transformation and growth for firms and the ecosystem in which they operate. Collaboration across the borders can fuel product upgrading, the adoption of more advanced technologies and business models, the accumulation of knowledge and a shift towards more remunerative sector specialisations. According to ESCA data[5] on over 100 European cluster organisations during the 2015-2017 period, clusters in the ten emerging industries display different patterns of internationalisation, as Table A shows.

Orientation towards internationalisation is higher for the Digital, Environmental and Blue Growth industries

The relative importance of internationalisation by cluster manager perspective and the degree of internationalisation of cluster participants is relatively higher for clusters operating in the Digital, Environmental, and Blue Growth industries. Conversely, there is scope for improvement in the level of internationalisation for the Advanced Packaging and Experience industries and to some extent, also for the Creative industries and Logistical Services. However, the intensity of cross-sectoral and cross-regional linkages and comparison with the level of internationalisation displayed in the previous Cluster Trends Report (2015)[6] indicate that the degree of internationalisation of these industries is growing over time.

Central Eastern Europe is relatively more open to collaboration with firms located in non-EU countries

Countries in central-western, southwest and northern Europe record the highest number of cooperation activities across the borders. In relative terms, clusters in Central Eastern Europe cooperate more with countries beyond the EU than with other European countries. North America and Eastern Asia are the regions where the highest number of collaboration activities are activated by European clusters.

[4] The colour scale indicates the number of emerging industries (from 1 to 10) for which each region has high cross-sectoral and cross-border linkages.

[5] These data were provided by the ESCA upon request (https://www.cluster-analysis.org/).

[6] https://ec.europa.eu/growth/industry/policy/cluster/observatory/european-cluster-trend-report_en.

Table A - Level of internationalisation of the ten emerging industries (2015-2017) according to ESCA data

Emerging industry	Importance of internationalisation according to the cluster managers	International orientation of clusters participants	Availability of internationalisation-oriented services
Advanced Packaging	🔴	🟡	🔴
Biopharmaceuticals	🟡	🟢	🟢
Blue Growth industries	🟢	🟢	🟢
Creative industries	🟡	🔴	🟡
Digital industries	🟢	🟢	🟢
Environmental industries	🟢	🟢	🟢
Experience industries	🔴	🔴	🟡
Logistical Services	🔴	🟡	🟡
Medical Devices	🟡	🟢	🟢
Mobility Technologies	🟢	🟢	🟡

Legend: Green: relatively higher level of internationalisation; orange: relatively medium level of internationalisation; red: relatively lower level of internationalisation (compared to the other emerging industries)

Source: EOCIC elaboration based on ESCA data

Besides providing collaboration opportunities, international partner countries also raise competition for European emerging industries

The analysis of sectoral strengths in a sample of international countries,[7] namely the **USA, Canada, Japan, Singapore and the Republic of Korea**, shows that all these countries enjoy a forefront or important position in many of the key sectors that define the ten European emerging industries. In spite of its good research and innovation capabilities, the EU generally lags behind the USA and Japan in some emerging industries, such as Digital industries, Mobility industries and Biopharmaceuticals. At the same time, the EU has to face increasing competition from other countries, such as Canada on artificial intelligence, Singapore on Logistical Services and South Korea on Environmental and Experience industries.

The future position of European emerging industries in the global value chain depends on the ability of the largest and most innovative European economies, defined as either "strong innovators" or "innovation leaders" by the European Innovation Scoreboard[8] (e.g. Germany, France, Sweden, Belgium, Denmark) to maintain high R&D and innovation levels and lead the industries' cross-sectoral transformation process, but also on the potential of the fast-growing and increasingly innovative Eastern European regions to rise as the new "European Silicon Valleys", i.e. innovative and vibrant tech hubs The latest European Innovation Scoreboard indeed shows that the innovative performance between 2011 and 2018 improved for 25 EU Member States, including not only the most innovative ones,[9] but also the so-called 'moderate innovators' like Poland, Slovakia, Lithuania, Latvia, Spain and others.

[7] See Chapter 4.

[8] European Commission (2019): https://ec.europa.eu/growth/industry/innovation/facts-figures/scoreboards_en.

[9] The only exception is Germany, which recorded a slight decline (less than 1%) in its innovation performance level over the 2011-2018 period, although it still maintains the position of 'innovation leader' in Europe.

The role of clusters for industrial transformation

Clusters are natural hot-spots of inter-sectoral and cross-border interaction

Clusters facilitate cross-sectoral and cross-regional collaboration, thanks to their model of governance that is based on vertical and horizontal cooperation and their embeddedness in regional business and innovation ecosystems, but also their integration in global value chains. Cluster organisations could effectively influence the degree of participation of European industries into global value chains, first by increasing participation of SMEs in clusters, and then by supporting their internationalisation activities, cross-sectoral linkages and transnational collaboration in research and innovation, skill development of SMEs and stimulating entrepreneurship among cluster members. All these support measures contribute to modernising industries and allow SMEs in clusters to move up in the value chain.[10]

High importance is attached to supporting cross-sectoral collaboration and internationalisa-tion

A survey of cluster programmes in the EU Member States and regions conducted by the European Observatory for Cluster and Industrial Change in 2018[11] shows that a variety of initiatives is in place to support clusters across Europe. National and regional cluster authorities consider that supporting cross-sectoral collaboration and promoting internationalisation are prominent objectives for cluster organisations. Support for internationalisation is considered crucial, especially by many Eastern European Member States such as Estonia, Hungary, Latvia, Czech Republic, Poland and Romania. This finding is coherent with the relatively higher collaboration activities that clusters in these countries undertake with countries in other geographical areas of Europe or non-European countries.

Since cluster policy is generally linked to innovation policies, the majority of cluster programmes surveyed attach great importance to innovation objectives too, by either promoting collaborative R&D projects, the commercialisation of innovation or industry digitalisation, but also business model innovation.

There is potential to increase cluster support to skill development and entrepreneurship

Support for skill development and entrepreneurship are not yet systematically targeted by cluster organisations, as they often fall within the mandate of other organisations that are part of the regional innovation ecosystems (e.g. universities, vocational schools, incubator centres). Nevertheless, consistent evidence highlights that the cluster policies and initiatives can be effective instruments for organising and delivering skill development and entrepreneurship policies thanks to their bottom-up dynamics and ability to exploit synergies with other support services.

[10] See Chapter 5.

[11] https://www.clustercollaboration.eu/news/report-cluster-programmes-europe-and-beyond.

1 Introduction

1.1 Purpose of the document

The European Cluster and Industrial Transformation Trends Report (the Trends Report, in brief) identifies and analyses where and how clusters of related industries are transforming themselves and where new specialisation patterns give rise to the emergence or renewal of industries.

The Trend Report supports policy-makers, cluster practitioners and companies in spotting transformation trends at an early stage, by examining, in particular, the ten emerging industries identified by the European Cluster Observatory (2012).

The analysis contributes to the policy efforts towards establishing favourable framework conditions for the development of emerging industries, which evolve at the borderlines of different competences and hence cut across and reshape traditionally defined sectors. It also helps European regions identify potential collaboration areas in which emerging industries cut not only across sectors, but also across borders.

The ten emerging industries:

- Advanced Packaging
- Biopharmaceuticals
- Blue growth industries
- Creative industries
- Digital industries
- Environmental industries
- Experience industries
- Logistical Services
- Medical Devices
- Mobility Technologies

The key questions of the Trends Report are the following.

- What are the global megatrends and their impact on industrial transformation?
- What are the ongoing dynamics of industrial reconfigurations that can lead to the emergence of new industries and new patterns of geographical clustering?
- What is the pattern of internationalisation of European emerging industries?
- How do European emerging industries perform compared to their main international partners?
- What is the role of clusters in industrial transformation processes?

The analysis focuses on the EU Member States and regions. Nevertheless, it also takes into account global trends in terms of industrial dynamics, cross-sectoral trends and global value chains. The objective is to make available fact-based analysis that facilitates modern cluster policy-making in support of emerging industries by identifying promising areas of related industries with strong cross-sectoral linkages by which new winners may emerge.

1.2 Structure of the document

The document is structured as follows:

- **Chapter 2: Global megatrends and their impact on emerging industries**. This chapter presents the global megatrends that impact on the current and future development of emerging industries.
- **Chapter 3: Cross-sectoral dynamics of industrial transformation.** This chapter analyses the dynamic trends of industrial transformation occurring in the ten cross-sectoral emerging industries.
- **Chapter 4: EU emerging industries in the global economy.** This chapter analyses the ten European emerging industries from a global perspective. Specifically, it investigates the internationalisation and trans-regional cooperation trends of clusters and the transformation trends identified for European cross-sectoral emerging industries compared with the trends observed in five extra-EU countries.
- **Chapter 5: The role of clusters.** This chapter presents and discusses the existing and desirable business support services to accompany or stimulate industrial transformation.
- **Chapter 6: Conclusions.** This chapter assembles the main findings from the previous chapters and provides a conclusive assessment.

Three annexes are enclosed to this report.

- **Annex A** includes a summary factsheet that reports upon the most important facts presented in the Trends Report.
- **Annex B** presents the detailed data of the main cross-sectoral linkages and the top and emerging regions for each emerging industry.
- **Annex C** includes the list of bibliographical references.

The Trends Report is accompanied by additional background documents that underpinned its preparation and that provide more information on specific topics to illustrate the robustness of the methodology and to make it possible to replicate the statistical analysis of cross-sectoral linkages. Several background materials have been produced by the European Observatory for Clusters and Industrial Change (hereafter EOCIC):

- Methodology for the European cluster and industrial transformation trends report (EOCIC, 2019b);
- Foresight scenarios of the ten global megatrends and their impact on the industry (EOCIC, 2019c); and
- Cross-sector trends, geographic patterns and value chains analysis of ten European emerging industries (EOCIC, 2019d).

2 Global megatrends and their impact on emerging industries

This chapter presents the main global megatrends that are expected to shape most of the future development of European emerging industries. It investigates the likely evolution of megatrends and their possible impacts on the ten cross-sector emerging industries.

2.1 Definition and identification of megatrends

The concept of megatrends emerged with the seminal work of John Naisbitt in the 1980s. He originally defined megatrends as "large social, economic, political, environmental or technological changes that are slow to form but continue relentlessly over several economic cycles" (Naisbitt, 1982). There is wide agreement in the literature on the main characteristics of megatrends (Kersten, 2014):

- they extend over a **long-term scale** (typically at least 25 to 50 years);
- they are **ubiquitous**, shaping and being shaped by different social systems (politics, economy, etc.);
- they are **global**, affecting the entire world on a global as well as on a local level, although specific impacts might vary by country or region; and
- they are **robust**, able to overcome temporary and localised setbacks.

A central assumption in the analysis of megatrends is that they can be detected from early weak signals (von Groddeck and Schwarz, 2013) that consolidate over time.

An extensive review of the most recent academic and grey literature led to the identification of ten global megatrends. The following main criteria were considered for the selection of megatrends: (i) the consensus in the literature on the relevance of the megatrend; (ii) the availability of information on the future development of the megatrend; and (iii) the pervasiveness and cross-sectoral impact of the megatrend.

Some of the selected megatrends relate to the diffusion of new disruptive technologies, while others are more closely related to demographic, socio-political, environmental and economic shifts. The list of megatrends includes both existing, long-lasting trends that have already undergone certain developments and other more recent trends, for which it is possible to identify only some weak and diffuse signals that indicate that a new relevant megatrend is emerging.

Table 1 presents the ten analysed global megatrends.

Table 1 – List of ten global megatrends

Global megatrend		Definition
Technological megatrends		
	**Automation**	Automation means the use of robotics and "various control systems for operating equipment with minimal or reduced minimal intervention" (RBC, 2014).
	**Mass customisation and servitisation**	Mass customisation means "Developing, producing, marketing and delivering affordable goods and services with enough variety and customisation that nearly everyone finds exactly what they want" (Business Innovation Observatory, 2013). Servitisation is the "innovation of an organisation's capabilities and processes to better create mutual value through a shift from selling products to selling product-service systems" (Baines et al, 2009).
	**Integration of subjects and objects**	It is the process driven by new technologies such as the Internet of Things (IoT), augmented/ virtual reality (AR/VR), and human-machine interactions.
	**Data-driven world**	It includes data analytics techniques and Artificial Intelligence (AI).
	**Cybersecurity and blockchain**	Cybersecurity is the process towards increased "protection of networked information systems" (Department of International Trade, 2018). Blockchain is a "distributed digital ledger technology utilising cryptography and timestamps to provide a permanent record of various types of transactions and interactions" (IHS Markit, 2018). As such, it is considered a possible solution to some cybersecurity and digital trust challenges.
Socio-political megatrends		
	**Globalisation and geopolitics**	It covers the prominence and transformation of global trade and the most recent shifts in international powers.
	**Demographic shifts**	It means population growth, migration trends and an ageing society.
Environmental and smart economy megatrends		
	**Green and circular economy**	It is the shift towards an economic system that is internationally competitive while achieving high social and environmental standards. It covers the energy transition processes and the transition from linear to sustainable production models to face resource scarcity.
	**Urbanisation and smart city**	It is the rising share of population living in urban areas and transitioning towards more efficient and smarter cities, thanks to decentralisation, governance shifts and new ICT solutions.
	**Smart mobility**	It is the transition towards new modes of transportation, the transformation of vehicles and the related changes in social norms and business models.

Source: EOCIC

2.2 Methodology of analysis

Megatrends were studied in detail by using foresight and impact analysis methodologies through a three-step methodology[12].

- **The development of a "conceptual future"**. This involved the description and graphical illustration of the future scenario that is most likely to emerge in the next 30 years as a consequence of the shifts underpinning the development of each megatrend (Kosow and Gassner, 2007). The paths of development, risk and uncertainty factors, linkages between different megatrends and possible alternative scenarios were explored. The analysis was based on a review of over 300 documents to ensure a comprehensive and balanced perspective.
- **The analysis of impacts of megatrends on the emerging industries**. The impact analysis was largely built on the same literature used for developing foresight scenarios. The analysis looked at five different types of potential impacts that carry the most important information to understand industrial dynamics (Eurofound, 2018; European Commission, 2018a; McKinsey, 2013; PRI, 2017). They are:
    - **business organisation**: transformations in business models, production organisation, technological integration and human resource management;
    - **new markets**: incentives or deterrents to the development of new markets by affecting the supply and/or demand of new products and services;
    - **employment**: change in the number of persons employed in particular industries, especially because of technological advances, market creation or organisational changes;
    - **skills** and productivity: both positive and negative shifts in skills requirements/development and the productivity of workers; and
    - **global value chains (re)organisation**: disruption of existing value chains and/or creation of new ones.
- **External validation**. The Delphi survey method was used to challenge critical points in the foresight scenarios and the impact analysis to validate the robustness of the initial hypotheses and also to collect additional evidence and new insights. This methodological tool allows refining long-term predictions in policy-making by favouring consensus-building between experts (UNIDO, 2004). A total of 41 experts in different disciplines, from different countries (both European and extra-European) and different types of institutions (academia, industry, government) participated in the two-round Delphi survey.

[12] The report "Foresight scenarios of ten global megatrends and their impact on the industry" (EOCIC, 2019c) provides extensive details on the methodology of analysis adopted.

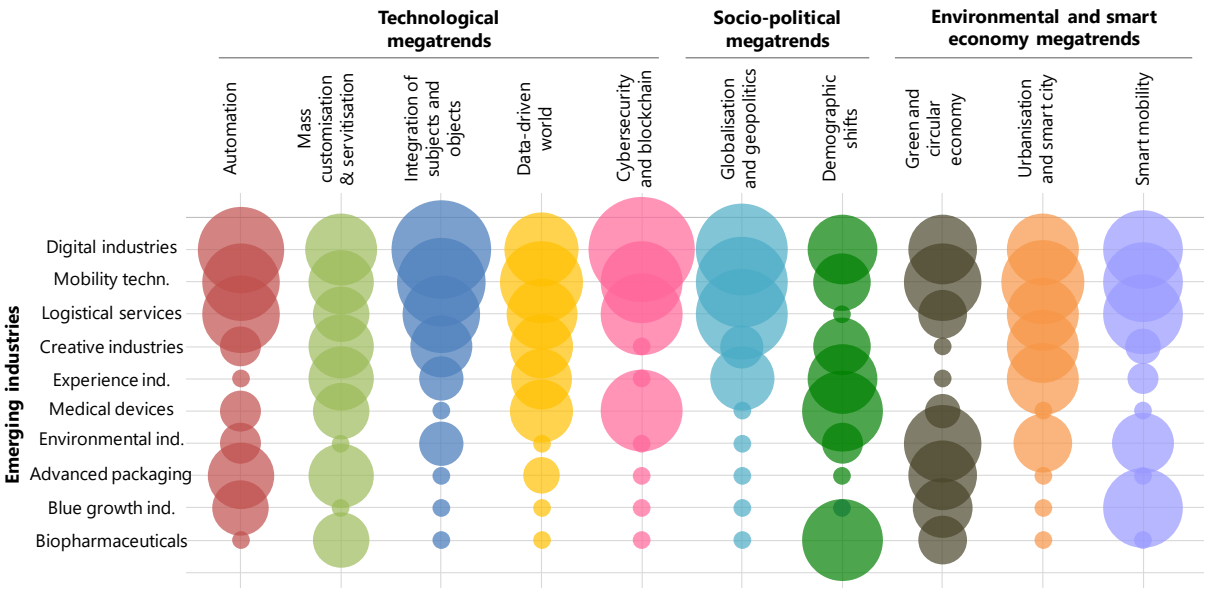
2.3 Foresight scenarios and impact assessment

2.3.1 Synthesis of results

The report "Foresight scenarios of ten global megatrends and their impact on the industry" (EOCIC, 2019c) provides detailed and comprehensive evidence on how each megatrend is expected to develop in the next decades and how it could impact the industry. This set of information is summarised in the following sections by jointly considering the five technological megatrends, the two socio-political megatrends and the three environmental and smart-economy megatrends[13]. This section provides a synthesis of the assessment by putting all the ten global megatrends at comparison to answer two questions.

- Which global megatrends are likely to have the strongest impact on the future of industries?
- Which emerging industries are expected to be affected the most by the global megatrends?

Figure 1 – Impact of ten global megatrends on ten emerging industries



Source: EOCIC

Figure 1 shows the overall impact of each megatrend on each emerging industry: the larger the bubble, the larger the expected impact of the selected megatrends for the considered industry[14]. The figure accounts for both positive and negative effects since every megatrend is expected to pose both great challenges and opportunities for industry development.

[13] Table 1 shows the specific megatrends considered under each category.

[14] More specifically, the bubble size reflects the number of impact dimensions (business organisation, market opportunities, skills and development, global value chain) that are considered to be affected the most by each megatrend on each emerging industry. For each megatrend and emerging industry, this value can go from 0 (i.e. the megatrend is not expected to impact the industry significantly) to 5 (i.e. the megatrend is expected to impact significantly all the five types of impact of the considered industry). The full results are displayed in EOCIC, 2019c.

The analysis indicates that the Digital industries, Mobility Technologies and Logistical Services are (and will be) impacted the most by all of the identified global megatrends. Conversely, some industries are more decisively influenced by specific megatrends. This is the case, for instance, of the Biopharmaceuticals industries, which have already started undergoing significant changes because of demographic shifts. Population ageing, in particular, creates opportunities for new products, services and applications in the biopharma field. Blue Growth industries, and especially the sectors related to maritime navigation, are affected by the changing mobility paradigm, driven by automation, green and circular economy and smart mobility trends. Cybersecurity and blockchain impact especially on health-related sectors (Medical Devices), insurance and mobility (Digital industries, Mobility Technologies and Logistical Services), but future technology development and the risks of new cyber-attacks may expand the overall impact of this megatrend to other industries as well.

Overall, the megatrends that are expected to impact the largest number of emerging industries are:

- mass customisation and servitisation, which trigger changes in business organisation and creation of new market segments;
- smart mobility, which is having disruptive effects on different sectors. The increasing focus on energy efficiency, alternative fuels, shared mobility, automated vehicles and transport systems require changes in business organisation models, skills sets and value chain structure of the emerging industries, which may present at the same time challenges and opportunities for firms, depending on their ability and willingness to embrace change; and
- green and circular economy, which determines the greatest challenges across all the industries, particularly regarding changes in business models and transformation of global value chains that will likely become shorter and circular. A more efficient use of resources is expected to improve productivity and boost competitiveness.

Other megatrends have important impacts (both positive and negative) on specific features of the industry structure. In Figure 2, the bar length reflects the number of emerging industries for which the megatrend is having the largest effect in terms of the considered type of impact: the longer the bar, the higher the number of emerging industries (up to 10) that are significantly impacted along a specific dimension [15].

For instance, automation causes the most changes in business organisation and skills and productivity of emerging industries. Demographic shifts, urbanisation and smart city and the data-driven world generates new market opportunities through the development of new products and services that meet changing demand. Compared to other megatrends, urbanisation and smart city impact employment levels of the largest number of industries. On the one hand, employment opportunities may arise in the (smart) mobility, ICT, housing, energy and environmental sectors. On the other hand, the traditional urban transport sectors (buses,

[15] For more details, see the report "Foresight scenario of the ten global megatrends and their impact on the industry" (EOCIC, 2019c).

taxis and rail) could witness a loss of employment due to large-scale automation and ICT pervasiveness.

Figure 2 – Degree of future impact of global megatrends for different types of impact

	Business organisation	New market creation	Employment	Skills and productivity	GVC (re)organisation
Automation					
Mass customisation and servitisation					
Integration of subjects and objects					
Data-driven world					
Cybersecurity and blockchain					
Globalisation and geopolitics					
Demographic shifts					
Green and circular economy					
Urbanisation and smart city					
Smart mobility					

Source: EOCIC own estimation

The next sections provide detailed information about the impact of each megatrend.

2.3.2 Technological megatrends

The global technological megatrends include five distinct but strongly interrelated megatrends: automation, mass customisation and servitisation, integration of subjects and objects, data-driven world, and cybersecurity and blockchain.

2.3.2.1 Automation

Automation allows the realisation of (primarily manufacturing/production) tasks with limited or no human intervention. Robotics has been the cornerstone of the automation process since the second half of the 20th century. Some industries, such as automotive, have a long history of use of robotics (RBC, 2014). However, this megatrend is revolutionised by the rise of new robots that are increasingly connected, digitised and powered by AI (BCG, 2014). While the penetration rate of robotics was low in the 2010s, there is considerable potential for development (RBC, 2014), given that investments in R&D (robotics and other automation-enabling technologies such as the Internet of Things and AI) and spending for automation capital are increasing substantially. The trend towards greater customisation of goods and services is already pushing for further automation because it reconciles the benefits of mass production and flexibility to deliver personalised products (Eurofound, 2018). In the late 2020s and early 2030s, pressure from population ageing and the related risks of labour shortages are likely to favour the generalisation of automation (OECD, 2017a; Strack et al., 2011).

An estimated **14%** of jobs face high likelihood of automation and another **32%** are likely to face significant change in how they are carried out (OECD, 2018).

2.3.2.2 Mass customisation and servitisation

Growing demand for personalised products and services requires adapted production/service offers and the ability to recognise individual demand shift. This shift in consumer behaviour is not only driven by changing values, such as the willingness to contribute to the design and manufacturing processes, but also by technological innovations that enable them (e.g. 3D printing, social media, e-commerce). Overall, the tendency of shortened product life cycles, faster and more flexible manufacturing processes and open innovation systems allow for mass production of personalised products and services. Servitisation, i.e. the process of creating value by adding services to products, was already widespread among manufacturers before the 2010s (Crozet and Milet, 2017).

An annual business growth of **5%-10%** is experienced by early adopters of servitisation models, with services generating **50%** of revenue (Business Innovation Observatory, 2016).

2.3.2.3 Integration of subjects and objects

This megatrend deals with the ever-greater use of technological linkages (mainly through ICT) to manage a wide range of economic, social and technical functions. It centres on the Internet of Things (IoT) and the renewal of human-machine interactions (e.g. through augmented/virtual reality). The IoT can be defined as the generalised "connection of devices (any devices) to the internet using embedded software and sensors to communicate, collect

and exchange data with one another" (EY, 2016b). Augmented and virtual reality "use next-generation information and communications technologies in near-eye display, perception and interaction, rendering processing, network transmission, and content creation to build a new industry across terminals, channels and the cloud, satisfy customers' requirements for an immersive experience, and drive the expansion and upgrade of information consumption and the integrated innovation in traditional industries" (CAICT and Huawei, 2017). The integration of subjects and objects has long-standing foundations. However, there is evidence that this megatrend is currently consolidating to deliver (parts of) the expected promises (Hewlett Packard Enterprise, 2017). As costs of technologies associated with this megatrend are relatively low, the uptake will probably be quick.

By 2010 there will be around **30 billion** of IoT devices worldwide (Roland Berger, 2017a) and **1 billion** users of augmented reality (Deloitte, 2017a).

2.3.2.4 Data-driven world

The world is increasingly being driven by data for industrial, economic and social applications. Modern data analysis techniques allow the analysis of very large datasets (e.g. Big Data) with which traditional methods are not efficient in getting useful information. The transition towards a data-driven world is driven by the development and generalisation of AI for concrete applications (McKinsey Global Institute, 2017b; Strategic Council for AI Technology, 2017) and the consolidation of the data environment, i.e. the technical, socio-economic and regulatory context of data production, storage, exchange and valorisation (European Commission, 2018b; European Commission 2018c; Villani, 2018). The foundations of the megatrend were already solidly established as of the late 2010s, with several private and public initiatives and policies around the role of data and AI, in particular for application in services and industry (European Parliament, 2018).

By 2030, the total absorption level of AI by companies will reach **50%. 35%** of companies will have fully adopted AI while **70%** will have adopted some AI technologies (McKinsey Global Institute, 2018b).

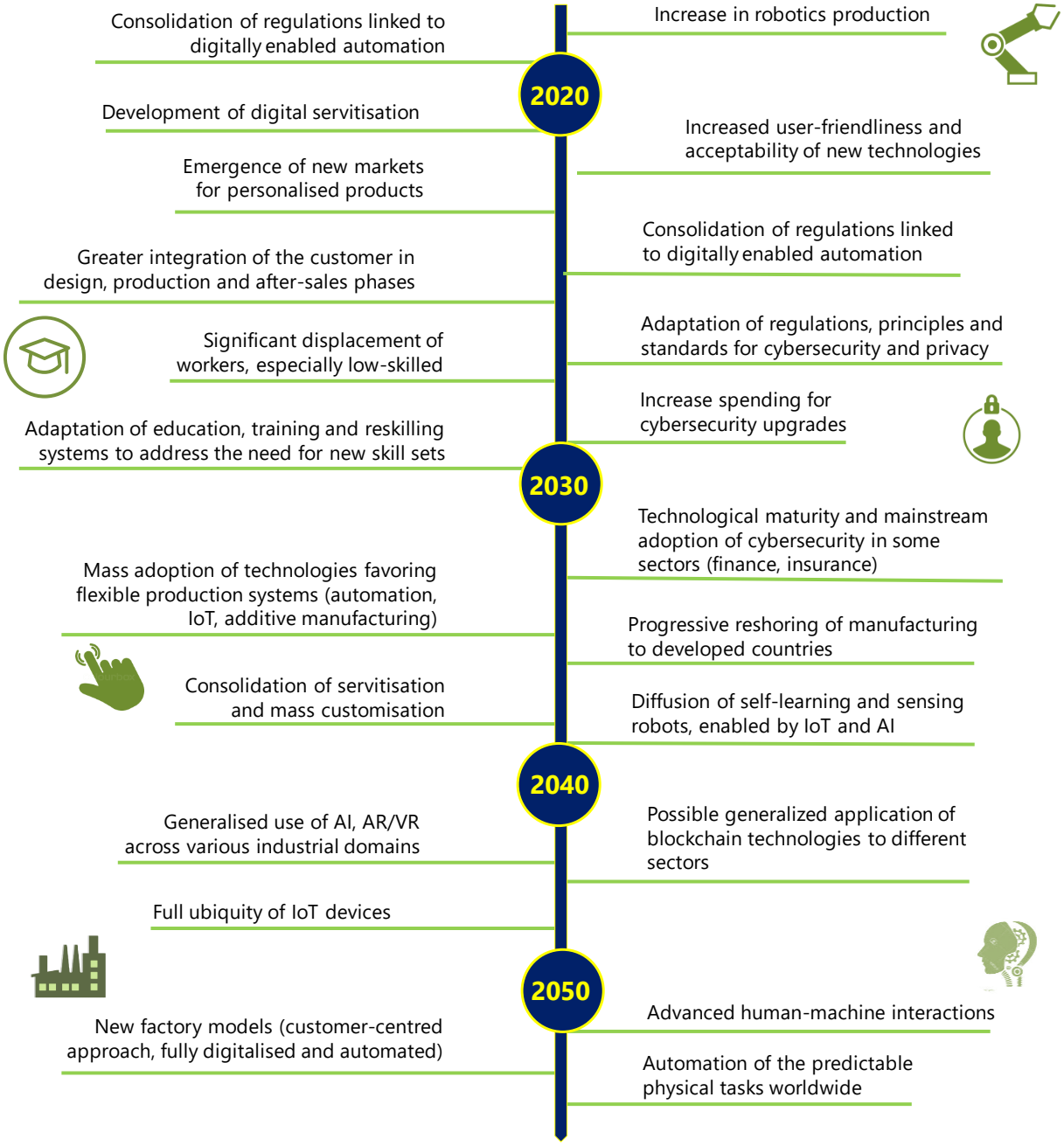
2.3.2.5 Cybersecurity and blockchain

The cybersecurity megatrend is becoming a major challenge for the future of the industry. The generalisation of ICT through automation, integration of subjects and objects and AI are notable contributors to the increase in the cybersecurity risk faced by industries because of vulnerabilities induced by the complexity of systems and multi-organisational dependencies (Dutch Cyber Security Council, 2016; MForesight and CCC, 2017). Cyber threats are expected to rise in frequency, complexity and potential impacts for citizens and businesses alike. Technical and social protection against these threats will be a priority in the following decades. Blockchain is considered one of the possible solutions to cybersecurity. Blockchain is "a real-time ledger of records stored in a distributed, peer-to-peer fashion independent from any central authority". It emerged as the technical backbone of cryptocurrencies (such as the Bitcoin) but also has the potential to disrupt several industries, like insurance services (e.g. through smart contracts).

Cybersecurity attacks might cause a loss in value creation of **USD 5.2 trillion** for companies over the next five years. (Accenture, 2019).

The main paths of development of these five megatrends in the long-term are extensively investigated in EOCIC (2019c) and briefly summarised in Figure 3.

Figure 3 – Foresight scenarios of technological megatrends



Source: EOCIC

The technological megatrends are affected by two main risks that could slow, to some extent, their future development paths: social acceptability and slow adaptation of the regulatory framework (McKinsey Global Institute, 2017a). On the one hand, the potential displacement of workers will be caused by automation and the necessity to reconsider human-machine collaboration and by ethical considerations in relation to the application of AI from increased use of data, which could significantly hinder social acceptability of AI. On the other hand, regulatory barriers could hold back technological progress and new business models. The

regulatory framework will need to be adapted, for instance, to ensure the smooth development of automation and AI applications (European Commission, 2018b; European Commission, 2018c; HQ for Japan's Economic Revitalization, 2015), to set proper protocols and communication standards, notably by enabling proper identification of the different devices (Miorandi et al., 2012) and to secure adapted privacy and cybersecurity models that balance the added value resulting from connected devices with social risks (Deloitte, 2015).

Technological megatrends will induce several changes to industries through the use of emerging technologies, new business models and redefinition of labour organisation. They will open up opportunities but also trigger challenges, such as shifting skills requirements and reorganisation of global industrial value chains. AI, as an emerging general-purpose technology, could have far-reaching effects in several sectors. Together, these technological advances can fuel industrial optimisation and evolution of production processes, but they can also trigger more radical social changes, especially in relations to the function of the labour market and increasing the gap between skilled and non-skilled employees.

Table 2 illustrates how technological megatrends are expected to influence the different types of impact previously identified.

Table 2 – Impact of technological megatrends on each type of impact

Type of impact	Main contribution of the technological megatrends to the impact
Business organisation	• Labour organisation will be transformed by the need to find ways to use data, **automation and AI solutions** to complement rather than replace human labour in a non-alienating way (Villani, 2018), e.g. by replacing workers for routine tasks. • The use of **robotics** could influence working conditions, theoretically allowing greater flexibility of working hours and improved safety conditions if the proper framework is delivered (physical and cybersecurity through better data collection for instance) (Eurofound, 2018; Maggi et al., 2017). However, emerging risks associated with working with robots (e.g. accidents) should not be underestimated. • Demands for **greater product personalisation** and the involvement of the customer in the different phases from design to after-sales and short product life cycles imply an overhaul of flexibility and responsiveness of the production systems (Tseng et al., 2017; UNIDO, 2013; Zawadzki and Żywicki, 2016). Common answers to these changes include the use of new technologies (e.g. cyber-physical systems and additive manufacturing), rationalisation of the production processes and organisational changes (KPMG International, 2014; Baines et al., 2009; Tseng et al., 2017; UNIDO, 2013). • The rise of **servitisation** will lead to challenges because its organisational imperatives may be at odds with traditional manufacturing principles (e.g. focus on the loyalty of customers and its involvement) (Baines et al., 2009). • **Automation and augmented reality** could optimise processes, e.g. by helping workers train, conducting R&D, spotting anomalies or conducting monitoring and maintenance activities (van Krevelen and Poelman, 2010; Rüßmann et al., 2015; McKinsey, 2015). • **AI and new data analytics solutions** are connected to the rise of new business models, such as platforms as a service (PaaS), which offer intellectual property-based models or monetisation of data (McKinsey, 2015). • The business organisation will have to adapt to the new realities of **cybersecurity and blockchain** comprehensively. Indeed, cybersecurity requirements will have to

Type of impact	Main contribution of the technological megatrends to the impact
	be included in product design, company strategy, production processes, communications, management and workforce training (Dutch Cyber Security Council, 2016; Maggi et al., 2017; MForesight and CCC, 2017). This shift will thus imply cultural adaptation and balance with other imperatives, such as flexibility of production and costs (Dutch Cyber Security Council, 2016).
New markets	• The rise of demand for **robotics** will consolidate existing ICT/machinery markets and increase the sophistication of related products. • The **customerisation of products and services** will force changes in market segmentation and open up several market opportunities (Deloitte, 2017a; EY, 2016a; UNIDO, 2013). In particular, industries will focus on designing and producing goods tackling specific individual needs with shortened product life cycles (Business Innovation Observatory, 2013; Weiss and Schweiggert, 2013). Moreover, services will be increasingly bundled with products in comprehensive solutions (Baines et al., 2009). These new market opportunities will spread across several sectors and are likely to contribute to the redefinition of traditional industries (EY, 2016a). • The **integration of subjects and objects**. First, the expected rise in the number of IoT devices or users of AR/VR (CAICT and Huawei, 2017; Roland Berger, 2017a) will open new opportunities for companies. It will primarily be concentrated on fragmented/sectoral applications, especially regarding wearables, health, smart homes and cities, cars, environmental monitoring and energy, and assistance to research and development or training (Goldman Sachs, 2014; McKinsey, 2013; Miorandi et al., 2012; van Krevelen and Poelman, 2010). In the longer run and with the transition to a fully integrated ecosystem, newer markets that bridge existing sectors will emerge (Miorandi et al., 2012) and reshape business models through servitisation (Eurofound, 2018). • The **generalisation of data and AI** use in businesses will have a strong potential for making new products and services emerge (Accenture, 2016; PwC, 2018; Strategic Council for AI Technology, 2017). In particular, these technologies could greatly improve the customerisation of products and services to specific individuals (Deloitte, 2017a; McKinsey Global Institute, 2017b), boost overall quality and time-savings (PwC, 2018) and develop markets for sector-specific solutions, such as autonomous cars, text and language processing for business applications (e.g. legal analysis), complex predictive analytics for sales/marketing and R&D. • Increasing attention on **cybersecurity** will raise the demand and supply of cybersecurity solutions (Department for International Trade, 2018; VTT, 2018), e.g. cyber forensics, threat intelligence collection, training and certification, specific architectures and consultancy services. Industries characterised by important digitisation of assets as well as by particular security or privacy concerns will probably be the most affected (Marr, 2018; Department for International Trade, 2018).
Employment	• There is a wide consensus that **automation, data-solutions and AI** will have a major impact on employment, destructing and creating an important number of jobs, although the net effect is uncertain (PwC, 2018; Villani, 2018). Historically, technology has not led to long-term unemployment (Mokyr, 2017) because new jobs will gradually be created to account for process and product innovations, replacing the old ones. Indeed, there is evidence that new jobs are being created concerning data and AI trends (IBA Global Employment Institute, 2017), such as data scientist (in ICT, finance and business services). Over the past decade, 4 out of 10 new jobs in the OECD were created in highly digitally intensive sectors (OECD, 2018). However, it is unclear whether these new jobs will compensate for job destruction. More critically, the skills required to carry out the newly created jobs will be unlikely to match those

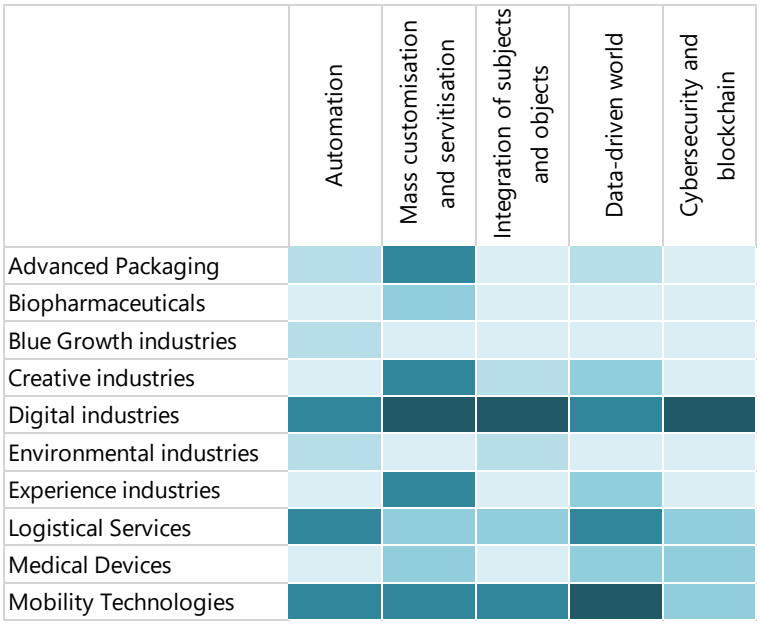
Type of impact	Main contribution of the technological megatrends to the impact
	required to perform obsolete jobs (typically low-skilled routine jobs). As such, the impact on employment will be different depending on the sectors and the territories (Frank et al., 2018). • The **cybersecurity and blockchain** megatrend is likely to have a limited effect on employment, likely concentrating on technical roles in cybersecurity solutions providers.
Skills and productivity	• More than on employment creation, technological megatrends such as **automation, AI and new data analytics** are likely to have a major impact on skills. The integration of these technologies into the workflow will alter the skills' requirements for several occupations and sectors. In particular, routine tasks will be easily performed by AI and robots, while other skills (such as complex problem-solving and adaptation, social skills) will gain importance (IBA Global Employment Institute, 2017). Skills directly connected to AI, advanced ICT and data science will also be more in demand. These changes imply an adaptation of education and training systems, especially to favour reskilling and transitions between jobs (IBA Global Employment Institute, 2017; Villani, 2018). • There is a consensus that **automation and AI** can provide a significant boost in industrial productivity, especially through speed, flexibility and reduction of errors (BCG, 2014; McKinsey Global Institute, 2017a). • **Servitisation, customisation and integration of subjects and objects** imply the development of competences in digital technologies, advanced supply chain management and interdisciplinary skills and cross-mutualisation of engineering, IT, management and marketing (Business Innovation Observatory, 2013; Salesforce research, 2017). Moreover, AR will favour the consolidation of workers' competences through new forms of training (van Krevelen and Poelman, 2010).
Global value chains (re) organisation	• Greater **automation, integration of subjects and objects and data-driven world** could favour the reshoring of production to the developed world, which has the capital and skilled labour to unlock its potential (IBA Global Employment Institute, 2017). This process may be supported by rising wages in emerging and developing countries combined with falling costs of robotics (Eurofound, 2018; McKinsey Global Institute, 2017a). • The greater **involvement of customers** in design, production and after-sales phases will recompose business-to-consumer but also business-to-business relationships (EY, 2016a). Power relationships will be modified, with downstream firms gaining influence compared to upstream ones, thanks to their closer links to customers (Vendrell-Herrero et al., 2017). These more direct linkages, alongside technological changes, will also potentially eliminate or replace several segments of value chains (Business Innovation Observatory, 2013). In particular, additive manufacturing could even favour decentralised production (by institutional or individual clients themselves) (EASME, 2016; Stratasys, 2016). • The **integration of subjects and objects** could support a dynamic of greater fragmentation of the value chain in a first step, with many companies potentially entering the market (CAICT and Huawei, 2017). However, the action of large ICT companies and standard-setting activities (Fujitsu, 2015a) could in a second step favour a concentration of the related industries and increase the power of some dominant stakeholders in the value chain.

Figure 4 illustrates which emerging industries are expected to be impacted the most by the global technological megatrends. While all megatrends, by definition, will have some impact

on any industry, the assessment was made by looking at the different dimensions (business organisations, new markets, employment, skills and productivity, global value chain) for which each emerging industry is likely to be affected the most by each technological megatrend.

The analysis reveals that global technological megatrends will impact mainly the Digital industries, which are both producers and users of new technologies. Major disruptions are also expected to take place in the Mobility Technologies industry and Logistical Services because of the application of new digital technologies and automation. Industries such as Biopharmaceuticals, Blue Growth and Environmental industries are expected to be impacted *relatively* less than other emerging industries, although some effects will still occur, especially in terms of shifts in the business organisation, skills and productivity.

Figure 4 – Emerging industries impacted the most by technological megatrends



Note: the darker the colour, the more impactful the megatrend is on each emerging industry.
Source: EOCIC

2.3.3 Socio-political megatrends

Two socio-political megatrends were considered: globalisation and geopolitics, and demographic shifts.

2.3.3.1 Globalisation and geopolitics

Globalisation is a phenomenon of significant interdependence and interrelationships between nations with economic, social and political aspects (see, e.g., Nierop, 1994 and Albrow, 1996). Even if globalisation had already reached heights in the 19th century, present levels of global integration are unprecedented, especially in terms of trade and global value chains configurations. It also drives major power shifts, such as the ongoing rise of Asian countries. Changes in trade, labour, capital and idea flows triggered by globalisation are likely to continue in the following decades, also driven by new technologies and demographics to reshape the world economy. However, recent dynamics and surges in protectionism (e.g. related to Brexit and the economic policy of the Trump administration in the US) have highlighted the fragility of this megatrend. Even if a full reversal is unlikely, the transition to a new form of globalisation that takes into consideration its negative effects and potential losers is a necessary condition for the further opening up of economies.

An increase of **USD 1** in tariff revenues can result in a **USD -2.16** fall in world exports and a **USD -0.73** drop in world income (OECD, 2010).

2.3.3.2 Demographic shifts

Major shifts in demographics are expected during the 21st century (OECD, 2016; UN, 2017: Roland Berger, 2017c). They relate to global population growth (with youth bulges in developing countries), significant ageing (first in developed countries, but occurring increasingly elsewhere as well), and international migration. These shifts were already largely at play in 2018 and will continue and strengthen in the next decades. Demographic shifts are a strong driver of the development of other megatrends, especially because population growth and ageing are contributing to radical transformations such as urbanisation, change in demand for products and services, and shifts in the international balance of powers. Figure 5 briefly summarises the main paths of development of these megatrends.

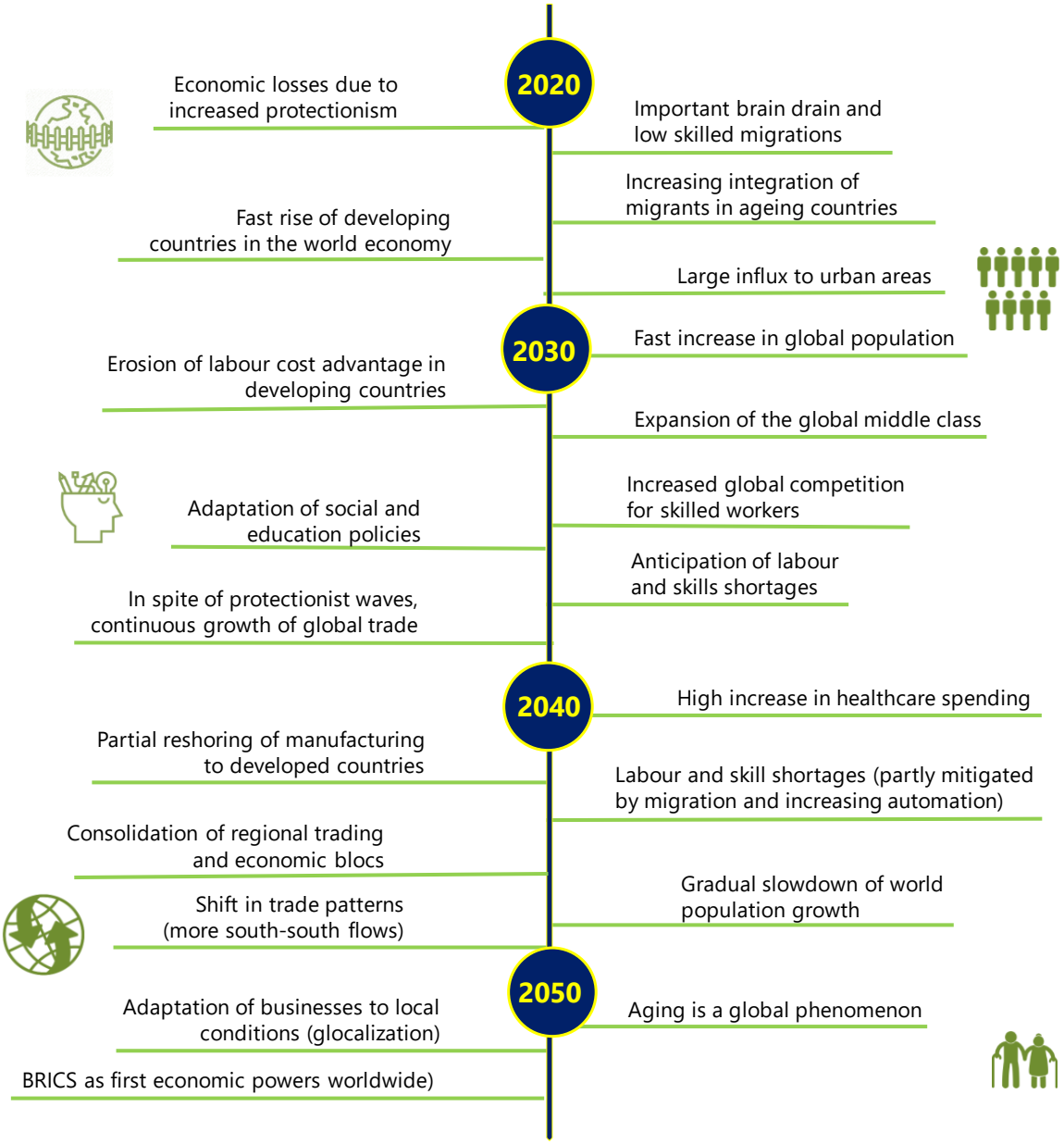
By 2030, **23%** of the population would have more than **65 years old** in developed countries. By 2050, for the first time in history, there will be more people older than 60 years old than younger than 15 years old (OECD, 2016).

Several risks and uncertainties could affect the extent and direction of future changes. Globalisation and future geopolitics will strongly depend on social acceptability, political stability and the strength of protectionism (BCG, 2016b; European Strategy and Policy Analysis System, 2015; OCP Policy Center, 2017; PRI, 2017). The pace of technological progress is also a critical determinant because globalisation interacts with production and communication technologies to set global value chains and organisation of businesses (BCG, 2016a; BCG, 2017; OCP Policy Center, 2017; PRI, 2017; Roland Berger, 2017b). The continuing development of globalisation also rests on economic feasibility imperatives, including transportation and

energy costs, digital infrastructures and labour costs (BCG, 2017; Pegoraro et al., 2017; KPMG, 2014; PRI, 2017; Roland Berger, 2017b).

Political unwillingness to reform pensions/healthcare, delays in integrating automation, hostility to immigration, poor planning and adaptation to the new needs and constraints of the workforce among companies and public services could hinder the adaptation to demographic shifts, causing, for instance, an uncontrolled slowdown of economic growth, severe difficulties in filling positions or finding specific skills, unfulfilled demand (e.g. healthcare) and alteration of global value chains.

Figure 5 – Foresight scenarios of socio-political megatrends



Source: EOCIC

Globalisation will pose new challenges for industries particularly in terms of global value chain reorganisation (shorter and regional value chain) and, as a result, changes in skills and business organisation models (see, among others, UNIDO, 2013; OECD, 2016, BCG, 2016b).

Nevertheless, new market opportunities for globalised companies may arise from the rising middle-class' demand in emerging countries and increasing international flows of innovation (OCP Policy Centre, 2017; PRI, 2017).

Demographic shifts also have far-reaching consequences for economic and social systems, especially in relation to the welfare system, labour supply/skills and the emergence of new needs and markets (e.g. for goods and services targeted to the middle class and the elderly). They come with important associated risks for the EU industry, but could also position the EU as an important global player for transformation that is likely to affect the entire world, depending on the ability to successfully deal with megatrends such as automation or mass customerisation.

Table 3 presents how socio-political megatrends are expected to influence the five identified types of impact.

Table 3 – Impact of socio-political megatrends on each type of impact

Type of impact	Main contribution of socio-political megatrends to the impact
Business organisation	• Increased **global competition** from companies from emerging countries will cause shifts in business strategies (Roland Berger, 2017b). • Strategies based on low labour costs and offshoring will become less relevant (BCG, 2016b; European Commission, 2013). Instead, businesses will adopt a **globalisation** perspective, i.e. combine an international strategy with adaptation to local demands and differences (BCG, 2016a; Bricklemyer, 2014; KPMG, 2014; Roland Berger, 2017b). • **Demographic shifts** will generate a major overhaul of labour organisation. Organisational changes will typically aim at securing the full potential of older workers (concerning productivity and availability), recruiting top talent and facilitating transfers of valuable experience and skills (Kuenen et al., 2011). • A wide range of major changes in human resources principles and practices will take place as a consequence of demographic shifts: lifelong training, non-conventional job mobility, adapted working conditions to retain older workers and attract talents, performance-based (instead of age-based) compensation, long-term skills forecasts in HR, planned and eased transitions between jobs (Strack et al. 2011) and adaptation to greater diversity to favour the integration of migrants into the workforce.
New markets	• High **population growth** at the global level will lead to an increase in the number of consumers. • The rise of a **global middle class** and the increasing international flows of innovation (Bricklemyer, 2014; OCP Policy Center, 2017; PRI, 2017) can create new market opportunities for globalised firms. • **Population ageing** will open very significant market opportunities in different fields (Dieleman et al., 2017; Allahar, 2014; Kuenen et al., 2011), particularly connected to new medical devices, biopharmaceuticals and smart living and mobility.
Employment	• The **globalisation** process (together with increasing automation) will keep causing localised negative effects on employment in traditional industries and low-skilled workers in developed countries, with the risk of rising social disparities (European Commission, 2017). At the same time, globalisation will support job creation through exports (OECD, 2017a), and potential reshoring may result in small employment gains in developed countries (UK Government Office for Science, 2017). • **Protectionist measures** (predicted to be limited in the baseline scenario) might result in job losses in some areas (Standard Chartered, 2017).

Type of impact	Main contribution of socio-political megatrends to the impact
	• With the **increase of the world population** and the associated demand, global employment is generally expected to rise, but with important national differences (OECD, 2017a). • Given the high risk of **labour shortages** (quantity and quality) in ageing countries (OECD, 2017a; Strack et al., 2011), the adaptation of human resources, education and training systems to an older (e.g. through specific working conditions and re-training requirements) and more diverse workforce will have extensive effects on sustaining employment and limiting social disparities. • **Migrations** are likely mitigating labour shortages (high and low skills) in ageing countries (OECD, 2016; OECD 2009) while avoiding risks linked to high youth unemployment in some countries.
Skills and productivity	• As a result of international competition, **globalisation and geopolitics** will contribute to a trend of upskilling, especially in developing countries (European Strategy and Policy Analysis System, 2015). To ensure the sustainability of the megatrend, public authorities and companies will be incentivised to develop workers' transferable skills (BCG, 2016b). • A renewed international division of labour and increased specialisation potential could bring productivity gains in both developed and developing countries (OECD, 2007; BCG, 2016a; PRI, 2017). • Global **population growth** (especially of the middle class) (OECD, 2009), combined with **migration** opportunities and **global competition for talent** will favour educational attainment and enable companies to secure critical skills more easily in the context of ageing (National Intelligence Council (US), 2012). However, these factors could also lead to a major displacement of workers, thereby increasing the gap between skilled and non-skilled employees (Eurofound, 2018).The ultimate impact will depend on the matching and quality of skills, as well as the continuation of migration flows (Bricklemyer, 2014). • More critically, the adaptation of HR, education and training systems will tackle a series of issues linked to the influence of demographic shifts in skills and productivity. Indeed, new attitudes and forms of training and mentoring will favour experience transfers between employees and help older workers upgrade their skills in a new environment (Kuenen et al., 2011; OECD, 2017a; Strack et al., 2011). In particular, declining productivity with age will be avoidable under this new system (Sharpe, 2011).
Global value chains (re) organisation	• **Globalisation and geopolitics** will have disruptive effects on the reorganisation of global value chains. The complexification and segmentation of global value chains will probably increase overall (BCG, 2016a; OECD, 2016), but technology and lower differences in labour costs will imply less focus on cost-based offshoring (BCG, 2016a). The role of emerging countries will also rise in global value chains, as will the development of regionalised value chains (UNIDO, 2013). New ICT, automation and digital technologies will favour the reshoring of some manufacturing activities to developed countries and change the global value chain structure by favouring the development of shorter global value chains and more regional production network. However, these impacts will be vulnerable to an escalation in protectionism (OCP Policy Center, 2017). • High population growth and the emergence of an educated and entrepreneurial middle class in the developing world could change global value chains, e.g. by leading to the inclusion of new stakeholders or shifting roles (UNIDO, 2013). • **Migrations and global competition for talent** might challenge existing global value chains (because large emerging economies have low outward migrations rate

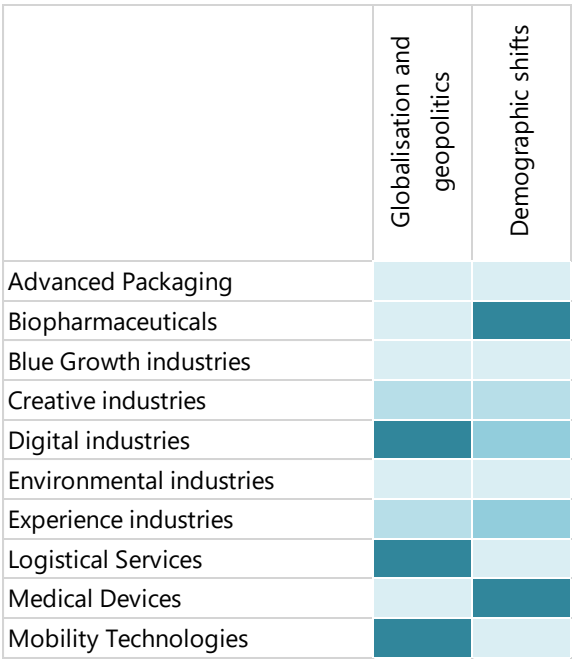
Type of impact	Main contribution of socio-political megatrends to the impact
	of the highly skilled (European Environment Agency, 2014b) and will likely reposition themselves to face competition from lower-cost countries (National Intelligence Council (US), 2012). However, the continuation of the brain drain will likely consolidate existing global value chains.

Figure 6 illustrates which emerging industries are expected to be impacted the most by the socio-political megatrends.

The Digital industries, Mobility Technologies and Experience industries are expected to be impacted the most by the future socio-political megatrends due to significant changes in any of the different dimensions considered and discussed in Table 3 (business organisations, new markets, employment, skills and productivity, global value chain). Transformations are triggered by the rising middle-class demand and increasing international glows of innovation.

Population ageing will particularly affect the healthcare-related industries (Biopharma and Medical devices industries), e.g. through the creation of new markets (e.g. telemedicine and pharma food).

Figure 6 – Emerging industries impacted the most by socio-political megatrends



Source: EOCIC

2.3.4 Environmental and smart-economy megatrends

Three of the megatrends refer to major environmental and economic transformations: the green and circular economy, urbanisation and smart city, and smart mobility. Although these megatrends are distinct from each other, they are also clearly interrelated with the technological and socio-political megatrends investigated previously. The environmental aspect is highly relevant to all three. Moreover, these three megatrends share some underlying assumptions about their future pace of development (see EOCIC, 2019c for more details). Therefore, it is appropriate to study them together.

2.3.4.1 Green and circular economy

The circular economy concept is "a production model that is restorative by nature; ideally, this implies that resources which are used for production enter an infinite loop of reuse, remanufacturing and recycling. Resources that cannot be fully salvaged must be based on renewable sources" (Business Innovation Observatory, 2015a). It is strongly related to sustainable development, i.e. the ability to "meet the needs of the present without compromising the ability of future generations to meet their own needs" (Emas, 2015). Climate change, ecosystems' degradation or energy and resource scarcity put pressure on ecological, economic and social processes. Social concerns and consumers' demands are also shifting towards more consideration of these issues. As a consequence, these factors push for a transition towards a green(er) and (more) circular economy, posing several challenges for the industries but also opening up new opportunities.

Circular economy would allow to generate a total benefit of EUR **0.6 trillion** per year by 2030 to European economies, leading the GDP to increase by **7** percentage points (Ellen MacArthur Foundation, 2015).

2.3.4.2 Urbanisation and smart city

Urban areas will continue to strengthen their political, social and economic importance during the 21st century. Mainly driven by population growth and migration, urbanisation poses several challenges to resource management, housing, transportation and social issues, but also unlocks opportunities regarding economic development and quality of life (among others, see OECD, 2015). The role and nature of cities will likely be profoundly altered in the following decades, with trends of decentralisation recomposing relationships between levels of government, the necessity to address more complex citizens' demands and the emergence of new models of cities (e.g. smart cities). In this new context, businesses will have a greater incentive to consider the urban-regional level in their strategies, to benefit from the related advantages (e.g. agglomeration economies) while avoiding potential side effects (e.g. high congestion costs).

By 2050, urban population will roughly be **6.7 billion** corresponding to about **68%** of the world's population (UNDESA, 2015).

2.3.4.3 Smart mobility

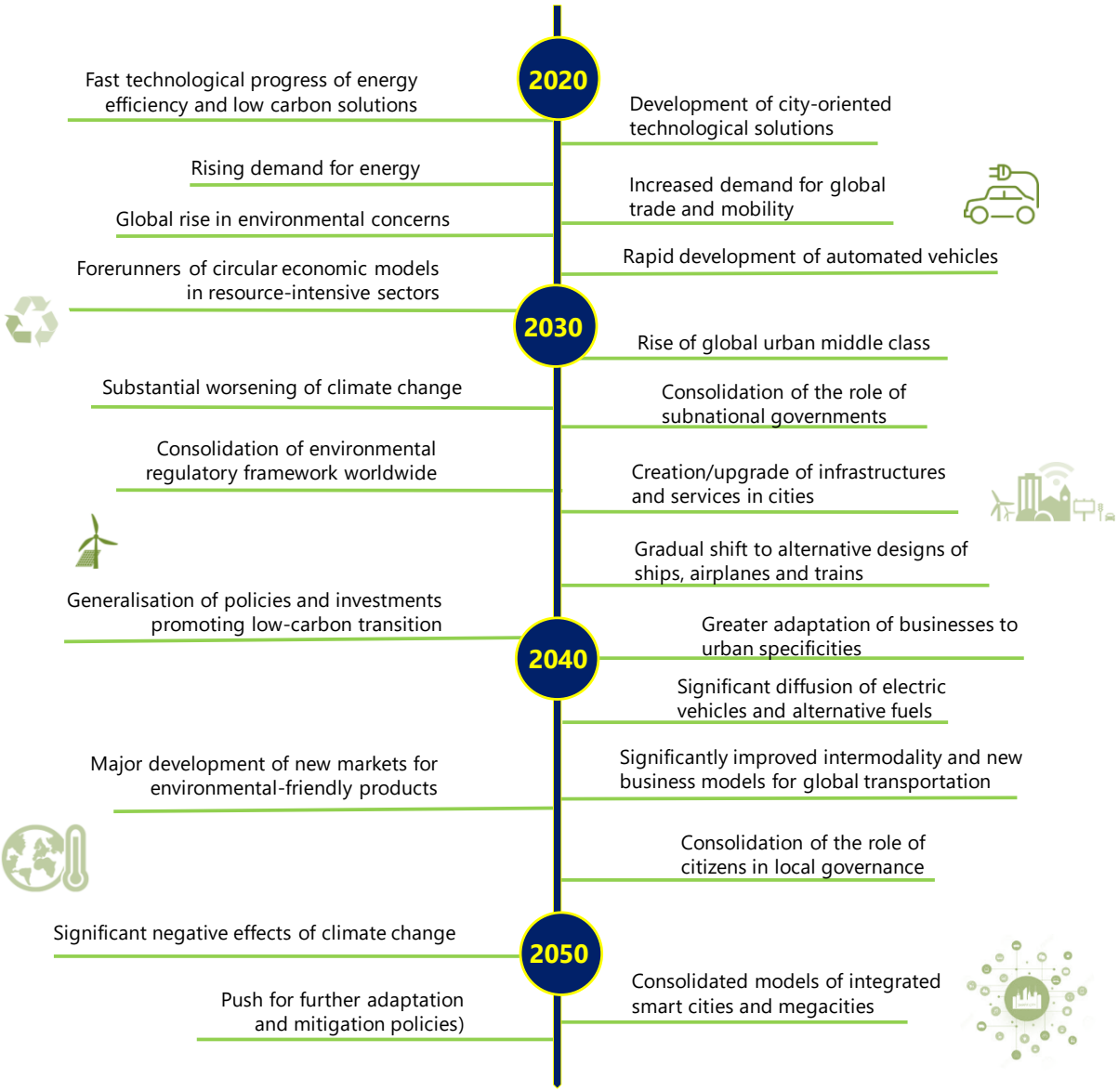
Smart mobility is a megatrend that is transforming the socio-technical systems of transportation (maritime, aerial and land) (Deloitte, 2017b). It implies the development of new

modes of transportation, the transformation of vehicles (e.g. electric and autonomous cars and connected cars) and shifting social norms and new business models (e.g. shared ownership, on-demand rides and integration with ICT). Although this megatrend is in its early stage of development, it has strong disruptive potential, affecting industries well beyond the transportation sector.

Self-driving vehicles' market will grow exponentially in the coming years creating new jobs and developing profits of up to **EUR 620 billion** for the EU automotive industry (European Parliament, 2019).

Figure 7 briefly summarises the main paths of development of these megatrends in the long term.

Figure 7 – Foresight scenarios of environmental and smart economy megatrends



Source: EOCIC

Different alternative scenarios can be devised for these megatrends depending on the fundamental assumptions. The foresight scenario of the green and circular economy

megatrend is based on the assumption that an increasing political and social will and technological and economic efforts at the global level will foster the transformation towards greener production and consumption patterns (European Environment Agency, 2013, 2014a). Yet, several obstacles, including energy prices, the inertia of current models, contradictions with other objectives (e.g. ever-growing international trade), the long period required to adjust business and consumption models and practices and the risk of political reversals (e.g. the Trump administration in the US), will slow the shift towards this new paradigm. In turn, the shift towards a more sustainable economy will impact the future urbanisation and smart mobility patterns (e.g. the pace of development of electric cars). Other important uncertainty factors relate to future demographic patterns, especially to the ability of stakeholders to successfully adjust urban models for the emerging social challenges (e.g. with reference to the integration of migrants).

Table 4 presents how environmental and smart-economy megatrends are expected to influence the five identified types of impact.

Table 4 – Impact of environmental and smart-economy megatrends on each type of impact

Type of impact	Main contribution of environmental and smart-economy megatrends to the impact
Business organisation	• The **green and circular economy** implies a transition to more sustainable economic models, profoundly affecting design, production processes and business models (UNIDO, 2013): less use of primary resources, maintenance of the highest value of materials and products, change in utilisation patterns (CEPS, 2017), focus on transparency and development of new metrics for environmental and social monitoring (Bricklemyer, 2014; Bontoux and Bengtsson, 2015). • The **urbanisation** trend will exert pressure to establish new models of factories that can operate in such an environment, notably in terms of agile cooperation and flexible supply chains (UNIDO, 2013). • The **city level** will keep gaining prominence in strategic choices, requiring localised market intelligence and a cluster-based approach for more efficient market penetration (McKinsey Global Institute, 2012; PwC, 2016). • **Smart mobility** will open up several opportunities for new business models, for instance on an ownership-usership spectrum for vehicles (Deloitte, 2017b). • Integration of ICT in **smart cities** and **smart vehicles** will challenge traditional business models (McKinsey Global Institute, 2018a) and alter the current factory organisation and processes (Eurofound, 2018).
New markets	• Even if the **circular economy** paradigm promotes longer product life cycles (European Factories of the Future Research Association, 2016) and may, therefore, reduce consumption, it will still open up new market opportunities, especially for solutions for adapting or mitigating the negative effects of environmental degradation and climate change (Business Innovation Observatory, 2015b; Fujitsu, 2015b; McKinsey, 2017a; UNIDO, 2013). • **Urbanisation** is strongly correlated with economic development and will allow the emergence of a global urban middle class by the 2030s, boosting demand for several products and services (Americas Market Intelligence, 2013; McKinsey Global Institute, 2012). Specific demands directly linked to the development of cities (e.g. infrastructures and urban services) will also rise (Americas Market Intelligence, 2013; Deloitte, 2017a; PwC, 2017) in developed and developing countries alike (upgrade and greenfield projects). In particular, the market for **smart city** and **smart mobility** solutions will greatly expand in the upcoming decades for a wide range of

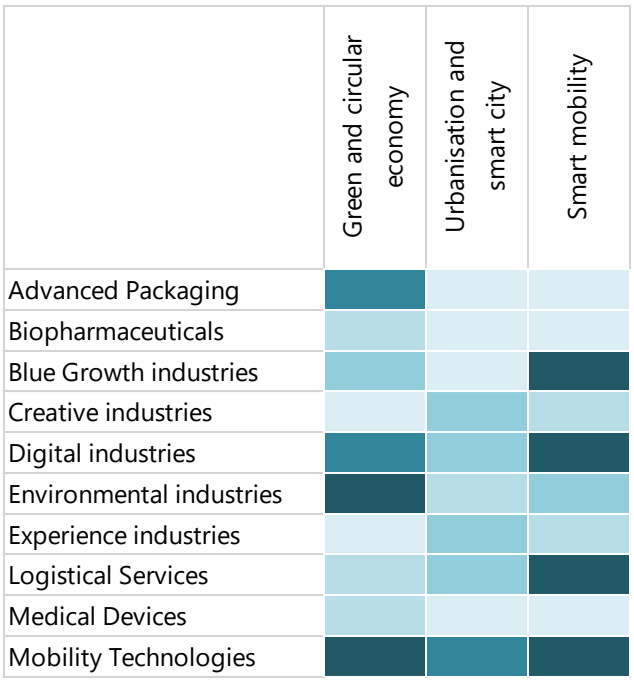
Type of impact	Main contribution of environmental and smart-economy megatrends to the impact
	applications, e.g. mobility, e-government (Fujitsu, 2015c; Jawad, 2014; McKinsey Global Institute, 2018a; Deloitte, 2017b; EFP, 2012; ERTRAC, 2015).
Employment	• Some jobs are expected to be created in sectors associated with the **green economy** (Business Innovation Observatory, 2015a; German Federal Ministry of Education and Research, 2014), with potential for all different skill levels (CEPS, 2017). These sectors include those related to renewables, waste and water management, air quality and biodiversity, and more marginal sectors modernising in a sustainable perspective (CEPS, 2017; German Federal Ministry of Education and Research, 2014), such as the mobility industry. • The transport sector (buses, taxis, rail, port and ship activities) could witness a loss of employment due to large-scale automation and ICT pervasiveness characterising **smart cities** and **smart mobility**. • Thanks to development dynamics, agglomeration economies and **urban entrepreneurship**, some employment opportunities could arise for workers in the industries addressing city-specific challenges (e.g. mobility, housing, energy) (Americas Market Intelligence, 2013; McKinsey Global Institute, 2012).
Skills and productivity	• The **green and circular economy** is associated with relatively specialised requirements for skills. In particular, circular economic models rely on a combination of engineering and management skills, which is often difficult to find (Business Innovation Observatory, 2015a; CEPS, 2017). These shifts suggest the importance of adapting existing training and education systems (German Federal Ministry of Education and Research, 2014). • Improved **resource and energy efficiency** will lower costs of inputs, improve productivity and boost the competitiveness of companies adopting environmentally friendly technologies and organisation (Business Innovation Observatory, 2015c; German Federal Ministry of Education and Research, 2014; UNIDO, 2013). • **Urbanisation** boosts productivity through several channels: the presence of high growth firms, hotbeds for innovation and entrepreneurship, labour market matching, sharing and learning externalities (Deloitte, 2017a; OECD and CDRF, 2010; European Commission and UN HABITAT, 2016; PwC, 2017). Similarly, urbanisation will favour the concentration of advanced skills (European Commission and UN HABITAT, 2016) and overall improved education levels. • The impact of **smart mobility** on skills will be primarily concentrated in the transportation sector. In particular, there will be a shift towards higher skill requirements (especially regarding ICT) and more specialisation (Deloitte, 2017b; Eurofound, 2018; NISS, 2016) of professionals. • **Smart mobility** will also improve productivity, especially as a result of reduced congestion and time spent in transportation systems (Deloitte, 2017b; ERTRAC, 2015). The extent of this productivity increase will thus be strongly reliant on the efficiency of developed solutions and their organisation.
Global value chains (re)organisation	• **Green and circular economy** will favour the rise of shorter and circular value chains (Business Innovation Observatory, 2015a; Business Innovation Observatory, 2015c; European Factories of the Future Research Association, 2016). These circular value chains are associated with longer product life cycles, minimisation of resource and energy usage, recovery and recycling strategies (CEPS, 2017; Business Innovation Observatory, 2015a; Business Innovation Observatory, 2015b). This megatrend can thus reduce revenues (fewer sales at constant customer volume) but also can develop new economic streams because waste can become a resource. Critically, they suppose strong cooperation between the different stakeholders of the value chains to organise a coherent system.

Type of impact	Main contribution of environmental and smart-economy megatrends to the impact
	• An **urban-centred world** could contribute to a reconfiguration of global value chains, according to different modalities. Indeed, the emerging urban models will favour short/regional value chains (GDF Suez, 2012; UNIDO, 2013), while others will promote international linkages and competition between cities (GDF Suez, 2012; PwC, 2017). It will largely depend on how cities and their stakeholders interact with the globalisation and green and circular economy megatrends. • The rise of **smart cities** and **smart mobility** will open new market opportunities worldwide and bring new competitors (e.g. ICT companies), challenging traditional industries and their well-established value chains (McKinsey Global Institute, 2018a); Deloitte, 2017b; GeSI and Accenture, 2015b).

Figure 8 illustrates which emerging industries are expected to be impacted the most by the environmental and smart-economy megatrends.

Mobility Technologies, Digital industries, Environmental industries, Logistical Services and Blue Growth industries are expected to be impacted the most by the future green and smart-economy megatrends. The overall assessment is based on the degree to which these megatrends are expected to affect any of the different types of impact discussed in Table 4 (business organisations, new markets, employment, skills and productivity, global value chain) for the ten emerging industries. Since all these emerging industries include activities related to transport technologies and services, they are relatively more affected than others, especially by the new smart mobility paradigm.

Figure 8 – Emerging industries impacted the most by environmental and smart-economy megatrends



Source: EOCIC

The Medical Devices and Biopharmaceuticals industries are relatively less affected by these megatrends compared to the other emerging industries. While the environmental considerations pushed by the green and circular economy megatrend can affect the production of low-energy consumption medical devices and the search for greener and more sustainable waste management solutions, these industries are less impacted (as compared to other emerging industries) by megatrends related to smart cities and smart mobilities. In fact, other megatrends (particularly the technological and demographic shirts megatrends) play a more decisive role in the transformation of these industries.

3 Cross-sectoral dynamics of industrial transformations

This chapter focuses on cross-sectoral industry dynamics. It analyses the ten emerging industries in terms of cross-sectoral dynamics and geographical patterns.

Cross-sectoral linkages are any form of interaction (e.g. supplier-client relationship, R&D activities, strategic alliances and collaborations) in which the two interacting parties belong to different industrial sectors, which are typically defined by industry NACE codes.[16] Cross-sectoral linkages play a central role in industrial transformation because they are expected to favour knowledge spillovers and innovation. The development of emerging industries is often driven by cross-cutting technologies, creativity and service innovation, and societal challenges such as the need for eco-innovative and resource-efficient solutions.

The relevance of cross-sectoral transformation is backed by substantial theoretical rationale and empirical evidence. The innovation literature suggests that spillovers across sectors play an important role in fostering industrial dynamics (see, e.g. Schumpeter, 1934, Audretsch and Feldman, 1996). Such spillovers can happen unintentionally through the proximity of industries and the mobility of personnel or can happen purposefully through collaborative projects or alliances for the search and exploitation of complementary knowledge. Hidalgo et al. (2007) study the network of relatedness between products, or 'product space', finding that most innovative and competitive products are located in a densely connected core, i.e. they are at the centre of a network of product classes that are strongly interconnected. Neffke et al. (2011) and Boschma (2017) look at technological relatedness of industries to analyse the regional growth paths. They find that the probability of firms entering and developing in a region depends on how technologically close they are to present local activities. If new activities are somewhat related to existing activities, stimulating knowledge transfer mechanisms (like entrepreneurship, labour mobility and networking) has a better chance of effectively embedding these new industries in regional production structures.

The analysis of cross-sectoral industrial linkages presented in this chapter provides insights into the transformation of industries and clues to future development trajectories of emerging industries. This analysis also contributes to investigating if the ten emerging industries identified in the European Clusters Panorama of 2014[17] are still relevant or instead if different cross-sectoral industries with high development potential have started to emerge

[16] European Cluster Observatory, 2015: https://ec.europa.eu/growth/industry/policy/cluster/observatory/european-cluster-trend-report_en

[17] European Cluster Observatory, 2014: https://ec.europa.eu/growth/industry/policy/cluster/observatory/cluster-mapping-services/cluster-panorama_en

3.1 Methodology of analysis

The approach to analysing the cross-sectoral dynamics of industrial transformation relies on one fundamental assumption: linkages between industries can be detected and analysed by considering indicators that can be regarded as reliable proxies of cross-sectoral linkages of industries at the regional level. The geographical dimension is important to investigate not only which cross-sectoral industrial linkages prevail and whether they have strengthened (or weakened) over the years, but also to examine the geographical patterns of such linkages[18]. Following the previous European Cluster Trends Report (European Cluster Observatory, 2015), the selected indicators are:

- **patenting and co-patenting**, retrieved from the PATSTAT database,[19] and allowing the analysis of the connections between different technology sectors related to the emerging industries;
- **mergers and acquisitions** (M&As), extracted from the Zephyr database[20] and used to investigate M&A transactions in which the acquirer and the target belong to different sectors; and
- **joint ventures, strategic alliances and innovation networks** (JV&As) from the SDC Platinum database, [21] capturing joint ventures, strategic alliances, research and development agreements, sales and marketing agreements, manufacturing agreements, supply agreements, and licensing and distribution pacts that occur between companies belonging to different sectors.

These indicators are assumed to capture cross-sectoral industrial transformation trends along the industrial value chain of each emerging industry. Whereas patenting and co-patenting activities reflect trends in upstream activities such as research and technological development, M&A and JV&A data reflect strategic business activities, often with an international character, that could take place both in upstream and downstream segments of the industrial value chain.[22] Consistently with the methodology adopted by the European Cluster Trends Report (European Cluster Observatory, 2015), data were processed to compute the total number of cross-sectoral linkages per year and the growth rate of cross-sectoral linkages over time. The

[18] The analysis focuses especially on finding linkages between the emerging industry and other sectors, which reflects the fact that the industry is moving towards new technologies and industrial sectors that were not included in the emerging industry as it was originally defined. To a more limited extent, the analysis also looks at changes in the intra-industry cross-sectoral activities, i.e. changes in the sectoral composition of the emerging industry (see Table 5).

[19] https://www.epo.org/searching-for-patents/business/patstat.html#tab-1

[20] https://www.bvdinfo.com/it-it/le-nostre-soluzioni/dati/specialist/zephyr

[21] https://www.refinitiv.com/en/support-and-training/sdc-platinum-training

[22] Consistently with European Cluster Observatory (2015), these indicators are used as proxy indicators for the research, technological and industrial development of emerging industries. It is however acknowledged that they are affected by some limitations as well. In particular, patent data may fail to capture the whole research and technological development trends, due to the fact that some technologies (like AR/VR, big data, blockchain, etc.) tend to be protected as industrial secrets and are not patented.

analysis was carried out by looking at cross-sectoral linkages starting from the year 2000 until the year 2016, the latest year for which patent, M&A and JV&A data are available. The analysis of the cross-sectoral temporal dynamics was carried out over three periods: 2000-2004, 2005-2010 and 2011-2016. For each emerging industry, the sectors characterised by the highest total number of interactions with the emerging industry under analysis in the most recent years (2011-2016) and with the highest growth rate between the last period (2011-2016) and the previous one (2005-2010) were identified. Annex B presents these results in a tabular form.

For each indicator, the location of actors involved in a cross-sectoral operation was investigated to identify regional communities and geographical hotspots, i.e. regions (at NUTS-2 level) with a high concentration of cross-sectoral and cross-regional interlinkages[23]. A network analysis was performed to detect the regions in which cross-sectoral linkages are concentrated and to identify larger cross-border or international communities that are the closest linked according to the selected indicators. As for the cross-sectoral analysis, the geographical analysis is also performed for each emerging industry for three different periods: i) 2000-2004, ii) 2005-2010 and iii) 2011-2016. This approach allows detection of changes in the geographical distribution, spreads and strengths of cross-sectoral linkages across European regions.

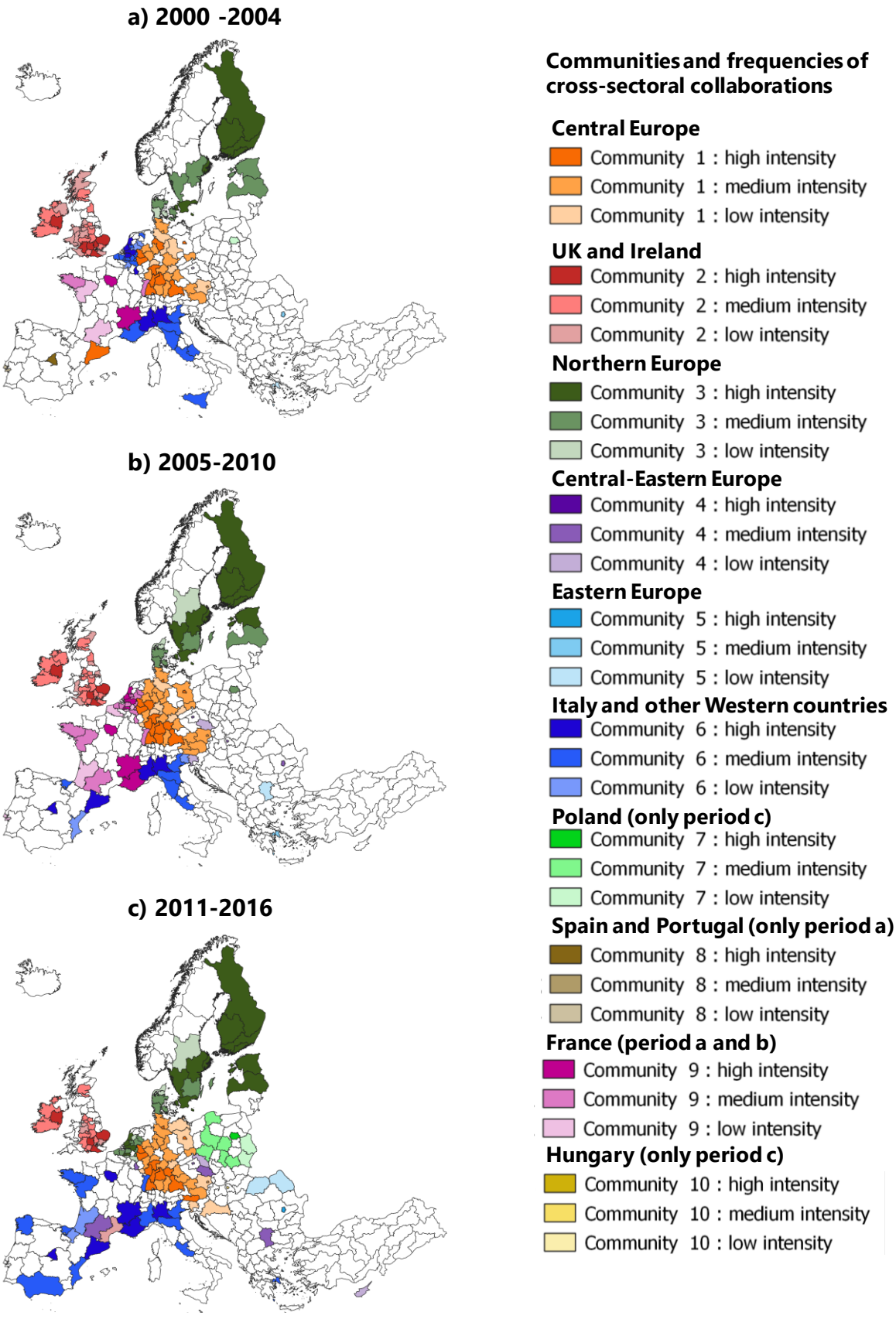
The results of the network analyses were visualised through maps at the NUTS-2 level of aggregation. For each emerging industry, three maps were produced, one for each period. The coloured regions in the map indicate the cluster of regions with a number of cross-sectoral and cross-regional linkages above the median. Different communities, detected through the spin-glass algorithm, are indicated by distinct colours. Within each community, the different shades of the same colour indicate the intensity of cross-sectoral linkages for each region (high, medium and low). The network analysis describes the strength of connections that exist across geographical borders and the wider areas (groups of regions, or "communities") that are the most connected. See, as an example, the geographical analysis for Digital Industries in the figure below (Figure 9 – .

Section 3.3 includes the map for each emerging industry and for the latest years. The full set of maps is enclosed in EOCIC (2019d). More information on the data, sources and methods utilised to produce the analysis of the cross-sectoral linkages and the identification of the regional communities and hotspots are presented in EOCIC (2019b). The analysis and interpretation of quantitative data have been complemented by qualitative research on various data sources, including academic and grey literature review, in-depth scrutiny of patent abstracts and details of the M&A and JV&A deals, review of the cluster facilitated projects for new industrial value chains funded by the Horizon 2020 INNOSUP-1 calls in 2015, 2016, 2017 and 2018,[24] and analysis of the assessment reports of regions in industrial transitions produced by the EOCIC and largely based on regional stakeholder consultation.

[23] The location of inventors is used for patents, which means that the location of the firms that have discovered or realised the inventions is considered, as opposed to entities that filed the patent applications. The location of companies involved in a business operation is considered for M&As and JV&As. This approach ensures that economic operators that have actually engaged in cross-sectoral operations are considered, and not their headquarters. More information on the methodology can be found in EOCIC, 2019b.

[24] https://www.clustercollaboration.eu/eu-initiative/innosup-calls.

Figure 9 – Geographical analysis of cross-sectoral collaboration communities for the Digital Industries



Source: EOCIC

3.2 Main findings from the cross-sectoral linkages analysis

Elaborations on cross-sectoral patents, M&A and JV&A data indicate that overall, the ten emerging industries keep being highly interconnected with a large number of sectors. The global megatrends push for substantial technological transformation at different levels of the value chain, increasing servitisation and product personalisation, attention towards greener and environmentally friendly solutions. Common challenges like these determine the need to develop solutions that are relevant for a diversified number of sectors, thus stimulating cross-sectoral collaboration and exchange of knowledge.

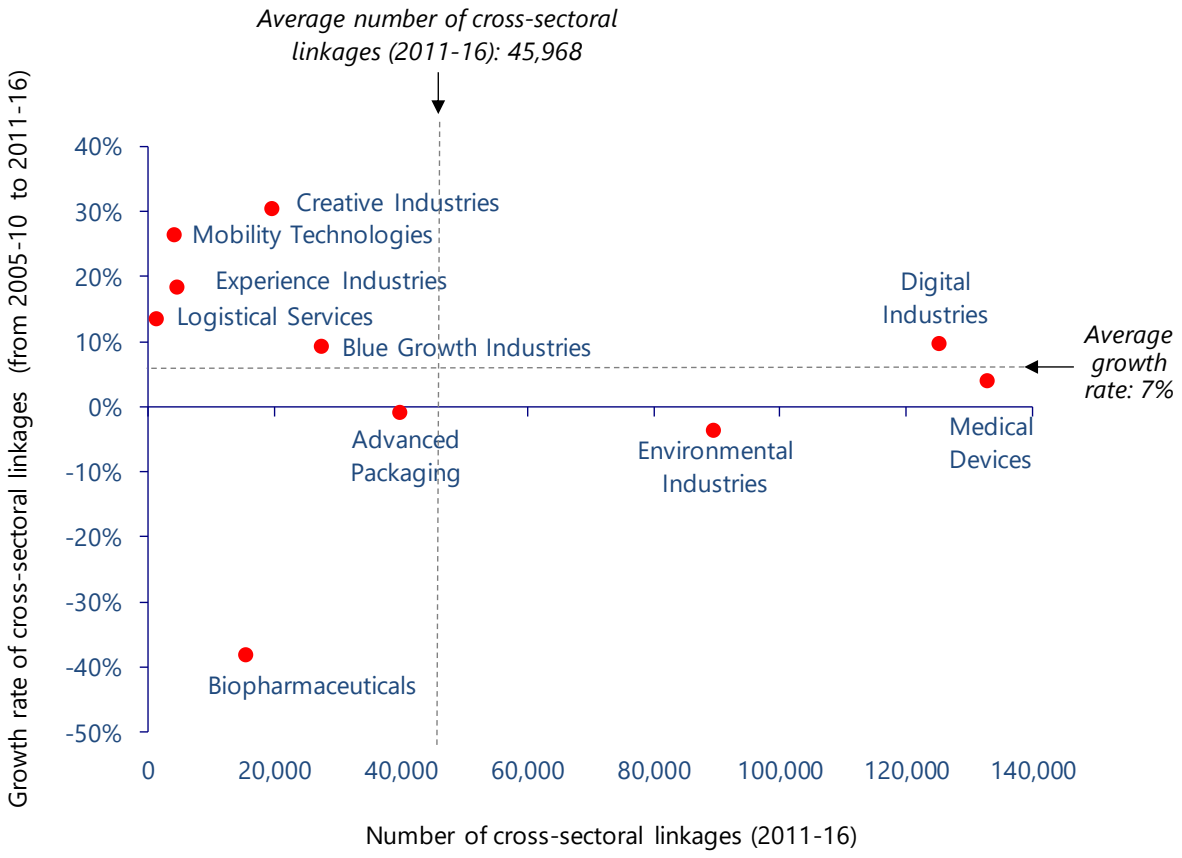
Figure 10 shows the total number of cross-sectoral patents, M&A and JV&A operations and their growth rate in the latest years (2005-2016). The most important findings are these.

- The **Digital industries** are one of the most interconnected industries because they provide key enabling technologies to other sectors. They are characterised by the largest number of cross-sectoral patents and also a high level of cross-sectoral business operations. The number of these linkages keeps increasing over time, especially in terms of patents and M&As.
- **Environmental industries** are also deeply associated with several industrial sectors, like energy, chemicals, electronics, automation and transportation. Innovations in the fields of pollution management, cleaner technologies and renewable energy sources, products and resource management trigger changes in the value chains of all other industries.
- The **Medical Devices** industries rely to great extent on technologies developed for other sectors, as evidenced by the number of patents across different technologies and sectors. As an illustrative example, sensor and automation technologies that are applied to the automotive sector are increasingly used for medical robotics. As another example, low-voltage power batteries or solar photovoltaic systems are increasingly applied to medical devices to generate significant energy savings (see section 3.3.9 for more details).
- The **Creative industries** recorded top-level numbers in M&A and JV&A operations, reflecting a growing integration of cultural and creative technologies and devices with other sectors, such as transportation and healthcare. For instance, designers and artists are more and more involved in the planning, designing and building of urban transport projects (see the "creative placemaking trend" in Chapter 3.3.4). . Patents are less numerous than for other emerging industries, even if significantly increasing over time.[25]
- **Experience industries** are becoming high-tech and high-touch, highly creative and cultural, connecting with media and design sectors as well as digital industries, because software and websites have acquired an increasingly prominent role.
- The **Logistical Services** and **Mobility Technologies** industries, even if not characterised by a high number of cross-sectoral operations as compared to other emerging industries, show a remarkable increase, especially in M&A operations. In fact, the smart mobility megatrend is driving deep transformation trends (e.g. smart warehouses, connected

[25] The reason for this lies in the composition of the Creative industries, which include NACE sectors traditionally characterised by low patenting activity (e.g. architecture, art, crafts, design, fashion, film, music, performing arts, publishing, toys and games, TV and radio and video games). The number of utility models and filed patents is however increasing over time, due to the increasing linkages with transport and civil engineering.

trucks, autonomous vehicles) that are likely to disrupt these two industries in the next years, by fostering cross-sectoral collaborations with the telecommunication, electrical technologies and transport infrastructure sectors.

Figure 10 – Number and growth rate of cross-sectoral linkages by emerging industry



Source: EOCIC

- The **Blue Growth** industries are undergoing similar transformations, pushed by the green and circular economy megatrend and the smart mobility megatrend, e.g. with the development of environmentally friendly ships and autonomous driving boats. Also, uncertainty over the availability of fossil-fuel reserves in the long-run is pushing for the use of alternative transportation fuels in the shipping industry (biofuels).
- Traditional cross-sectoral linkages along the value chain of the **Advanced Packaging** industries (e.g. with the food and beverage sectors) have weakened, but stronger linkages are emerging with other sectors, especially in the upstream stages of the value chain, reflecting the introduction of advanced materials (eco-packaging), advanced machinery (digital printing), intelligent manufacturing and smart packaging.
- The **Biopharmaceuticals Industries** record a positive growth rate in the number of strategic business operations (M&A and JV&A), but a decreasing number of cross-sectoral linkages in terms of patents. This is particularly due to a drop in the number of cross-sectoral patents between biopharmaceuticals and the basic-materials chemistry sector, which suggests that the biopharma emerging industries are increasingly less focused on developing traditional drugs and chemical compounds (like paints and similar

coatings), and more oriented toward new trends. For instance, the Food and Beverage sector is increasingly linked with Biopharmaceuticals, which reflects the strong growth of the pharma food market segment.

Table 5 provides preliminary indications of which sectors are increasingly connected with each emerging industry and those that show decreasing relevance over time. Some sectors that were not included in the original definition of emerging industries[26] are increasingly connected with these industries, indicating their dynamism and progressive transformation. For instance, the food and beverage sector is increasingly linked with Biopharmaceuticals, which reflects the strong growth of the pharma food market segment. Also, the Creative industries have significant intersections with the medical/health sectors due to the increasing adaptation of game and virtual reality technologies for medical treatment.

Table 5 – Dynamic cross-sectoral linkages of the ten emerging industries over 2000-2016

Cross-sectoral emerging industry	Sectors gaining importance	Sectors losing importance
Advanced Packaging	Construction, electronics, machinery, materials (mainly plastics)	N.A.
Biopharmaceuticals	Food and beverage, healthcare, materials, biotechnology	Manufacture of paints and similar coatings
Blue Growth Industries	Construction, electronics, energy (production and transmission of electricity), transport	Distribution: agents involved in the sale of machinery and equipment
Creative Industries	Construction, electronics, energy, transport, web portals	N.A.
Digital Industries	Construction, machinery, materials, electronics, transport, insurance	Telecommunication activities other than wireless and satellite
Environmental Industries	Construction, electronics, electricity production, transport, biotechnology	N.A.
Experience Industries	Construction, retail and web portals, museum activities	Computer service activities other than computer programming and business and management consultancy
Logistical Services	Construction, sensor and devices, freight air transport, taxi operations and other passenger land transport	N.A.
Medical Devices	Chemicals, healthcare, machinery, automotive, business services	Manufacture of machinery for paper and paperboard production
Mobility Technologies	Chemicals, construction, machinery, automotive	N.A.

Source: EOCIC

Moreover, the analysis indicates that **the boundaries of each emerging industry are increasingly blurred**, with industries that are so strongly interconnected one to another that it is becoming challenging to distinguish between them. The ongoing transformation trends bring about significant overlapping, for instance, between the Digital industries and other

[26] The list of industrial (NACE) sectors included in the definition of each emerging industry is presented in EOCIC (2019b).

emerging industries. Digital technologies (e.g. AR/VR, social media, big data) drive the development of an increasing variety of services provided by the Experience industries (e.g. gaming technologies applied to the cultural and educational sectors). Also, the use of wearable technologies is causing transformations in the Creative industries (e.g. fashion technologies) and Medical Devices (digital health technologies). The distinction between Mobility Technologies and Logistical Services is also weakening, as the Logistical Services increasingly rely on the developments taking place in the Mobility Technologies industries, with particular reference to autonomous vehicles and connection technologies.

In parallel, the analysis indicates that the construction section is increasingly interlinked with several emerging industries, as shown in Table 5 above. This finding may suggest that a new cross-sectoral industry is emerging in the European landscape. It is the **(smart) construction industry**, generally covering transport, energy, communication, water and waste infrastructures, buildings (housing, public services, commercial and industrial), construction services (architecture, engineering, technical consultancies), manufacturing and trading of construction products and materials. As recently highlighted also by the European Business Innovation Observatory,[27] while often considered a traditional and low-tech industry, the construction industry is undergoing important transformation processes driven by the introduction of new technologies, greater attention to environmental sustainability and energy efficiency. Smart materials, eco-building, sustainable hotels, intelligent systems and smart technologies to control building operations (e.g. heating, security) are trends that are profoundly changing the value chain of the construction industry and increasing the interlinkages between this industry and other manufacturing and service sectors. The construction industry plays a strategic role in the EU economy, accounting for 9% of Gross Domestic Product (GDP) and 18 million direct jobs (European Commission, 2016). Despite its significance, its global reach remains limited because the vast majority of construction companies, namely SMEs, operate mainly at local levels, while only a small number of international contractors have a global outreach. Yet, considering the sustained slowdown of the European market and its moderate prospects, international competitiveness plays an increasingly important role in the long-term sustainability of the construction sector. Several support initiatives are being adopted, both at Member State level and the EU level[28].

All the summarised developments suggest the **need to update the definition of European emerging industries** to reflect more recent transformation trends. A revised conceptualisation of the emerging industries should be based on a robust statistical analysis (co-location

[27] See the case study on smart construction products and processes (the https://ec.europa.eu/growth/content/smart-construction-products-and-processes_is).

[28] International competitiveness features prominently in Construction 2020, the strategic policy agenda for the construction sector in Europe. The Thematic Objective 5, "Fostering the global competitive position of EU construction enterprises", outlines policy measures foreseen in the Construction 2020 action plan both for the European Commission and national stakeholders. The Commission plays a key role in this regard because it drives the trade policy of the EU as well as international cooperation on regulation and standards. Furthermore, it plays a key role in "business diplomacy" and provides financial support via a number of financial instruments and cooperation funds. The EU is also active in promoting the internationalisation of SMEs through various support measures.

analysis), following the methodology adopted in 2012 (European Cluster Observatory, 2012) to define the current ten emerging industries.

In terms of geographical patterns of cross-sectoral linkages, the network analysis of patents, M&A and JV&A data for each emerging industry reveals some findings that are common to all the emerging industries.

- **The number of regions connected to each other by cross-sectoral linkages tends to increase in size over time.** Indeed, the network analysis shows that the network's size has been increasing from 2000 to 2016, with a higher number of regions being strongly interconnected via cross-regional and cross-sectoral activities (Table 6).
- **As the overall cluster of connected regions expands, more regional communities[29] emerge, particularly in Eastern European countries**. Data for all emerging industries show that new communities are emerging in Eastern Europe. Regions in Poland, Bulgaria, Romania and Czech Republic are increasingly connected among each other and with Western European regions, exhibiting absolute numbers of cross-sectoral linkages similar to countries with strong industrial traditions and an increasing number of regions with a number of cross-sectoral linkages above the European median (Table 7). Eastern countries also saw an increase in the number of hotspots, i.e. regions having a relatively high number of cross-sectoral linkages and connected to the largest number of regions (Table 8).
- Among the western Member States, it is interesting to notice that **the Spanish regions are increasingly interconnected with each other by cross-sectoral linkages**. The long-term analysis highlights that this Spanish community of regions has remarkably expanded from 2000 until 2016, with a growing number of interconnected regions.
- Because of agglomeration economies, **the most interconnected regions are usually located around the national capital cities. Yet, other regions are also emerging** as important centres of cross-sectoral interlinkages. These include, for instance, Spanish regions like Galicia, Comunidad Valenciana and Andalusia, Wielkopolskie, Dolnośląskie and Pomorskie in Poland, the Nord-Vest region in Romania (especially for the Digital Industries centred in the area of Cluj-Napoca) and the Severozapaden region in Bulgaria (especially for Creative and Experience industries). The map in Figure 10 shows the regions that have a number of cross-sectoral linkages above the median by considering all emerging industries together. Annex B includes the list of regions that emerged in the 2011-2016 period for each emerging industry.
- **The cross-sectoral and cross-regional linkages of Italian regions have decreased over time, with particular reference to regions in the south of Italy** (Campania, Calabria, Sicily and Apulia). If in the previous years these regions exhibited significant cross-sectoral exchanges with other regions, both in Italy and in other Member States, in the latest years (2011-2016), the number of linkages has significantly decreased compared to the figures recorded by other regions. In particular, a general shift of the

[29] In network analysis, a community is defined as a subset of regions within the cluster (giant component) that are strongly interconnected via cross-regional and cross-sectoral activities. Communities were identified using the spin-glass algorithm. For more details, see EOCIC, 2019b.

centre of gravity towards the east can be observed: Eastern European regions demonstrate higher dynamism in terms of cross-sectoral and cross-regional linkages, while regions of Southern Italy are lagging behind.

Table 6 – Number of NUTS-2 regions included in cross-sectoral communities (regions connected by a number of cross-sectoral linkages above the median), by emerging industry and time period

Emerging industry	2000-2004	2005-2010	2011-2016	Variation 2000-2016
Advanced Packaging	105	127	119	13%
Biopharmaceuticals	98	114	119	21%
Blue Growth industries	130	129	135	4%
Creative industries	117	130	132	13%
Digital industries	119	133	134	13%
Environmental industries	129	134	134	4%
Experience industries	114	121	128	12%
Logistical Services	75	97	100	33%
Medical Devices	100	121	130	30%
Mobility Technologies	112	123	124	11%
Total	**1,099**	**1,229** ↑	**1,255** ↑	**14%**

Source: EOCIC

Table 7 – Number of NUTS-2 regions included in cross-sectoral communities (regions connected by a number of cross-sectoral linkages above the median), by country and time period[30]

Country	2000-2004	2005-2010	2011-2016
AT	30	43	32
BE	73	67	54
BG	5	6	32 ↑
CY	2	4	5
CZ	14	15	29 ↑
DE	224	252	243
DK	33	34	34
EE	9	10	10
EL	7	10	9
ES	42	49	101 ↑
FI	37	40	40
FR	93	107	94
HR	2	5	4
HU	3	8	9
IE	16	20	16
IT	69	72	49 ↓
LT	5	5	5
LU	9	10	10

[30] The figures in Table 7 indicate the number of regions that are connected most with other regions (both within the same country and other Member States) by cross-sectoral linkages for all the ten emerging industries. Thus, each NUTS 2 region could be counted more times (until 10 times), depending on the number of emerging industries for which each region had relatively higher cross-sectoral linkages. Information for each emerging industry is provided in a map format in section 3.3.

LV	6	7	9
MT			3
NL	75	84	71
PL	10	20	87
PT	8	11	5
RO	6	6	11
SE	49	65	59
SI	3	5	5
SK		2	3
UK	269	272	226
Total	**1,099**	**1,229**	**1,255**

Source: EOCIC

Table 8 – Number of hotspot regions (regions connected by the largest number of regions and the largest number of cross-sectoral linkages within each community), by country and time period

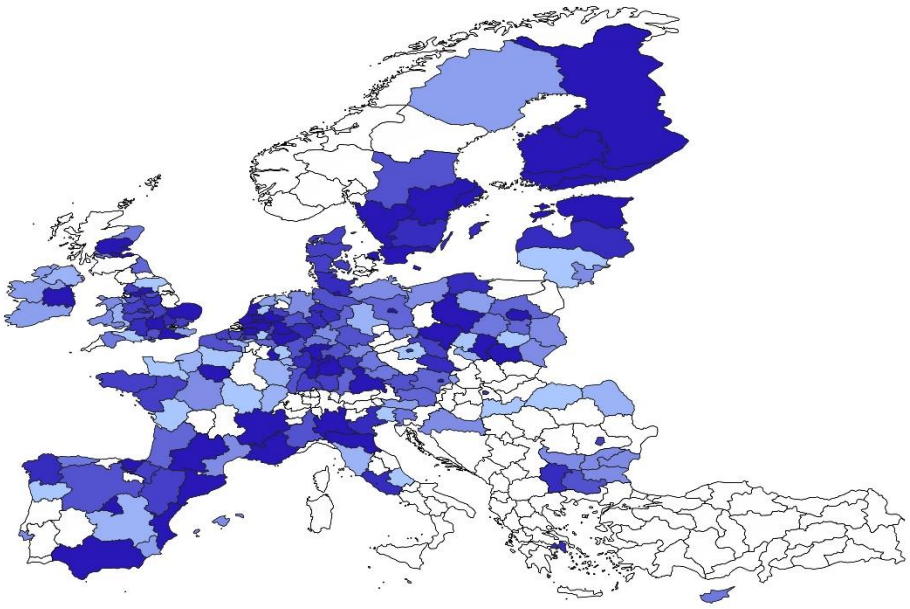
Country	2000-2004	2005-2010	2011-2016
AT	3	1	
BE	2		
BG	2	4	6
CY		1	
CZ	3		1
DE	9	11	11
DK	2		1
EL	2		2
ES	8	7	7
FI	10	10	8
FR	11	11	8
HU		3	2
IE		1	1
IT	6	7	6
LU	1		1
LV		1	3
NL	10	9	8
PL	3	5	7
RO	3	1	4
SE	2	1	
SI		3	
UK	11	10	9
Total	**88**	**86**	**85**

Source: EOCIC

Figure 11 provides the full picture of EU regions with a higher degree of cross-sectoral linkages (i.e. above the EU median in the 2011-2016 period). The colour scale indicates the number of emerging industries for which each region has higher cross-sectoral linkages: the darker the colour, the more numerous emerging industries for which the region has stronger cross-sectoral linkages. Annex B includes the list of NUTS-2 regions with the highest intensity of cross-sectoral linkages in the 2000-2016 period (top regions) and the list of NUTS-2 regions

with the highest growth of cross-sectoral linkages in the latest period (2011-2016) (emerging regions).

Figure 11 – EU regions with a higher degree of cross-sectoral and cross-regional linkages for all emerging industries in 2011-2016



Source: EOCIC

The following sections (3.3.1 - 3.3.10) present the results of the cross-sectoral linkages analysis with reference to each emerging industry. In particular:

- the main transformation trends affecting each industry are discussed;
- a chart is included to depict the value chain of the emerging industry and show which sectors are increasingly interacting with specific parts of the value chain; and
- a geographical map at NUTS-2 level shows the communities of the closest-connected regions through cross-sectoral linkages in the 2011-2016 period and the most dynamic hotspots in the EU for each emerging industry.

Similar information, but with a higher level of detail, is provided in the accompanying report EOCIC (2019d).

3.3 Detailed findings by emerging industry

3.3.1 Advanced Packaging

Advanced Packaging is a very composite emerging industry with a large network of cross-sector linkages between the "paper and packaging" core sector and many other industries and technology areas. It comprises the conventional packaging industry as well as operators creating and providing additional value-added products and services that expand the scope of the core functions of packaging. Advanced Packaging includes the paper and packaging traded industries, complemented with packaging-related sectors from plastics, automotive and downstream metal products.

Recent data suggest that some traditional cross-sectoral linkages along the value chain have weakened - for example, the linkages with the Food and Beverage sector, as analysed by Wendt (1992). However, some new trends are emerging. The strongest cross-sectoral linkages concern the sectors of Electrical Machinery, Measurement, and Materials and Metallurgy, indicating that new technologies, such as advanced materials, advanced machinery, intelligent manufacturing, and smart packaging, very much drive the Advanced-Packaging value chain, especially its upstream segment. The main cross-sectoral trends are presented in Table 9.

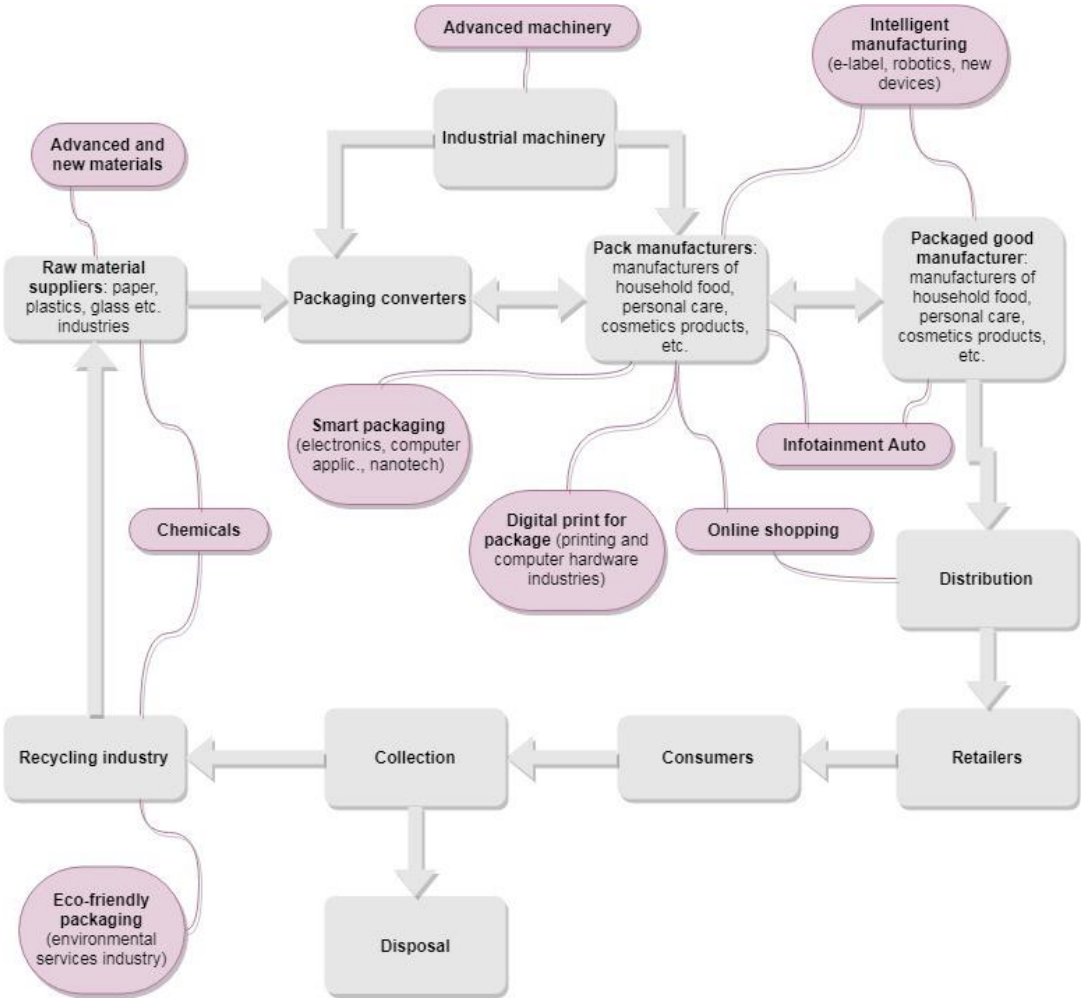
Table 9 – Emerging cross-sectoral trends for the Advanced Packaging industry

Definition	
Eco-packaging	The Advanced-Packaging industry is transforming itself in order to rely increasingly on new eco-friendly and recyclable materials. An example of recent M&A highlighting the increasing interlinkages between Advanced Packaging and environmental services industries is the acquisition of a recycling business in the Netherlands, Reparenco, by the Irish Smurfit Kappa, one of the world leaders in paper-based packaging (July 2018).
Digital printing	The interlinkages between advanced packaging and electronics and professional services industries are particularly strong. For instance, they resulted in the introduction of digital printing, which allows more flexibility and personalisation of packaging.
Intelligent manufacturing	Developments in the packaging industry depend not only on new materials but also on new innovative packaging equipment. This is leading to the emergence of the advanced machinery industry, a crossover of advanced packaging to electrical machinery and energy sectors. Intelligent manufacturing is increasingly relevant for the packaging industry, which needs mechanical engineering solutions (i.e. advanced robotics and new devices) to optimise the packaging process. To this end, new devices and measurement methods are being developed and applied to this industry. For example, methods to detect leaks in packages or foreign matter in a product have recently been developed. Another example is the British company that has developed 'a liquid intake tracking device for removable insertion into a beverage container in order to track an amount of liquid consumed, the rate of liquid consumption over time, and to provide alerts to the user. The device connects wirelessly to an application executing on an external electronic device which provides user with liquid consumption data and reports concerning the user's interaction with the beverage container'.[31]

[31] Source: patent abstract retrieved from PATSTAT.

Definition	
Smart packaging	Smart Packaging is another important trend affecting the packaging value chain. Defined as "packaging that contains an external or internal indicator to provide information about aspects of the history of the package and/or the quality of the food" (Robertson, 2006), this new trend arises as a crossover of the packaging industry with the electronics industry and nanotechnology. It includes aspects related to the intelligent-labelling trend that includes, in turn, printed electronics technologies (e.g. features developed in the electronics industry). The German company Karl Knauer provides an example— its patented HiLight, smart LEDs® technology for integrating LED into any cardboard, corrugated cardboard or paper product in an aesthetic, functional and affordable way. Another example is the case of Softbox System. This UK firm, the leader in temperature-control packaging, has formed several partnerships with biotech, pharmaceutical, clinical research and logistics companies[32].
Infotainment Auto	The Infotainment Auto trend is pushing cross-sectoral operations between the Automobile & Components and Packaging industries

Figure 12 – The cross-sectoral value chain of Advanced Packaging industry



Source: EOCIC

[32] For more details, see https://www.softboxsystems.com/about-softbox/

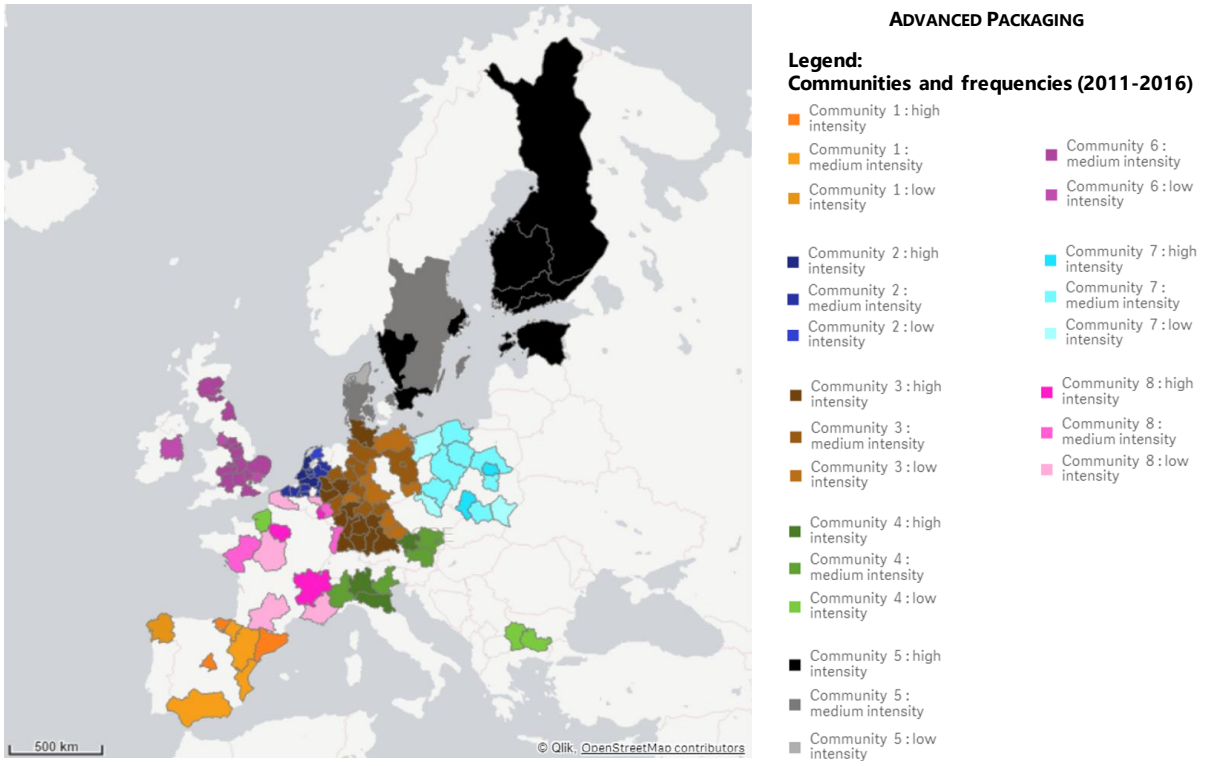
The social-network analysis of patent, JV&A and M&A data identified eight communities of regions that are the most closely connected through cross-sectoral linkages in the 2011–2016 period. These communities are centred around specific node regions (hotspots), namely:

Community 1: Comunidad de Madrid (Spain)	Community 5: Helsinki-Uusimaa (Finland)
Community 2: Noord-Brabant (Netherlands)	Community 6: Northumberland and Tyne and Wear (United Kingdom)
Community 3: Oberbayern (Germany)	Community 7: Warszawski stołeczny (Poland)
Community 4: Emilia Romagna (Italy)	Community 8: Ile-de-France (France)

Ireland and Denmark are significantly interconnected with the UK and Sweden respectively. Spain witnessed an increase in cross-sectoral and cross-regional activities since 2000 and thus an enlargement of the Spanish community (i.e. the Spanish community is formed today by a larger number of regions than in previous years). In contrast, the size of the community centred on the Italian region of Emilia-Romagna (Community 4) has decreased. In fact, southern Italian regions previously very active in this industry have reduced the number of cross-sectoral and cross-regional operations. Furthermore, in the most recent years, a new regional community has emerged, composed of Polish regions.

Figure 13 shows an overall picture of cross-sectoral communities (in terms of the number of linkages) and high-incidence regions across European NUTS-2 regions.

Figure 13 – Cross-sectoral communities and hotspots of Advanced Packaging Industry in Europe (2011–2016)



Source: EOCIC

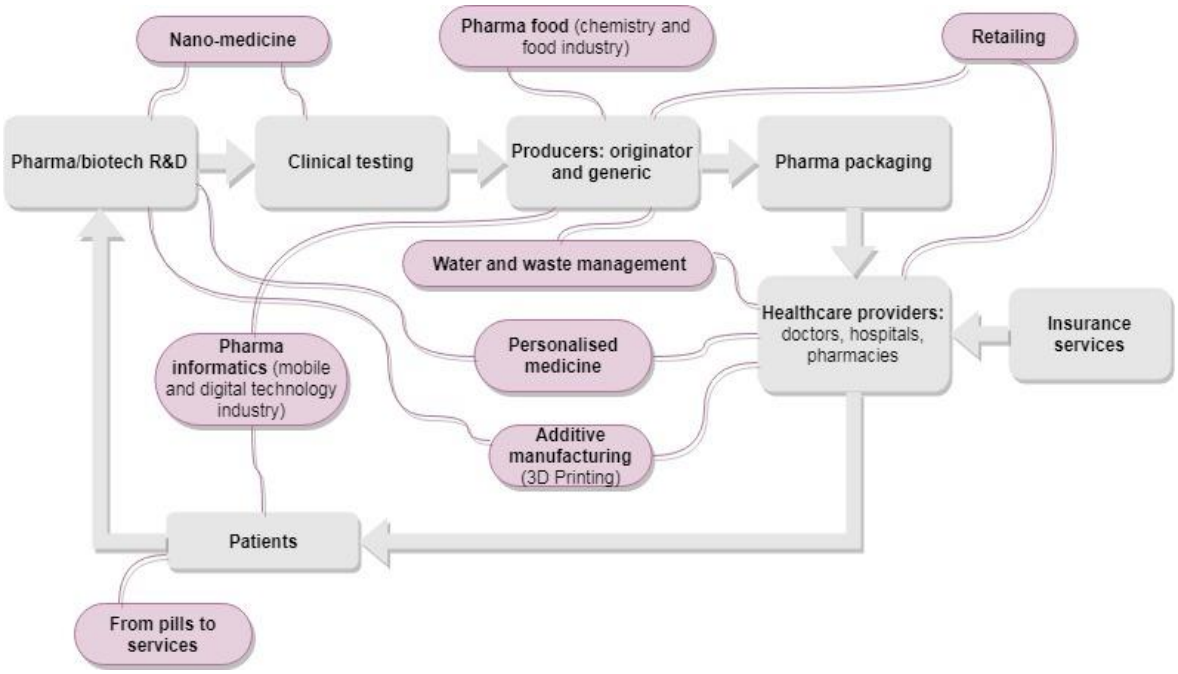
3.3.2 Biopharmaceuticals

The biopharmaceutical industry (Biopharma) is the result of an evolution of the traditional pharmaceutical industry that emerged in the late 1800s, mainly based on chemical production. The industry has incorporated the more recent emergence of biotechnology developed on living cells and molecules, stemming from key innovations in the 1970s and 1980s. Today, the global biopharmaceutical industry is a momentous driver of scientific advancement, and the source of innovative medicines addressing a wide range of human health-related needs around the world. The most specific area of biopharmaceutical product development includes vaccines, blood components, hormones, antibodies, cell-based therapies, stem cells, gene therapy or enzymes.

The European Cluster Observatory (2015) found the emerging Biopharma industry 'to show the most dynamic cross-sectoral linkages', with a number of linkages to other industries and technological areas. Elaborations on more recent patent, M&A, and JV&A data confirm that this emerging industry is one of the most interconnected, even if the dynamics of cross-sectoral patenting and JV&A have slowed during the last 15 years. On the other hand, cross-sectoral M&As have steadily increased.

An important drop in the number of cross-sectoral patents between biopharmaceuticals and the basic-materials chemistry sector suggests that this emerging industry is increasingly less focused on developing traditional drugs, and more oriented toward new trends. An in-depth analysis of the sectors increasingly involved in patents, M&As, and JV&As with the biopharmaceuticals industry reveals that the following emerging technologies and industries are transforming the biopharmaceuticals value chain.

Figure 14 – The cross-sectoral value chain of Biopharmaceuticals Industry



Source: EOCIC

Table 10 – Emerging cross-sectoral trends for Biopharmaceuticals industry

Trend	Description
Pharma food	The pharma food industry is blurring the lines between pharmaceuticals and food and beverage industries. The two sectors increasingly combine to provide food or beverage with pharmacological additives to improve health (e.g. to lower cholesterol). Unlike simple nutraceuticals (e.g. vitamins), pharma food cannot be bought off the shelf; physicians must prescribe it and pharmacies distribute it.[33]
Nanomedicine	Nanomedicine is the application of nanotechnologies in a healthcare setting. It is a branch of medicine that applies the knowledge and tools of nanotechnology to the prevention and treatment of disease. It is a crossover of the pharmaceutical sector, micro-structural and nanotechnology, basic material chemistry and other materials. From a dynamic perspective, whereas the total number of cross-sectoral patents is decreasing over time, those with the sector Micro-structural & Nano Technology rose by 571% between 2000–2004 and 2005–2010 and by 152% between 2005–2010 and 2011–2016. Basic materials chemistry is another relevant technology area increasingly interlinked with biopharmaceuticals.
Personalised medicine	Personalised medicine arises as a crossover of pharmaceuticals and the healthcare sector (healthcare equipment and healthcare providers). It aims to move away from a 'one size fits all' approach and to tailor therapies and medical treatment to ensure better patient care. Potential personalised medicines are estimated to represent 42% of drugs being developed, and the share increases to 73% if the focus moves toward personalised medicines treating cancers (i.e. medical oncology segment).[34] Since January 2017, the EU, through the Horizon 2020 programme, is supporting the INNOLABS project, whose final goal is to develop, improve and deliver disruptive technologies primarily related to personalized healthcare.
Additive manufacturing	Additive manufacturing is a new technological trend driven by the growing demand for customised pharmaceutics and medical devices. 3D printing enables the production of personalised medicines and easily altering the drug-release characteristics, increasing traceability (e.g. by printing barcodes directly on pills), and decentralising the production model, shortening the figurative distance between final consumers and the producers. At which stage of the value chain the technology would play a role is still uncertain. One possibility seems to be that pharmacists either tailor and print out customised drugs upon request or alter drugs previously produced by a given amount of active pharmaceutical ingredient (API). Another possibility is that doctors could directly customise pill dosage.
From pills to services	The pharmaceutical industry is increasingly interested in moving the focus from pills to patients by adopting a person-centred care approach. As consumers' engagement in care-related issues keeps increasing, pharma companies face the challenge of providing services rather than pills. For instance, some pharmaceutical companies exploit social networks to better target patients and build relationships with them, since online platforms bring together consumers with similar health interests. The increasing number of operations between biopharmaceuticals and business services industries confirms this trend.

[33] The previous European Cluster Trends report (European Cluster Observatory, 2015) had already detected this relatively new trend supported by the high number of patents related to both Biopharmaceutical and Food Chemistry technologies (1,611 patents over the period from 2011 to 2016), as well as by the increasing number of M&As between companies active in the biopharmaceuticals and in the Food and Beverage industries (48 operations in the 2011–2016 period with a growth rate of 140% over the previous period).

[34] For further details see the link: http://phrma-docs.phrma.org/sites/default/files/pdf/pmc-tufts-backgrounder.pdf

Trend	Description
Direct retailing	Pharmaceutical manufacturers have a growing interest in direct delivery to pharmacies, using only a restricted number of wholesalers as sole agents (Direct-To-Pharmacy) or using wholesalers as logistics providers for the same purpose (Kanavos et al., 2011). This new trend is reflected by the high number of JV&A between biopharmaceuticals companies and business services companies reflects this new trend. Despite the novelty of this type of approach, some evidence is already available. In countries such as Denmark, Greece, Ireland, Luxembourg, Netherlands and the UK, the proportion of pharmacy sales originating directly from the manufacturer is over 10%, and the share rises to over 20% by adding the Czech Republic, France and Italy.
Water and waste management	Environmental concerns are influencing biopharmaceutical manufacturing by emphasising the importance of recycling instead of recurring landfill disposal or incineration, especially given the increasing utilisation of single-use (i.e., disposable) systems in the sector.[35] The manufacture of medicines and drugs makes use of chemicals, materials and other substances that are potentially toxic if allowed into the environment. Environmental issues pose a challenge in terms not only of waste treatment, but also of water management. Innovative technologies that provide a solution for water and wastewater treatment include active carbon filtration, biological degradation, membrane filtration technology, reverse osmosis, ultrafiltration, oxidation technologies or hydrogen peroxide with radiation from UV light. A range of companies has arisen and expanded to provide such services for pharmaceutical-producer firms and, as the analysis of M&A data shows, there is an increasing number of acquisitions of pharma companies by water and waste treatment firms.

Because science-based innovation requires a continuous exchange of explicit and tacit knowledge, the industry has typically developed into regional clusters of industrialized countries. Focusing on cross-sectoral linkages along the value chain of the Biopharma industry in Europe, the most dynamic hotspots are spread throughout Europe. The social-network analysis identifies eleven communities of regions that were the most closely connected through cross-sectoral linkages during 2011–2016. These communities centre around specific node regions (hotspots):

Community 1: Małopolskie (Poland)	Community 7: Lombardia (Italy)
Community 2: Cataluña (Spain)	Community 8: Ile-de-France (France)
Community 3: Bucureşti - Ilfov (Romania)	Community 9: Zuid-Holland (Netherlands)
Community 4: Hovedstaden (Denmark)	Community 10: Berlin (Germany)
Community 5: Praha (Czech Republic)	Community 11: Inner London - West (UK)
Community 6: Attiki (Greece)	

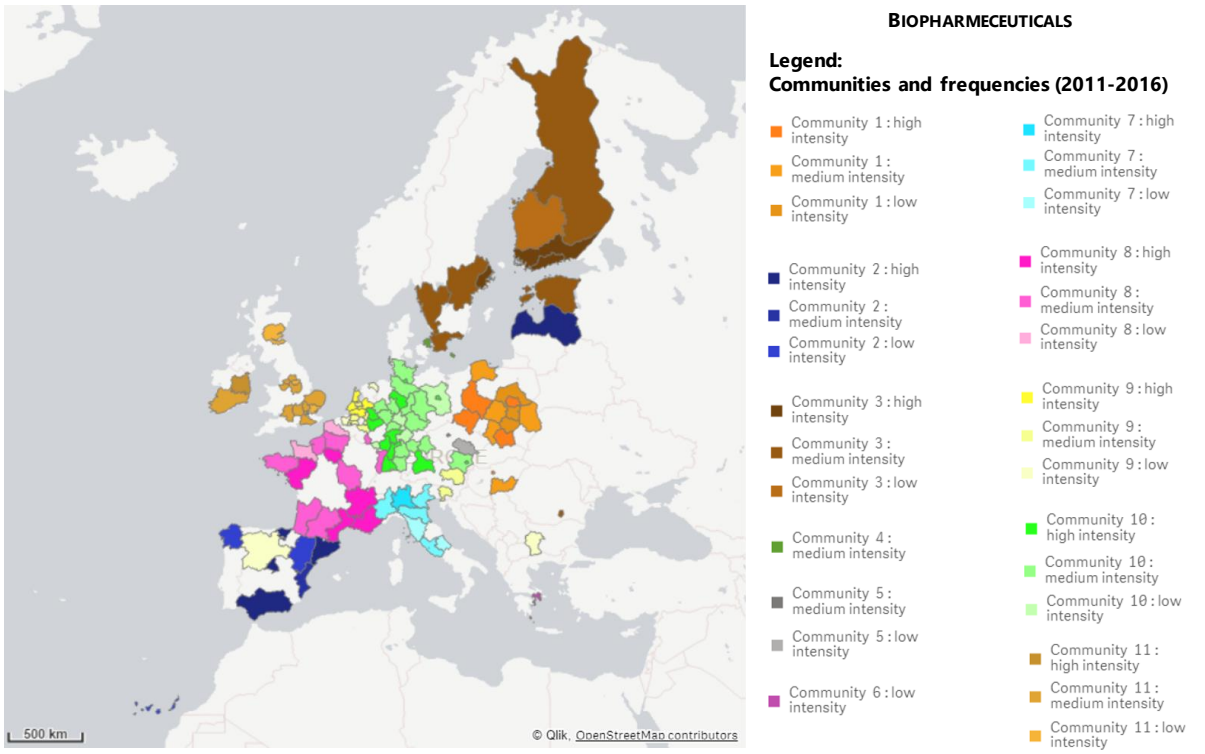
By comparing the cross-sectoral communities over the three periods, several observations emerge:

- The Spanish community (community 7) has enlarged. While the community comprised only two Spanish regions in the 2000–2004 period, the number of Spanish regions with a significant number of cross-sectoral and cross-regional interlinkages has increased.

[35] http://www.pharmtech.com/waste-management-disposable-biopharmaceutical-manufacturing-components.

- While southern Italian regions had a high number of cross-sectoral interlinkages with other regions in the periods 2000–2004 and 2005–2010, their cross-regional connections have significantly decreased.
- A new community has emerged (community 1) covering most of the Polish regions. The pharmaceutical and biotechnological sector is considered one of the most innovative branches of the Polish economy. In the last years, it has been one of the priority sectors supported by the national government, also through the European Structural and Investment Funds.[36] The industry is showing a clear tendency to leave behind the production of generic drugs and to focus on new innovative drugs.[37] While the Italian, French and Spanish regions were grouped in one community in the period 2005–2010, they belong to three different 'national' communities in the most recent period.

Figure 15 – Cross-sectoral communities and hotspots of Biopharmaceuticals industry in Europe (2011–2016).



Source: EOCIC

[36] Polish Information and Foreign Investment Agency "Pharmaceutical and biotechnological sector in Poland" (2013). https://www.paih.gov.pl/files/?id_plik=17195

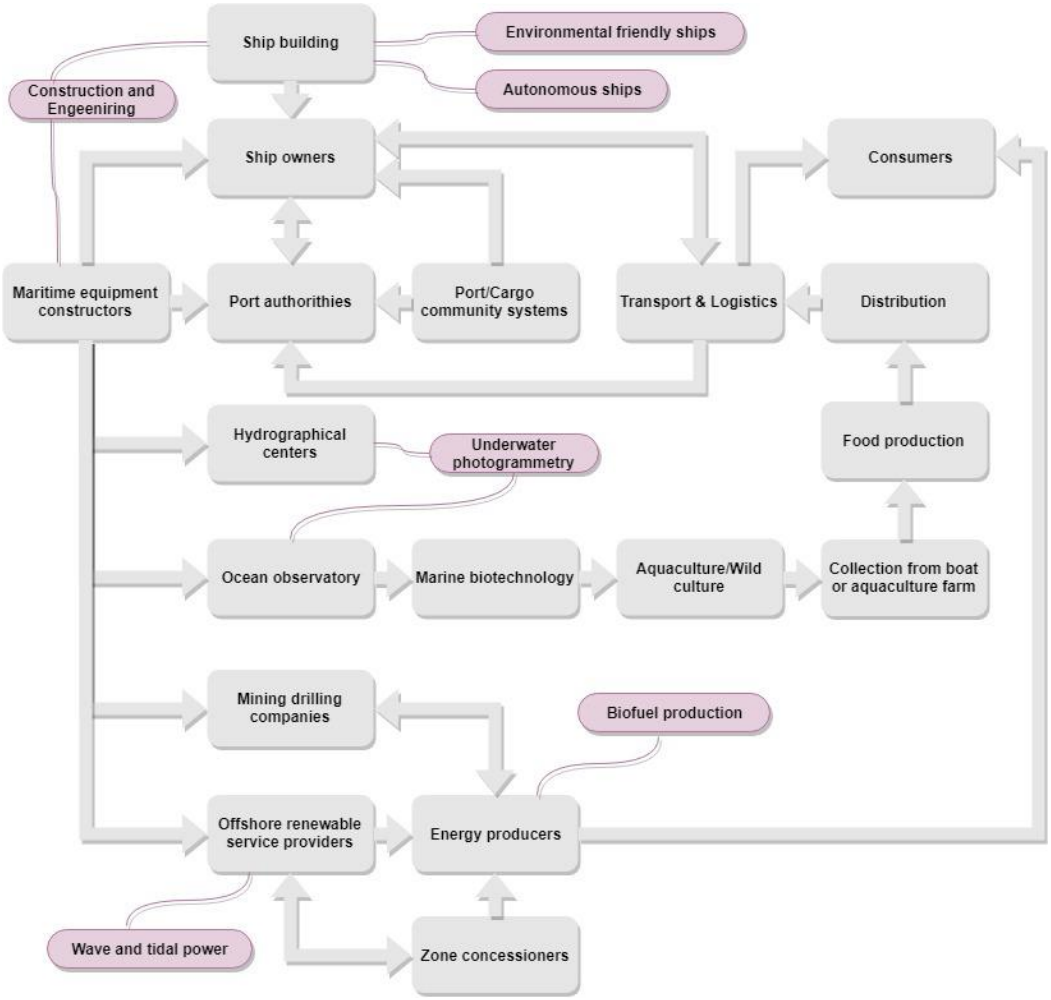
[37] Ageron Polska and Ageron Internacional, "Report of Polish biotech and pharma" https://ireland.trade.gov.pl/en/f/download/fobject_id:16208

3.3.3 Blue Growth industries

The Blue Growth industry covers both traditional maritime activities (i.e. fisheries and aquaculture; shipping, shipbuilding and marine equipment; marine extraction of oil and gas; maritime transport; coastal tourism) and new and high-growth sectors, such as marine biotechnology, desalination, use and treatment of fresh-water sources, ocean renewable energy, (e.g. water power, off-shore wind energy) and seabed mining. A wider definition also includes 'blue data', high-quality information for activities such as maritime spatial planning, efficient and sustainable management of maritime activities and integrated maritime surveillance.

The Blue Growth industry shows an appreciable dynamic in cross-sectoral linkages. Activities performed by other sectors with which Blue Growth forms complex cross-sectoral value chains often complement the core activities. Elaborations on cross-sectoral patenting, M&A and JV&A confirm that this emerging industry is strongly interconnected with a multitude of other sectors. The cross-sectoral analysis points to the emerging cross-sectoral trends presented in Table 11.

Figure 16 – The cross-sectoral value chain of Blue Growth industries



Source: EOCIC

Table 11 – Emerging cross-sectoral trends for Blue Growth industries

Trend	Description
Environmentally friendly ships	A crossover between the blue growth industry (maritime transport), energy technologies and the automotive industry, this new trend is driven by the increasing interest in environmentally sustainable solutions, further stressed by legal pressure on the industry with regard to CO2 emissions. To this end, more technologies (related, for instance, to propulsion motors) are transferred from the automotive into the maritime industry. Electric propulsion ships provide an example. The emergence of this new industry is confirmed by the high number of patents related to blue growth and energy technologies, as well as the high number of M&As between maritime companies and automobile and component companies.[38] In Amsterdam, the Big Data company Xomnia has built the first self-driving boat that works entirely on artificial intelligence. The Norwegian company Yara is currently building a full-electrical container ship fitted with an autonomous control system: the Yara Birkeland.
Autonomous driving boats	This trend is a crossover of maritime and electronics industries. Automation motivates the development of new technologies that are gradually enabling the building of self-driving boats.
Underwater photogrammetry	This is a crossover of the fisheries blue growth industry segment and electronics. Underwater photogrammetry is a 3D reconstruction technique that would allow mapping of oceans. Applications of underwater maps and models are already recognized as helpful for certain industries such as environmental monitoring, archaeology, forensics and infrastructure inspection.
Biofuel production	Increasing oil prices and uncertainty over fossil-fuel reserves are pushing for alternative transportation fuels that could substitute for fossil-carbon based materials. Biofuels have many advantages in the shipping industry (higher energy density, easy to store and transport, suitable to existing infrastructures) and are likely to be more widely used if they are made in large volumes at an advantageous price. The International Energy Agency reports expecting about 27% of transportation fuel to come from 'biological sources' in 2050.[39]
Wave and tidal power	Wave and tidal energy technologies are emerging, and the state of the sector varies by technology. Tidal-stream resource locations in Europe include areas around Scotland (Orkney Islands), off the coast of Northern Ireland, off the coast of Normandy and Brittany, the area between the Greek islands Korfu and Paxi and the Greek mainland, Spain, the Netherlands and Denmark. Key locations for wave-energy resources are in the Atlantic Ocean, i.e. United Kingdom, Ireland, Spain, Portugal and France, and in the North Sea (Denmark).[40]

The largest European Blue Growth economies are the UK, Spain, Italy, France and Greece. Spain accounts for one-fifth of total employment, followed by Italy, the UK and Greece. Combined, these four EU Member States account for more than half of the total blue-economy-related jobs. The social network analysis identifies seven communities of regions that were the most

[38] The automobile industry in particular has been one of the most dynamic partners of the Blue Growth industries, as the increasing number of cross-sectoral acquisitions shows (growth of 325% between 2005–2010 and 2011–2016).

[39] https://www.iea.org/newsroom/news/2011/april/biofuels-can-provide-up-to-27-of-world-transportation-fuel-by-2050-iea-report-.html

[40] https://publications.europa.eu/en/publication-detail/-/publication/03c9b48d-66af-11e7-b2f2-01aa75ed71a1/language-en/format-PDF/source-32210477

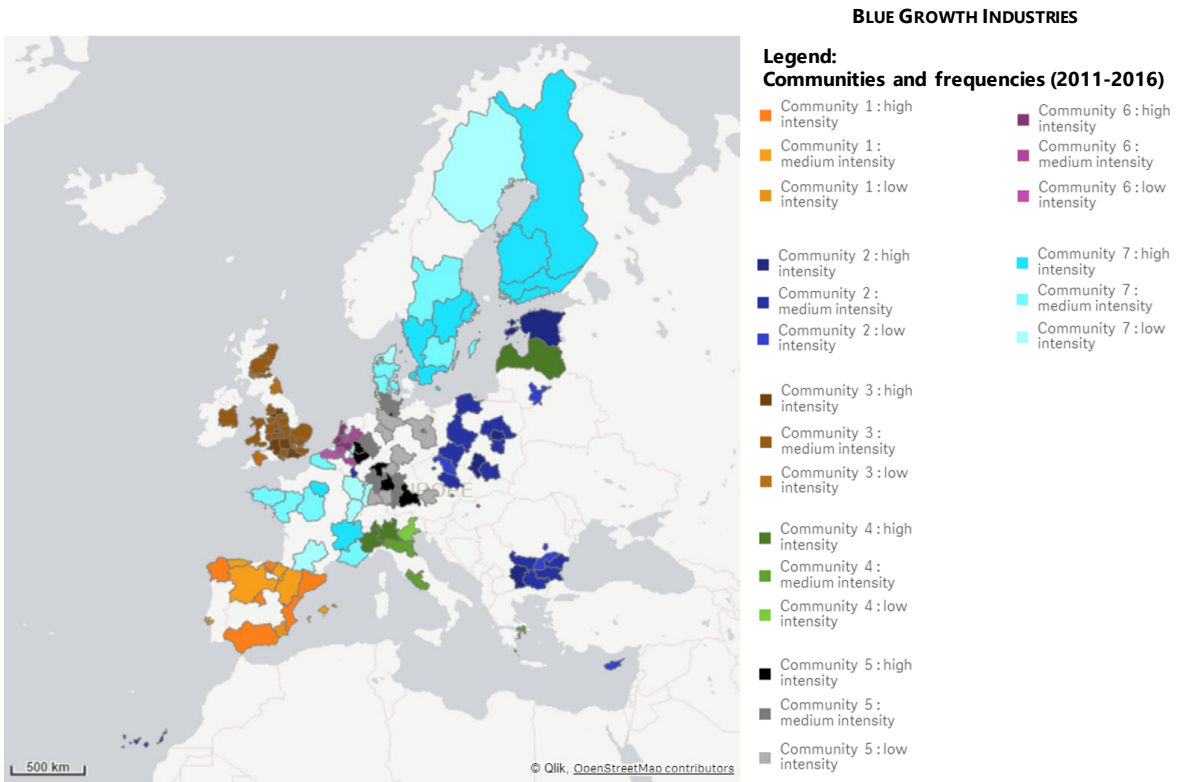
closely connected through cross-sectoral linkages in the 2011–2016 period. These communities centre around specific node regions (hotspots):

Community 1: Comunidad de Madrid (Spain)	Community 5: Oberbayern (Germany)
Community 2: Yugozapaden (Bulgaria)	Community 6: Zuid-Holland (Netherlands)
Community 3: Inner London - West (UK)	Community 7: Helsinki-Uusimaa (Finland)
Community 4: Latvija (Latvia)	

Comparing the regional communities in the 2000-2016 period shows that the community centred in Spain has enlarged over time. The Spanish Multi-Year Strategic Plan for Aquaculture 2014-2020 has certainly contributed to the development and innovation of the Spanish aquaculture sector, to embrace the new "Aquaculture 4.0" trend. This term was introduced by the Horizon 2020 Innovation Action call in October 2017, which focused on the application of Industry 4.0 technologies, such as the Internet of Things and artificial intelligence, to aspects related to the development of sustainable smart breeding programmes, feeding methods and monitoring systems for aquaculture.[41]

More regions have increased their number of cross-sectoral and cross-regional connections related to the Blue Growth industry. Moreover, a new community (community 1) centred on a Bulgarian region and covering Poland, Czech Republic, Lithuania, and Greece has emerged.

Figure 17 – Cross-sectoral communities and hotspots of Blue Growth industries in Europe (2011–2016).



Source: EOCIC

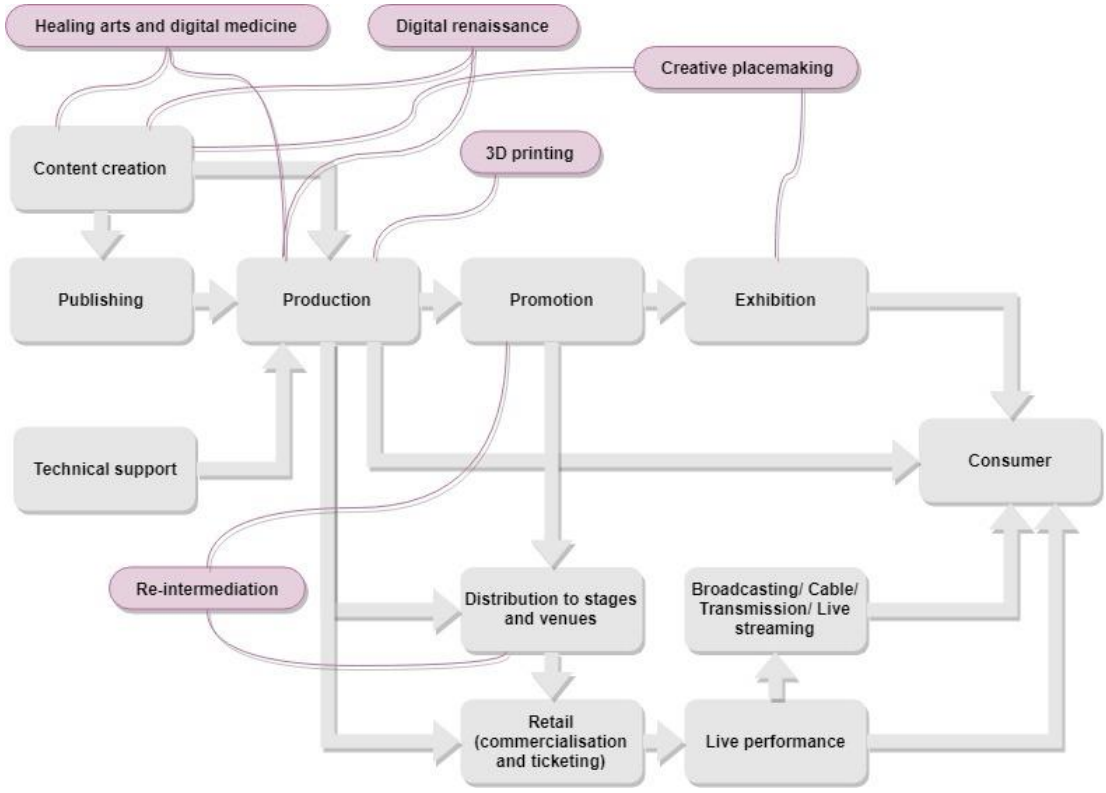
[41] https://www.governmenteuropa.eu/aquaculture-4-0/93038/

3.3.4 Creative industries

Creative industries relate to the creation, production and/or distribution of creative goods and services as well as to the integration of creative elements into wider processes and other sectors. The term "creative industries" encompasses a broad range of activities in which the product or service contains a substantial element of artistic or creative endeavour (UNESCO, 2006). Creative industries thus consist of activities drawing on advertising, architecture, art, crafts, design, fashion, film, music, performing arts, publishing, R&D, software, toys and games, TV and radio and video games. The cultural and creative industries are the modern economy activities that produce culture and distribute it through industrial means, by applying the creativity of individuals and groups to the generation of original cultural product that may have commercial value, either through direct sale to consumers or as intellectual property. The cultural and creative industries typically include the arts, media and design sectors, focusing in recent times especially on digital technologies. Culture or creative industry are often high-tech, high-touch, highly creative, and with great development potential (Eikhof and Hauschild, 2007; European Commission, 2010).

Elaborations on patent, M&A and JV&A data confirm the strong cross-sectoral nature of the Creative Industry. The most important cross-sectoral linkages of the Creative Industry are to the sectors related to Measurement, Transport and Electrical Machinery, as well as Publishing, Electronics and Power. The temporal dynamic trend of all types of cross-sectoral linkages is strongly increasing. The Creative Industry is being transformed by new technologies and industry niches as described in Table 12.

Figure 18 – The cross-sectoral value chain of Creative industries



Source: EOCIC

Table 12 – Emerging cross-sectoral trends for Creative industries

Trend	Description
Digital medicine	It refers to an emerging trend of adapting game technologies, i.e. virtual reality, to medicine in order to give 'games' a role in the actual treatment. Virtual-reality technology developed in the video game space has recently started to be transposed in medicine, giving rise to brain-computer interfaces. GTX, a Swiss company, is working on a brain implant that could potentially restore mobility in paralyzed individuals. The implant records brain signals and sends them to a computer that can understand which muscles to stimulate and how. Videogames could potentially function as a medical treatment. Still in Switzerland, the company Mindmaze uses virtual reality to improve the neurorehabilitation of patients in whom stroke has reduced upper-limb mobility. In this case, while the patient plays a series of games and does exercises as part of the neurorehabilitation treatment, a device that uses 3D motion tracking captures the patient's movements.
Healing arts	Art in healthcare is a fast-growing industry and acknowledged to help patients heal faster. Researchers have found that not only does art relieve pain but also that different types of art are preferable depending on the patient's targeted issue. Thus, hospitals, senior residences, acute-care hospitals, surgery centres, medical office buildings, physicians' offices, rehabilitation centres and military hospitals are integrating creative arts in their facilities.
Digital renaissance	The culture-heritage sector is transforming itself and becoming a laboratory for developing new technologies, materials and methods. Diffusion of digital technologies and new media, as well as advancements in diagnostics, new materials and building technologies, drive this transformation.
Creative placemaking	Creative placemaking is an emerging approach in planning, designing and building transportation projects. It involves the application of art, culture and creativity in planning and designing infrastructure projects to create a stronger connection between people and the place/infrastructure. In this vein, public authorities ask artists to collaborate starting in early planning phases. An example of this phenomenon is the metro line in Naples, the so-called "Metro of Arts" or "Museo-metro line", which incorporates art products in all its underground stations.

Trend	Description
3D printing	3D printing shortens the production process of solid cultural and creative products by facilitating the transition from the design to the development phase. This technology is used by a large number of creative industries. In the creative fashion sector, designers are using 3D printing technology to convert their ideas into reality. Potentially, designers can use 3D printers to realise anything that is wearable, from clothing to shoes and accessories. Although the 3D-printed fashion products realised insofar are not yet commercialised, it is likely that they will represent the future of the mass-customisation. The H2020-funded WORTH Partnership Project aims to support transnational collaborations between fashion designers, creative people, manufacturing enterprises and technology firms.[42] Moreover, 3D printing has vast applications in the healthcare sector. Visual artists and designers support medical scientists and engineers in the development of prosthetics that are not only more affordable and reliable from an orthopaedic point of view, but also aesthetically promoting acceptance by the patient. For instance, in order to support children with disabilities, 3D-printed superhero prosthetic arms use comic book heroes like Wolverine and Iron Man as models.
Re-intermediation	This new trend emerges from the cross-sectoral linkage between creative industries, electronics and publishing. With the rise of social networks and digitalisation, artists are now able to avoid using intermediaries and take up promotion activities themselves. Furthermore, thanks to the smartphone, music artists can record themselves without the need of a producer.

The extension of industrial value chains in the Creative Industry is regional or global, with the production process fragmented among various companies located in different regions and countries.

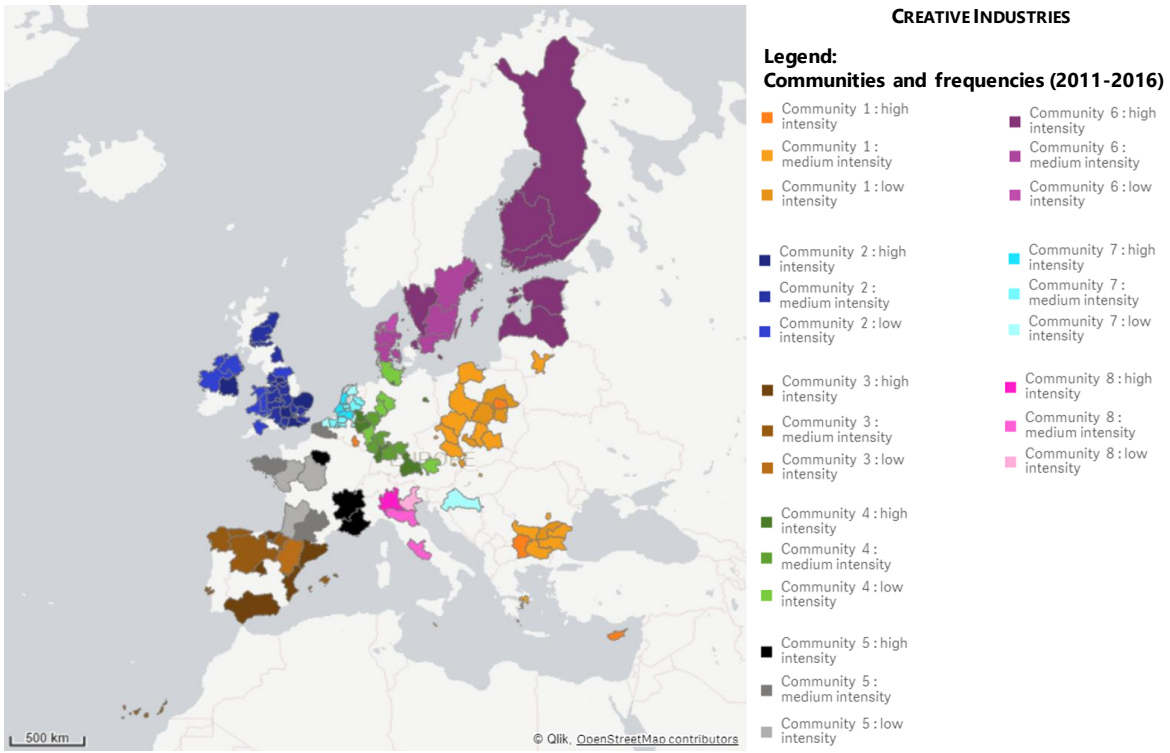
The social-network analysis identified eight communities of regions that were the most closely connected through cross-sectoral links in the 2011–2016 period. These communities centre around specific node regions (hotspots):

Community 1: Yugozapaden (Bulgaria)	Community 5: Ile-de-France (France)
Community 2: Inner London–West (UK)	Community 6: Helsinki-Uusimaa (Finland)
Community 3: Comunidad de Madrid (Spain)	Community 7: Noord-Holland (Netherlands)
Community 4: Karlsruche (Germany)	Community 8: Lombardia (Italy).

Comparing the size of regional communities in the three periods shows that the community centred around Madrid (community 3) has enlarged over time. More Spanish regions have a higher number of cross-sectoral interlinkages, compared to previous years.

[42] https://www.worthproject.eu/

Figure 19 – Cross-sectoral communities and hotspots of Creative industries in Europe (2011-2016).

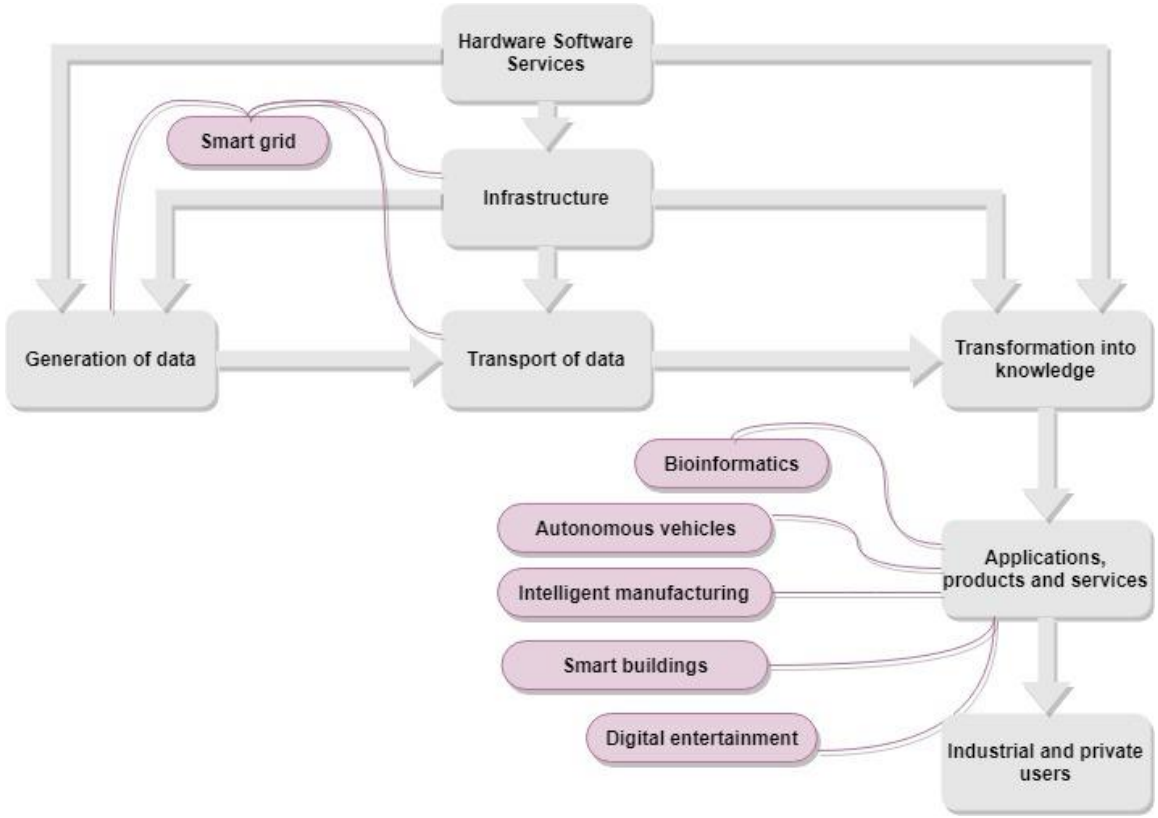


Source: EOCIC

3.3.5 Digital industries

The phenomenon of digitalisation concerns a wide range of new applications of information technology in products and business models that are profoundly transforming the economy and society. The heterogeneity of digital products explains why there is no generally agreed-upon definition of the 'digital economy'. Bukht and Heeks (2017) provide a list of definitions adopted over time, helping to illustrate why the term spans a large number of traditional industries. A widely used and narrow definition of Digital industries or 'digital sector' focuses on the core activities of digitalisation, such as ICT goods and services, online platforms and platform-enabled activities originating the so-called 'sharing economy' (International Monetary Fund, 2018). The European Cluster Observatory (2017) defines the Digital emerging industries as a combination of the core sectors in the information age, including 'services related to information technologies as well as manufacturing of modern computer hardware and devices for various application contexts'. The Digital industries show remarkable dynamics in cross-sectoral linkages. The fact that many industries use cross-cutting information technology in their production process or to create new products explains the high degree of cross-sectoral connections. One of the dominant trends in the digital sector is the shift from hardware to software, and within the software area from product to service.

Figure 20 – The cross-sectoral value chain of Digital industries



Source: EOCIC

Table 13 – Emerging cross-sectoral trends for Digital industries

Trend	Description
Digital medicine	It refers to an emerging trend of adapting game technologies, i.e. virtual reality, to medicine in order to give 'games' a role in the actual treatment. Virtual-reality technology developed in the video game space has recently started to be transposed in medicine, giving rise to brain-computer interfaces. GTX, a Swiss company, is working on a brain implant that could potentially restore mobility in paralyzed individuals. The implant records brain signals and sends them to a computer that can understand which muscles to stimulate and how. Videogames could potentially function as a medical treatment. Still in Switzerland, the company Mindmaze uses virtual reality to improve the neurorehabilitation of patients in whom stroke has reduced upper-limb mobility. In this case, while the patient plays a series of games and does exercises as part of the neurorehabilitation treatment, a device that uses 3D motion tracking captures the patient's movements.
Mobile health	This trend refers to the application of digital technologies to keep the patient health monitored. Digital biomarkers, smartwatches, smart rings, fitness trackers, medical wearables are examples of new products, increasingly used because of their affordability, that has been developed out of the interaction between digital and medical industries.
Intelligent manufacturing	This trend contributes to explaining the cross-sectoral interlinkages between the Digital Industry with the Machine Tools and Civil Engineering sectors. Smart factories are fully connected and flexible, able to integrate data from system-wide physical, operational, and human assets to drive manufacturing, maintenance, inventory tracking and digitisation of operations. The Digital Industry supports this transformation process by providing tools and applications for measurement, generation of digital data and automated real-time analysis (European Cluster Observatory, 2015).
Digital entertainment	This is a crossover of the Digital Industry, audio-visual technologies, and amusement and recreation services. Digital entertainment is a type of entertainment displayed digitally on electronic devices, computers, laptops, tablets or smartphones. The fact that entertainment products, such as music and books, are sold through digital distribution channels poses challenges for traditional distribution channels.
Autonomous vehicles	Self-driving cars are vehicles capable of moving with little or no human input. They combine a variety of sensors that perceive the surroundings. Driverless cars are being tested in America, e.g. Google's and Uber's autonomous cars, but are not yet commercially available.[43]
Bioinformatics	Bioinformatics is the application of IT to the biology industry with the aim of better understanding biological processes. Hahn and Mohanty (2017) find that within bioinformatics is an emerging interest in cancer informatics, and that the cancer research has shifted toward using big-data techniques in recent years. Such a shift is observed also in other research areas such as the sequence alignment and genome annotation.
Digital grid	This consists of the digitisation of electricity, gas and water networks using advanced technologies. [44] It shortens the distance between the utility operators and its customers by enabling automation and control across the utilities' operations, increasing power-supply reliability and efficiency.

[43] More information is presented with reference to the Smart Mobility megatrend (section 2.3.4).

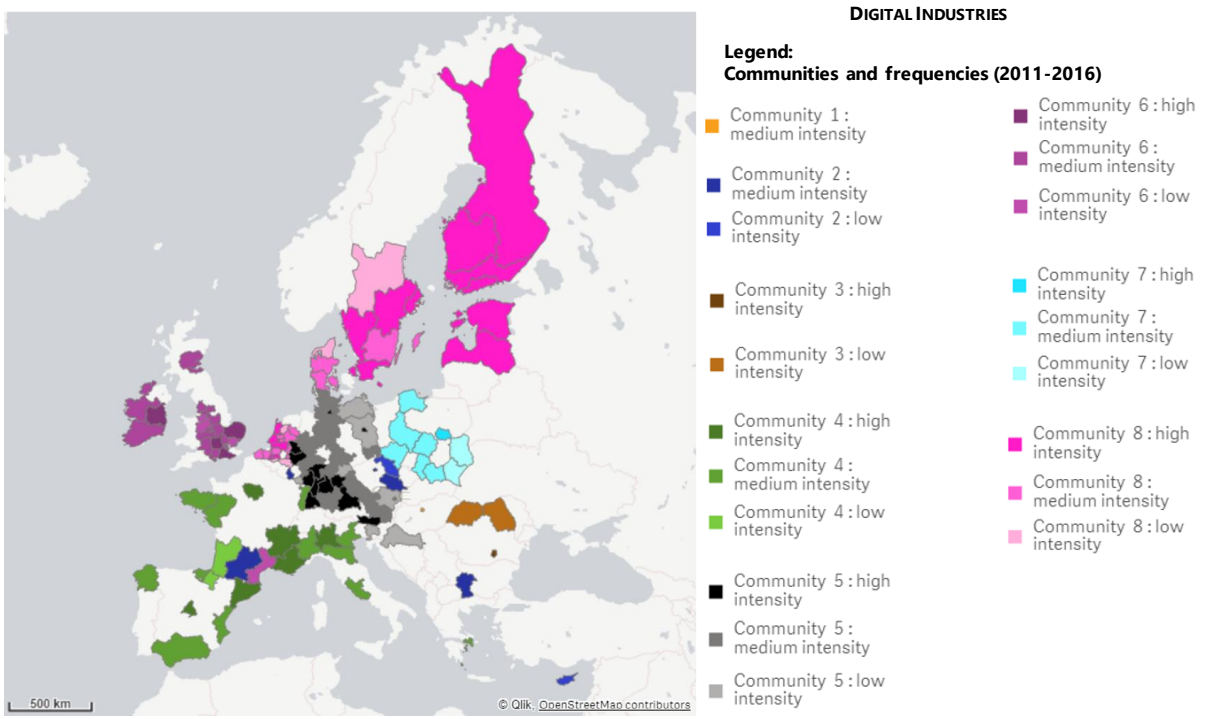
[44] https://www.ey.com/Publication/vwLUAssets/ey-digital-grid-powering-the-future-of-utilities/$FILE/ey-digital-grid-powering-the-future-of-utilities.pdf

Trend	Description
Smart building	The increasing diffusion of advanced systems and IoT pushes for the creation of smart buildings, defined as any structure that uses automated processes to control building operations (e.g. heating, security). Thus, smart buildings are 'automated buildings', 'intelligent buildings' or buildings incorporating smart technologies. The first smart buildings are currently being put onto the market and many more will follow in the coming years.
InsurTech	It refers to the application of new information technologies in the insurance sector. The number of insurTech companies worldwide has been increased since 2010. Blockchain and IoT are the most significant technologies that are revolutionising the insurTech industry, by enabling insurance companies to access and share a large amount of information and data, with the ultimate goal of providing smart, highly personalised and more transparent contracts. In the coming years, cybersecurity will drive the expansion of the insurTech industry: the global cyber insurance market is expected to be worth EUR 20 billion by 2025.[45]

The social-network analysis identifies eight communities of regions that were the most closely connected through cross-sectoral links in the 2011–2016 period. These communities centre around specific node regions (hotspots):

Community 1: Budapest (Hungary)	Community 5: Oberbayern (Germany)
Community 2: Yugozapaden (Bulgaria)	Community 6: East Anglia (United Kingdom)
Community 3: Bucuresti–Ilfov (Romania)	Community 7: Warszawski stołeczny (Poland)
Community 4: Ile de France (France)	Community 8: Helsinki-Uusimaa (Finland).

Figure 21 – Cross-sectoral communities and hotspots of Digital industries in Europe (2011–2016)



Source: EOCIC

[45] https://www.insuranceup.it/it/scenari/insurtech-che-cos-e-e-quali-sono-i-suoi-pilastri/

By comparing the size and location of regional communities over time (from 2000 to 2016), the Polish community emerged recently, as the number of cross-sectoral and cross-border interlinkages in the digital industry increased. In fact, even if Poland is lagging behind in the digital race according to the Digital Agenda Scoreboard indicator,[46] it has recently witnessed the flourishment of a number of successful tech start-ups. The new Google Campus in Warsaw provides a catalyst for innovation and entrepreneurship. The "Future of Industry Platform", launched in 2016 by the Polish Ministry of Finance and Development, aims to accelerate the digital transformation of Polish industry in the next 25 years.[47]

Moreover, while the Italian, Spanish and French regions were part of three different national communities until 2010, they are now part of a unique and larger community, indicating that cross-sectoral interlinkages increasingly occur beyond the national borders.

[46] https://ec.europa.eu/digital-single-market/en/digital-economy-and-society-index-desi

[47] https://www.forbes.com/sites/alisoncoleman/2016/05/20/poland-on-track-to-becoming-a-major-european-tech-startup-hub/; https://ec.europa.eu/growth/tools-databases/dem/monitor/sites/default/files/DTM_Poland%20_vf.pdf

3.3.6 Environmental industries

The Environmental industries consist of activities for 'producing goods and services to measure, prevent, limit and correct (or minimize) environmental damage to water, air and soil, as well as problems related to waste, noise, and eco-systems' (EOCIC, 2019a). A useful classification (OECD/Eurostat, 1999) breaks down Environmental industries into three broad categories of activity: pollution management, cleaner technologies and products and resource management. The area of Environmental industries also includes traditional economic sectors, such as renewable energy production.

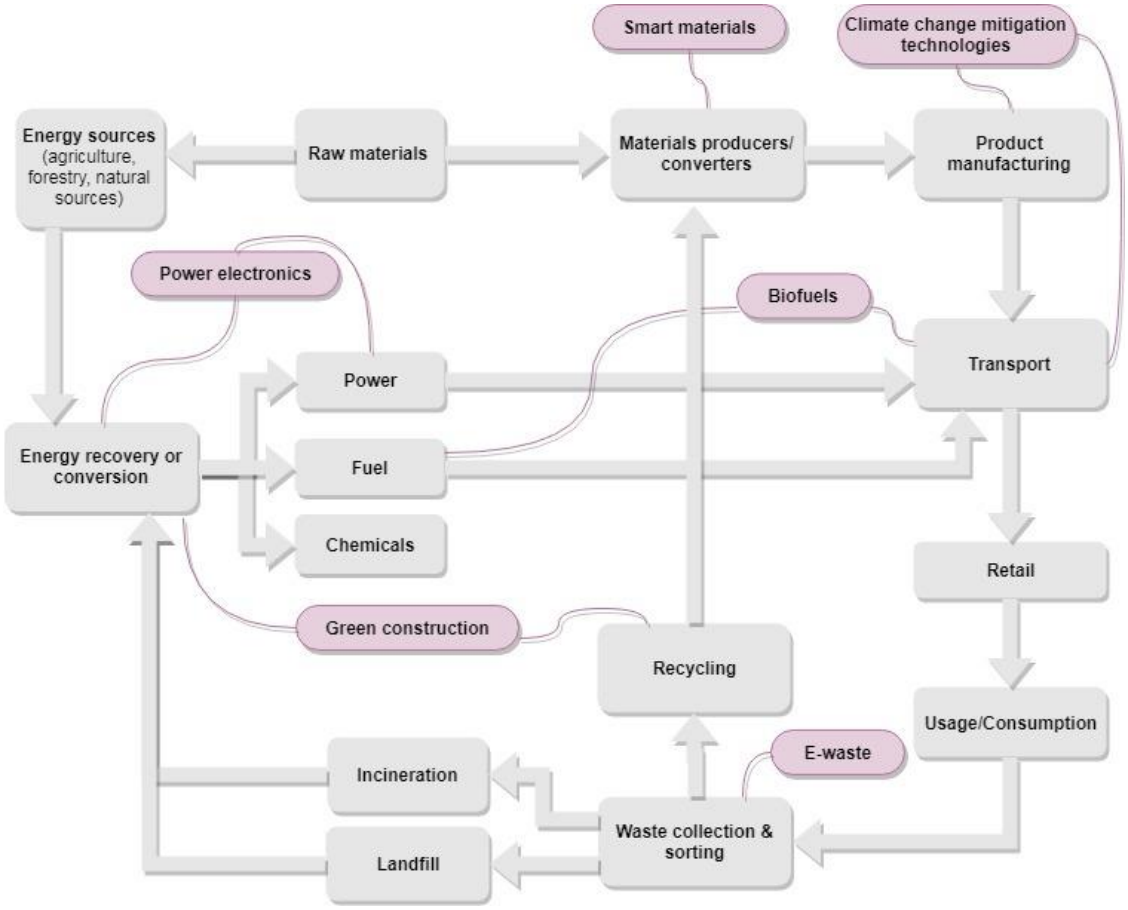
The Environmental industries are highly interdisciplinary and with high growth potential. Because of strong cross-sectoral linkages, the structure of the industry is rapidly changing. The sectors more closely connected to the Environmental Industry are Transport, Electrical Machinery, and Measurement (in terms of patents), Business Services and Construction (in terms of JV&A) and Electronics, Chemicals and Power, Machinery, Chemicals and Automobiles (in terms of M&As).

The main transformation trends taking place in the Environmental industries are presented in Table 14.

Table 14 – Emerging cross-sectoral trends for Environmental industries

Trend	Description
Smart materials and green construction	Green construction relates to the effort to build responsibly, reduce waste and help preserve the environment in the construction activities. The construction of smart structures, such as smart windows, smart shade, roofing, ceilings, smart concrete and smart bricks, uses new materials being developed to perform better against changes in electricity, magnetic, waves or heat. These materials respond to environmental considerations, in that they are eco-friendlier, lead to less energy consumption, and guarantee a more sustainable recycling process.
Climate-change mitigation technologies	Cross-sectoral R&D is undertaken to reduce the climate-change impact of several industries, particularly transportation sectors (automotive, air and maritime transport).
Biofuels as a new energy source	The increasing price of oil on one side and the increasing awareness of eco-friendly issues on the other push the search for alternative energy sources and increasing efforts to ensure the transition from fossil fuels to biofuels. New technologies are being developed to improve the efficiency of biofuel production, to foster its use in the transportation and energy sectors.
Power electronics	While the power electronics industry has existed since 1902, over the last years the focus has shifted to power electronics applied to renewable energy systems. More specifically, power electronics provide a key element in effectively managing, stabilising and boosting the power of renewable energy systems. Power electronics is now emerging as a high-tech frontier of power engineering. It appears that the role of power electronics in future will be as important as computers, communication and information technologies.
E-waste	Electronic waste refers to activities of reuse, resale, salvage, recycling and disposal of electronic devices and components. It is becoming more and more important, given the high volume of electronic waste as a consequence of the high rate of growth of consumer electronics.

Figure 22 – The cross-sectoral value chain of Environmental industries



Source: EOCIC

The European Panorama of Clusters and Industrial Change report (EOCIC, 2019a) shows that the environmental economy has been growing faster than the overall economy in twelve Member States. Most noticeably, contributions to the GDP increased in Estonia (13%), Bulgaria and Hungary (both 10%). The social network analysis identifies nine communities of regions that were the closest connected through cross-sectoral linked in the 2011-2016 period. These communities centre around specific node regions (hotspots):

Community 1: Inner London–west (UK)	Community 6: Ile-de-France (France)
Community 2: Oberbayern (Germany)	Community 7: Lombardia (Italy)
Community 3: Bucureşti-Ilfov (Romania)	Community 8: Śląskie (Poland)
Community 4: Yugozapaden (Bulgaria)	Community 9: Helsinki-Uusimaa (Finland).
Community 5: Zuid-Holland (Netherlands)	

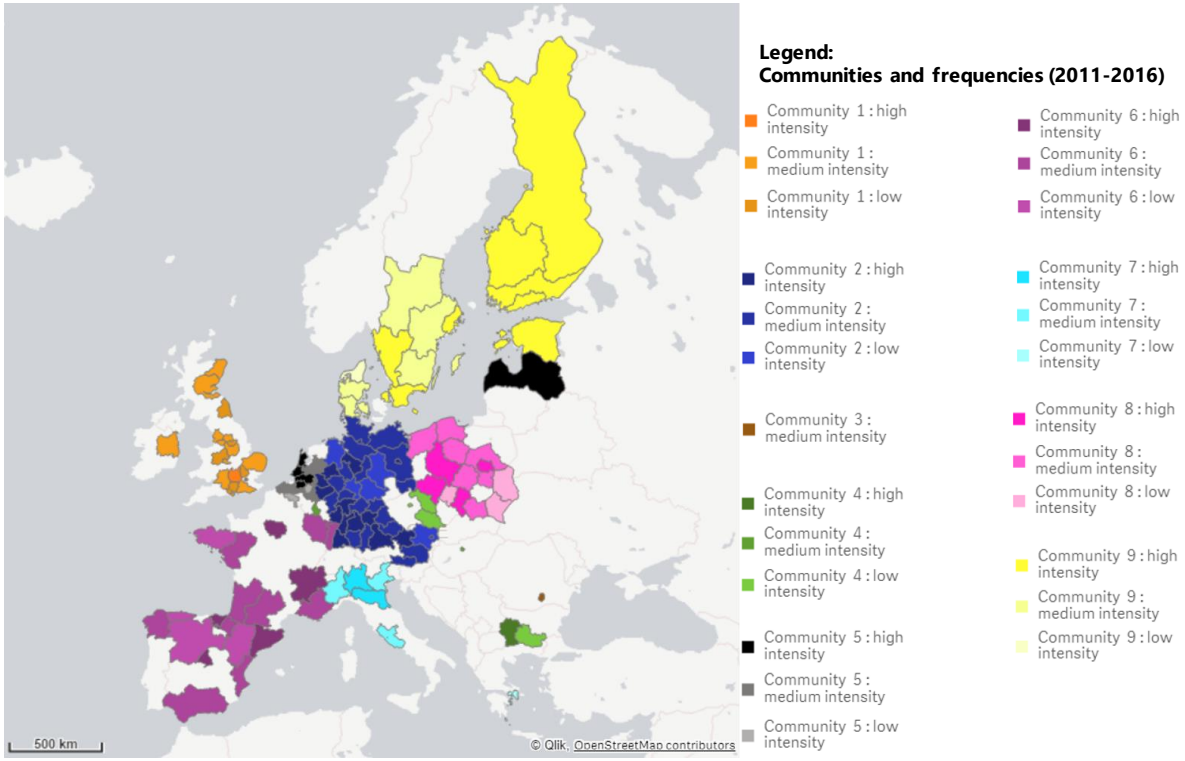
By comparing the size and number of cross-sectoral communities from 2000 to 2016, the following findings emerge:

- Whereas in the first period (2000–2004), Italian, Spanish and French regions formed a unique community, since 2005 the Italian regions have formed a separate community centred around Lombardia;

- The number of cross-sectoral and cross-regional linkages between the Polish regions started increasing in 2005. This community had expanded over time and today it counts 13 regions;
- The number of cross-sectoral and cross-regional operations among Eastern European regions has increased and a new community (community 4), centred around Yugozapaden (Bulgaria), has emerged, grouping together Bulgarian, Hungarian and Czech Republic regions, as well as Luxembourg.

Figure 23 provides an overall picture of cross-sectoral communities (in terms of the number of linkages) and hotspots across European NUTS-2 regions.

Figure 23 – Cross-sectoral communities and hotspots of Environmental industries in Europe (2011-2016).



Source: EOCIC

3.3.7 Experience industries

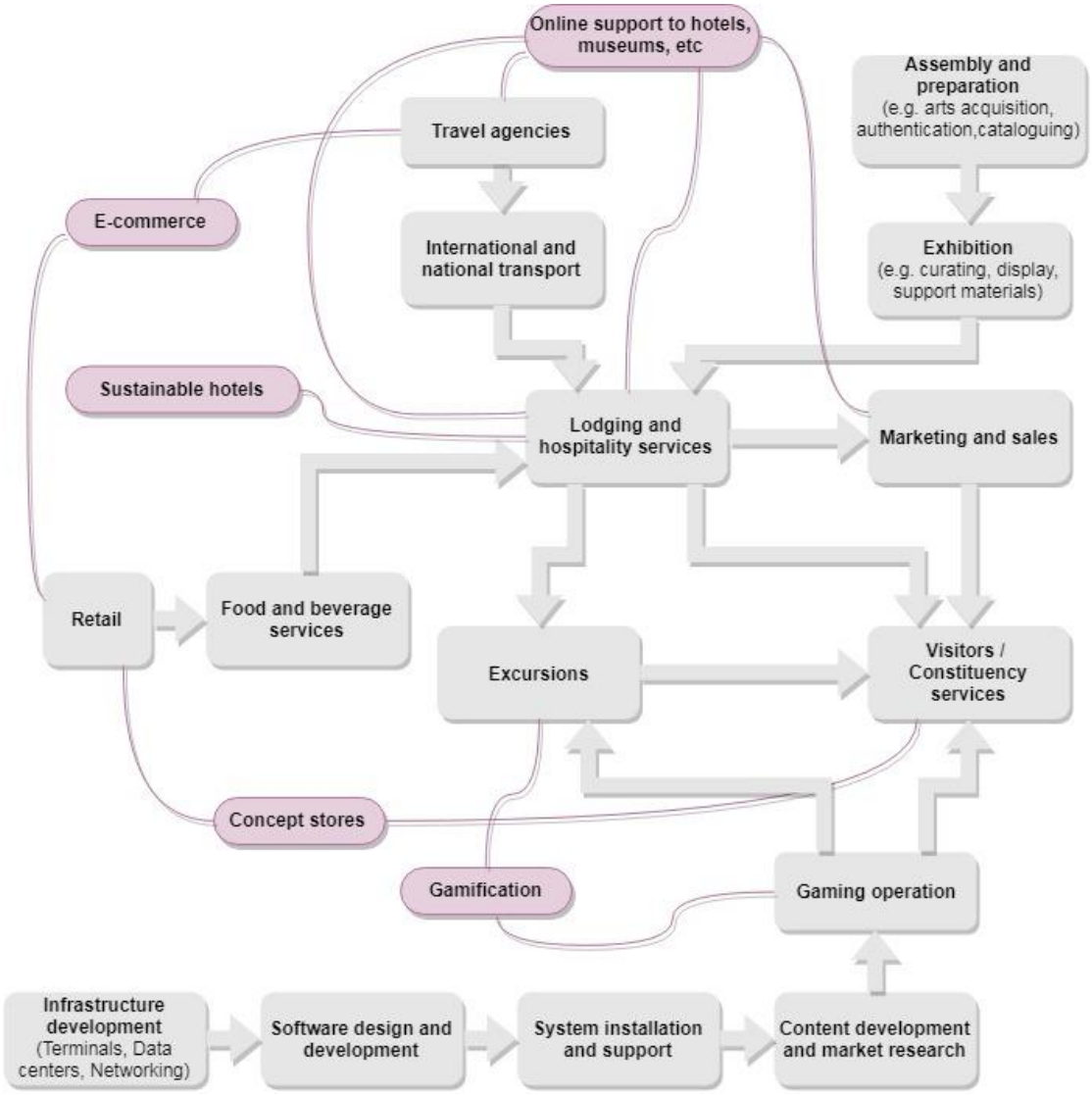
Experience industries include activities traditionally associated with the sectors of tourism, arts, culture or leisure, particularly related to 'the creation and operation of visitor attractions such as museums, galleries, science centres, heritage sites, zoos and aquaria and theme parks' (UK Trade and Investment, 2014). Moreover, especially in recent years, the Experience industries have become high-tech and high-touch, highly creative and cultural, connecting with media and design sectors as well as digital industries, as software and web sites have acquired an increasingly prominent role. The Experience industries also rely on its own set of support industries, including e-commerce, software publishing and management consultancy.

Considering the cross-sectoral linkages indicated by the M&A and JV&A data and the review of the grey literature, the new trends that have been identified for the Experience industries are presented in Table 15.

Table 15 – Emerging cross-sectoral trends for Experience industries

Trend	Description
Online support to hotels, museums, events	Thanks to the development of the Internet, new ways of travelling, playing, and watching sports have arisen. Consequently, many online platforms and websites that automate operations have become widespread. Nowadays, people are used to buying their tickets online, and some hotels allow online check-in. Through their smartphones, people can also check in to the so-called 'smart arenas' when they go to sports events.
Sustainable hotels	This new trend is linked to the green construction approach (see the previous section on Environmental Industries, section 3.3.6). Environmental sustainability is among the main standards of the hotel industry. Hotels must show their environmental impact and their effort to increase their resource efficiency. Travellers expect hotels to be eco-friendly, but at the same time they do not want to give up comfort.
Concept stores	This trend arises as a crossover of the Experience and Retail industries. A concept store differs from traditional stores in that it aims to provide the customer with actual experience. In this vein, this is more like a multibrand store where the consumer can compare different types of products. Part of the consumer's experience builds on the architecture of the store itself, where the lighting also plays an important role.
E-commerce	Technological progress has enabled people to order and buy online through an app on their smartphones. This trend not only translates into more comfort for the consumer but also provides the retailer with accurate information on consumers' behaviours, which in turn allows better setting of price and product strategies.
Gamification	Nowadays, it is not uncommon to use gaming as an instruction tool. Gaming technologies are increasingly used in the educational sector to ease the learning process by making it more exciting and interactive.

Figure 24 – The cross-sectoral value chain of Experience industries



Source: EOCIC

The firms and activities of the Experience industries are not homogenously distributed across Europe but show strong patterns of concentration around certain regions. The social-network analysis identifies eight communities of regions that were the most closely connected through cross-sectoral linkages in the 2011–2016 period. These communities centre around specific node regions (hotspots):

Community 1: Ile de France (France)	Community 5: Noord-Holland (Netherlands)
Community 2: Helsinki-Uusimaa (Finland)	Community 6: Oberbayern (Germany)
Community 3: Inner London–west (UK)	Community 7: Lombardia (Italy)
Community 4: Luxembourg (Luxembourg)	Community 8: Yugozapaden (Bulgaria)

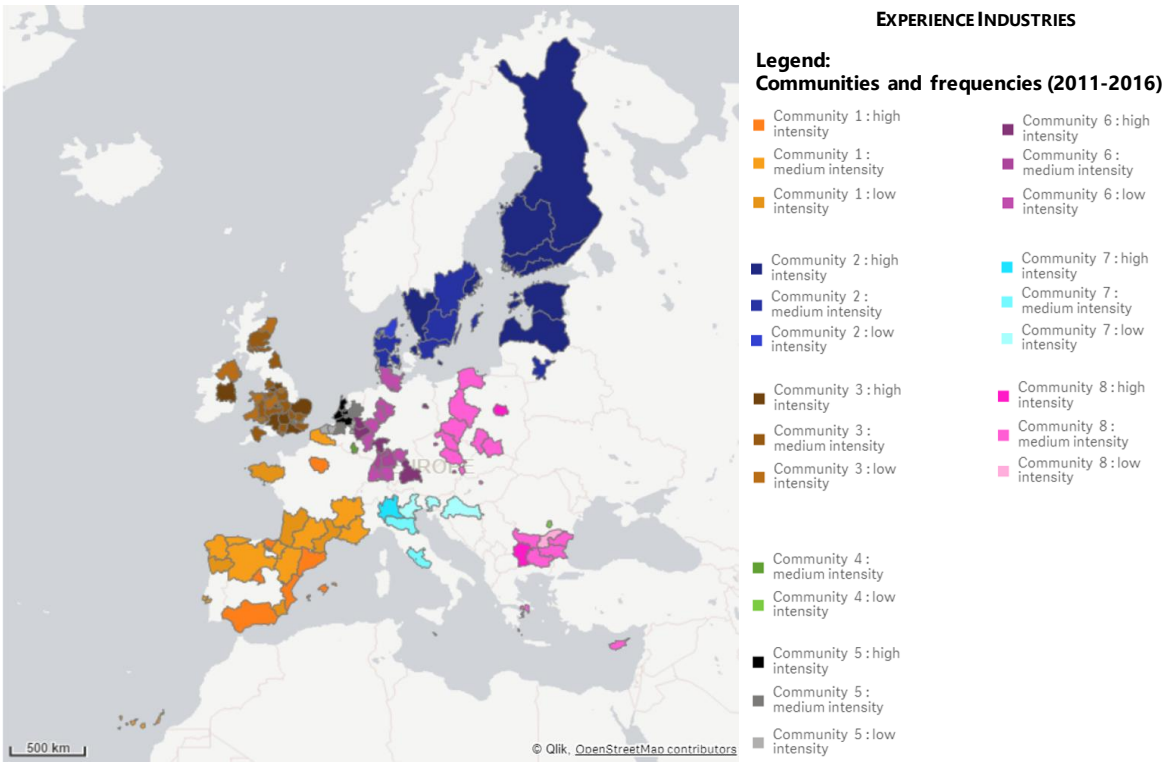
The geographical analysis shows that polarisation increases over time. The community centred around Ile-de-France covers French, Spanish and Portuguese regions that in previous years were spread in multiple communities. Moreover, it is interesting to notice that the number of

Spanish regions more actively involved in cross-sectoral business operations has increased from 5 in the 2000–2005 period to 13 in 2011–2016.

At the same time, Eastern European regions are increasingly interconnected by cross-sectoral linkages. Community 8, centred around Yugozapaden, covers different regions in Bulgaria, Poland, Czech Republic, Hungary, Cyprus, Greece, Slovakia and Malta

Figure 25 provides an overall picture of cross-sectoral communities (in terms of the number of linkages) and hotspots across European NUTS-2 regions.

Figure 25 – Cross-sectoral communities and hotspots of Experience industries in Europe (2011-2016).



Source: EOCIC

3.3.8 Logistical Services

Coyle et al. (2016) define 'logistics' in terms of 'getting the right product, to the right customer, in the right quantity, in the right condition, at the right place, at the right time, and at the right cost'. Their definition illustrates the broad scope and purposes of a complex of activities dealing with managing the process of transporting goods between a departure point and a specific destination. The industry also encompasses all services contributing to the smooth operation of the transport and the provision of carriers or vehicles, the logistics operation and IT-systems for the logistical planning, organisation, and management.

The Logistical services industry has recorded an intense growth and transformation in the last decades, driven by technological advancements and the numerous and deep linkages with other traditional and emerging sectors. The main transformation trends are highlighted in Table 16.

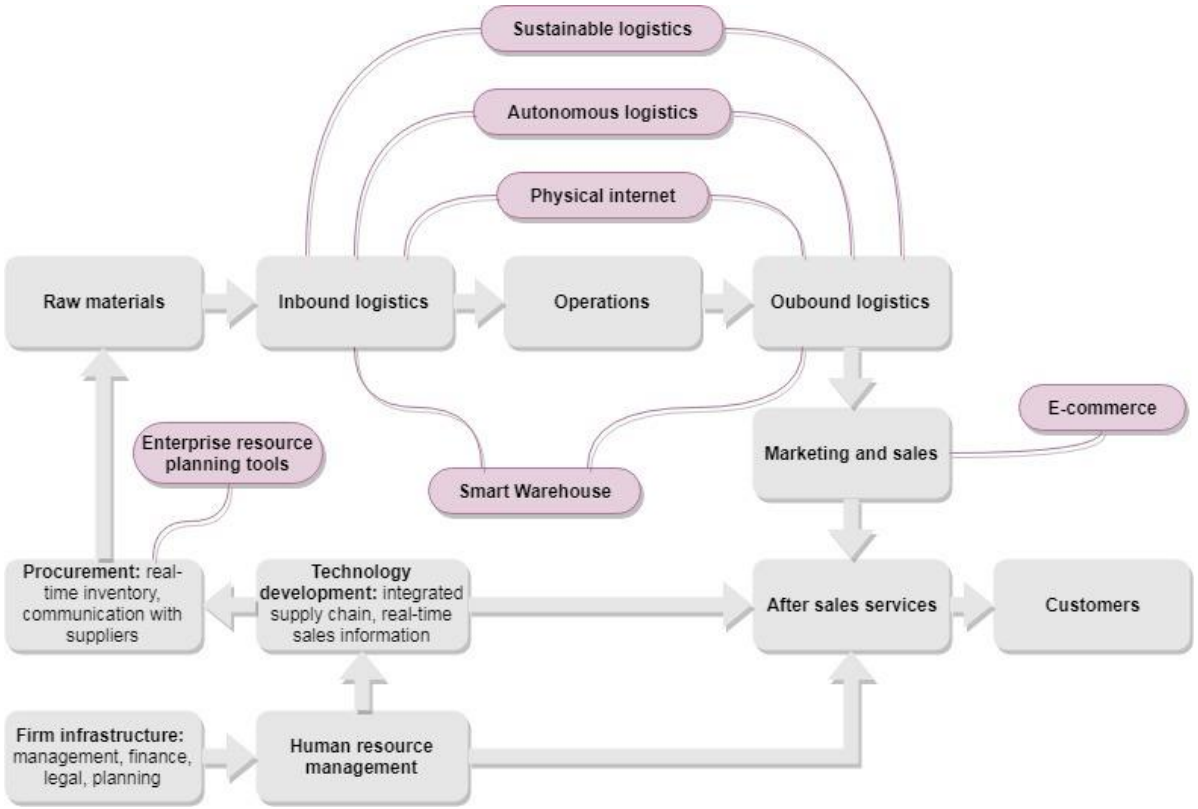
Table 16 – Emerging cross-sectoral trends for Logistical Services

Trend	Description
Connected truck	The connected truck approach is making rapidly obsolete the concept of the 'lone truck travelling down the lonesome highway' (Nowak et al., 2016). It is based on a number of innovative technologies such as the Vehicle-to-Infrastructure communication (allowing constant communication between the vehicle and infrastructure installations through GPS tracking and digital links); the Vehicle-to-Vehicle communication; the advanced (autonomous, in the future) driving, designed to optimise traffic flows, automate routing, improve parking efficiency and safety; the remote diagnostics to constantly monitor the condition of the truck, make more timely repairs, develop more efficient maintenance schedules, and reduce truck downtime. In the future, artificial intelligence alone could control trucks and ships.
Integrated supply chain	The integrated supply chain aims at integrating the transport agent into real-time logistics data 'across the entire supply chain, from parts and materials suppliers to manufacturers to warehouses and distributors and finally to the end customer' (Nowak et al., 2016).
Physical internet	The integrated supply chain trend is related to the concept of the physical internet.[48] It means applying the principles of Internet to logistical services. It is a global, open, interconnected network that uses a set of collaborative protocols and standardised smart interfaces, in order to send and receive physical goods contained in standard modules. A physical internet approach would ensure greater efficiency and sustainability by transforming the way physical objects are moved, stored, realised, supplied and used. E-commerce is also widely spreading the logistics industry, leading to major changes in the supply value chain.
Automated freight matching	The newly born automated freight matching technology is based on sensor-based automatic tracking of available load area on vehicles, and platforms processing this piece of information for fast rescheduling of freight pickup and delivery.

[48] http://parisinnovationreview.com/articles-en/the-physical-internet-logistics-of-the-future-is-just-around-the-corner

Trend	Description
Smart warehouses	Automation and IT technologies are also driving the diffusion of Smart warehouses. A smart warehouse is one designated to operate with maximum efficiency by using automation and other technologies. To be smart, a warehouse not only must integrate automation in its processes, but also to respond quickly to rapid changes and allow the operator to get real-time updates on all ongoing activities. New and developing smart-warehouse technologies include automated picking tools, guided vehicles and inventory control platforms; warehouse management systems, IoT implementation, collaborative robots, automated storage and retrieval systems.

Figure 26 – The cross-sectoral value chain of Logistical Services



Source: EOCIC

The activities of the Logistical Services industry are spread all over the world and particularly in developed countries. Logistics clusters are common in Germany (Logistics Villages), Spain (Logistics Platforms), Japan (Distribution Parks) and many other countries with various other names, more often near large infrastructural plants (Rotterdam Port in Holland; the Singapore Port area; the Panama Canal Zone).

Focusing on cross-sectoral linkages along the value chain of the Logistical Industry in Europe, the most dynamic regions are located in several European countries. Île de France and London stand out with a high number of cross-sectoral linkages. After these, larger coastal cities and important logistics hubs like the North and South Holland, Oslo, the Helsinki region in South Finland, Stockholm or Hamburg are dynamic regions as well. Finally, in Southern and Central

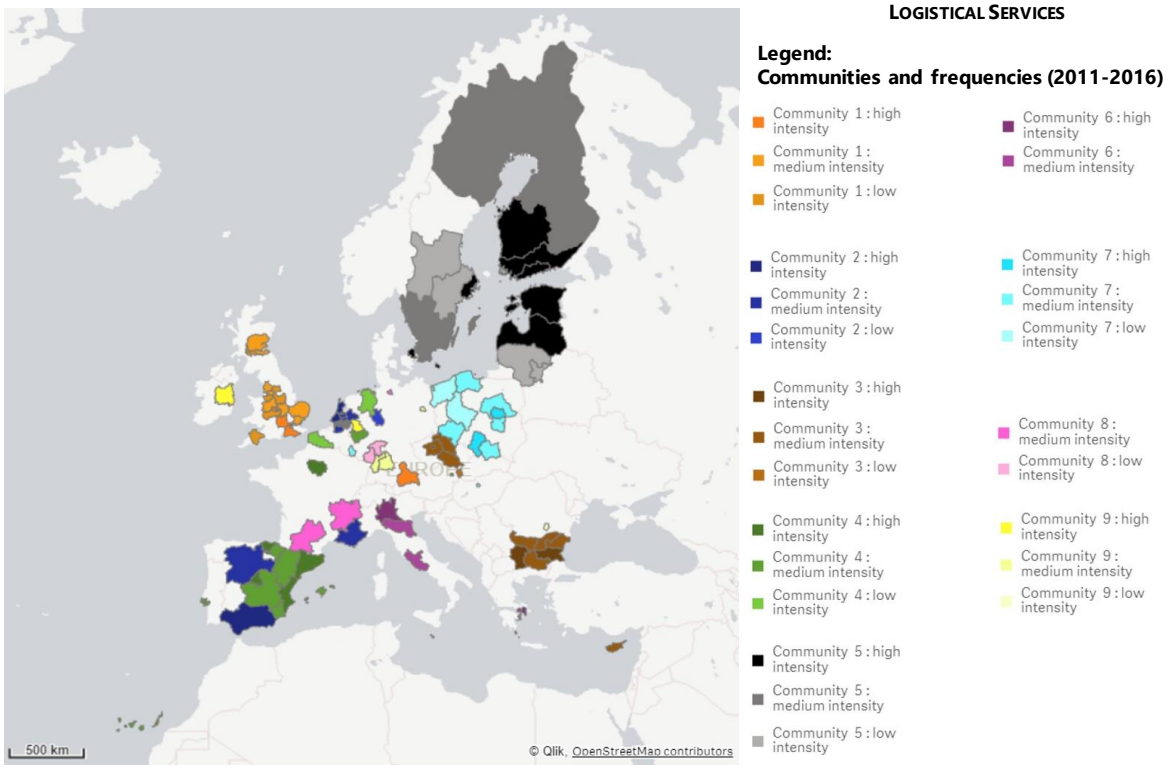
Europe, hotspots emerge in Italy centred in Lombardy and Emilia-Romagna, and more recently (2011–2016) Poland and Bulgaria, around Sofia in the Yugozapaden region.

The social-network analysis identifies nine communities of regions that were the most closely connected through cross-sectoral links in the 2011–2016 period. These communities are centred around specific node regions (hotspots):

Community 1: Inner London—East (UK)	Community 6: Attiki (Greece)
Community 2: Andalucía (Spain)	Community 7: Śląskie (Poland)
Community 3: Yugozapaden (Bulgaria)	Community 8: Hamburg (Germany)
Community 4: Comunidad de Madrid (Spain)	Community 9: Düsseldorf (Germany) and Eastern and Midland (Ireland)[49]
Community 5: Latvija (Latvia)	

Figure 27 provides an overall picture of cross-sectoral communities (in terms of the number of linkages) and hotspots across European NUTS-2 regions.

Figure 27 – Cross-sectoral communities and hotspots of Logistical Services in Europe (2011–2016).



Source: EOCIC

[49] According to the centrality measure of the network analysis, Community 9 has two hotspots (Düsseldorf in Germany and Eastern and Midland Ireland), which play an equally central role in the community.

3.3.9 Medical Devices

According to a broad definition (EOCIC, 2019a), a medical device is an instrument, apparatus, software, or material used for the diagnosis, cure, mitigation, treatment or prevention of disease, without being absorbed or metabolized by the body. The term applies to a huge number of products ranging from surgical gloves to artificial joints to imaging equipment; however, the activity of the technologically most advanced subsectors is often based on biomedical engineering and devoted to products that permanently or temporarily replace or support a function of the body. The Medical Devices industry is thus an important component of the larger healthcare system, playing an essential role by developing new medical technologies that can improve the ability to diagnose and treat illness.

The industries more closely connected to Medical Devices are the Transport and Electrical Machinery sector (in terms of cross-sectoral patents and M&A), Metal Products and Electric, Gas and Water Distribution sectors (especially in terms of JV&A). The industry is transforming itself in response to the push of the trends described in Table 17.

Table 17 – Emerging cross-sectoral trends for Medical Devices industries

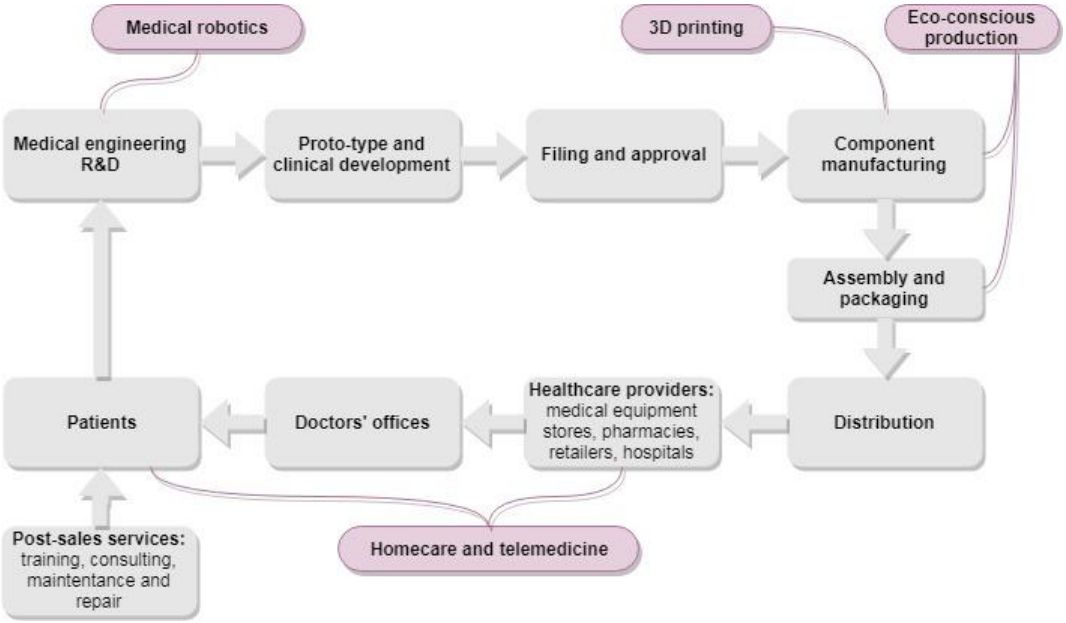
Trend	Description
3D printing	3D printing is a type of additive manufacturing that creates a three-dimensional object by building successive layers of raw material. This new technology is enabling the creation of ad hoc medical devices, because manufacturers can create the device matched with the patient's anatomy or, in any case, with very complex internal structures. This technology is becoming a reality in the development of orthopaedic and cranial implants, surgical instruments, dental restorations such as crowns, and external prosthetics. In the future, 3D printing could be used to replace human-organ transplants.[50]
Eco-conscious production	This is a crossover of Medical Device and Energy industries. According to the World Health Organization, medical-device companies are increasingly aware of environmental and energy issues. Indeed, companies are starting to produce devices designed to use low-voltage DC power supplied by batteries and solar photovoltaic systems. The application of these new technologies would not only have environmental benefits (reduced air pollution emissions) but also generate energy savings for health centres.
Medical robotics	Artificial intelligence and robotics are changing the healthcare sector. Robotics experts believe that autonomous robots could soon be regular members of hospital medical staff. However, not fully autonomous robots are already widely supporting surgeons, e.g. the daVinci system used by more and more surgeons worldwide since 2000.[51]
Homecare and telemedicine	Telemedicine allows healthcare professionals to monitor and treat patients remotely, using telecommunication technologies. For example, telemedicine technology is used for follow-up visits, management of chronic conditions (e.g. allergies, asthma), medication management (e.g. post-operation check-ins) and specialist consultation (e.g. in case of infections, conjunctivitis).[52]

[50] https://www.medicaldevice-network.com/features/3d-printing-in-the-medical-field-applications/

[51] https://interestingengineering.com/15-medical-robots-that-are-changing-the-world

[52] https://evisit.com/resources/what-is-telemedicine/

Figure 28 – The cross-sectoral value chain of Medical Devices industries



Source: EOCIC

The key countries of the European medical-devices market are Germany, the UK and France. Concerning cross-sectoral activities, elaborations here pinpoint the most important and dynamic regions in Germany (Oberbayern, Darmstadt, Freiburg), France (Île de France and Rhône-Alpes), UK (East Anglia and Berkshire, Buckinghamshire and Oxfordshire) Belgium and Netherland (Brabant), and Northern Italy (Lombardia and Emilia-Romagna).

The social network analysis identifies nine communities of regions that were the most closely connected through cross-sectoral links in the 2011–2016 period. These communities centre around specific node regions (hotspots):

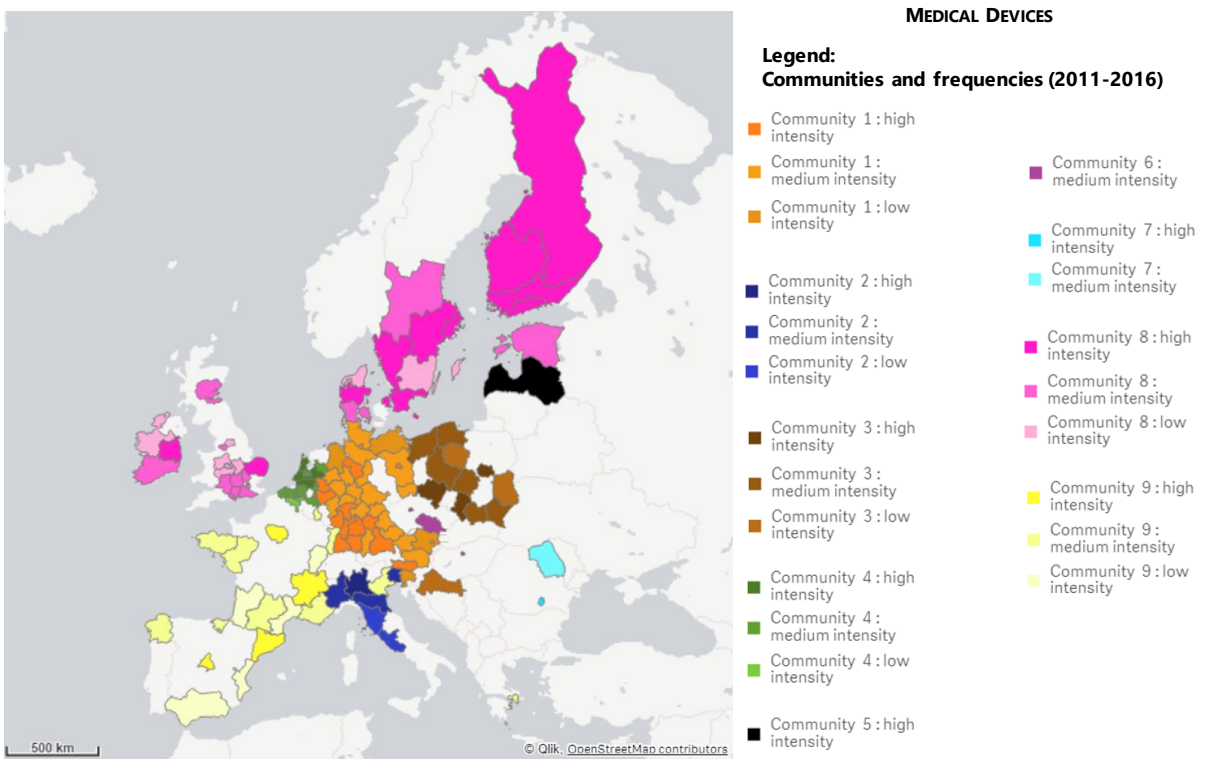
Community 1: Oberbayern (Germany)	Community 6: Budapest (Hungary)
Community 2: Lombardia (Italy)	Community 7: Bucureşti–Ilfov (Romania)
Community 3: Warszawski stołeczny (Poland)	Community 8: Helsinki-Uusimaa (Finland)
Community 4: Noord-Brabant (Netherlands)	Community 9: Ile-de-France (France).
Community 5: Latvija (Latvia)	

Comparing the size and number of regional communities over the 2000-2016 period shows that cross-border operations between German and Austrian regions have increased, as reflected by a larger number of regions belonging to community 1. Cross-sectoral interlinkages between Italian regions have also been reinforced.

In the last years (2011–2016), two new communities have emerged. One (community 3) is centred around the region Warszawski stołeczny and cover 11 Polish regions and one Hungarian region. Although the medical device industries in these countries are still relatively small, they are rapidly expanding, pushed by the development of medical technologies, particularly in the home-care and e-health segments, the increasing demand of the ageing

population, and increasing R&D investments by the private sector and EU funds.[53] The other community (community 7) covers two Romanian regions. The increased domestic demand and risk capital investments are both fuelling the development of new products, services (e.g. e-commerce) and technologies (e.g. the use of miniaturised electronics for medical technology uses).[54]Furthermore, it is interesting to notice that the Ireland and UK regions are increasingly interconnected with the Nordic regions of Denmark, Estonia, Finland and Sweden (community 8).

Figure 29 – Cross-sectoral communities and hotspots of Medical Devices industries in Europe (2011–2016).



Source: EOCIC

[53] https://www.innowo.org/userfiles/publikacje/Polish%20Healthcare%20Sector.pdf; https://www.emergobyul.com/resources/market-poland.

[54] https://www.exceet.com/en/group/exceet-news/news-detail/detail/exceet-staerkt-mit-uebernahme-der-valtronic-romania-marktposition-in-der-medizintechnik/.

3.3.10 Mobility Technologies

The Mobility Technologies industry includes all activities and agents providing products, services and technologies that enable people and goods to move around more freely and efficiently. Stemming from the automotive sector as a core, it comprises related technologies, such as the production technology and aerospace cluster, as well as few related upstream activities like metalworking and plastics. Topics dealt with by technological innovation in the field of mobility include road vehicle engineering, internal combustion engines, batteries and motors, electric and hybrid powertrains, urban and high-speed rail transportation, aircraft types and aerodynamics, radar, navigation, GPS, GIS, etc.[55]

The complexity of the Mobility Technologies value chain implies a thick network of cross-sectoral linkages. Recent data indicate that this emerging industry is significantly and increasingly interconnected. The most important cross-sectoral M&A operations are carried out with the Machinery sector, followed by Electronics and Chemicals. Some JV&As have taken place in the considered time span, and the most numerous deals involved the Business services and Electric, Gas & Water distribution sector.

The Mobility Technologies industry is characterised by the transformation trends presented in Table 18.

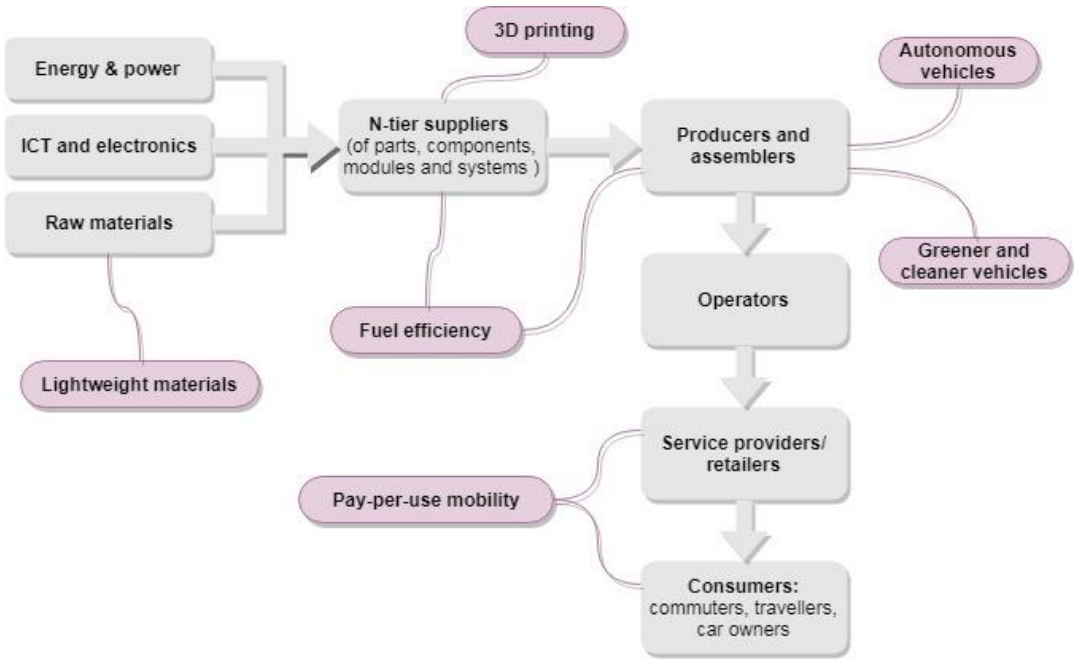
Table 18 – Emerging cross-sectoral trends for Mobility Technologies industries

Trend	Description
Lightweight cars	Future cars are expected to feature fuel efficiency and light weight. Regulatory authorities that push more and more attention to fuel efficiency drive lightweight-vehicle production. Indeed, lightweight vehicles are not only a matter of weight but also the idea that lighter cars need less energy (e.g. to accelerate) and so achieve better fuel efficiency and handling.
3D printing	3D printing technology will impact the automotive manufacturing industry. Some attempts to manufacture cars using 3D printing technology have already occurred. For instance, in 2014, a Swedish manufacturer called Koenigsegg produced a car using 3D-printed components. In 2017, the German automotive manufacturer AUDI launched a 3D-printing centre in Ingolstadt.
Autonomous vehicles	This trend contributes to explaining the high number of cross-sectoral operations between the mobility industry and the machinery and electronics sectors. Self-driving cars are vehicles capable of moving with little or no human input. They combine a variety of sensors to perceive their surroundings. Driverless cars are being tested in America, e.g. Google's and Uber's autonomous cars.
Greener and cleaner vehicles	Increasing environmental concerns push for greener and cleaner vehicles. Alternative fuels are being developed and consequently, electric and fuel-cell-powered cars and hybrid cars are now common on the market.
Pay-per-use mobility	This new trend is driven by young generations that instead of owning a car prefer to use car-sharing and so paying for a car only if and when they use it. This shift in mobility preferences would significantly affect the retailers' business model.

[55] To avoid overlapping with the range of activities covered by other emerging industries (e.g. Logistical and Blue Growth), the reach of the Mobility Industry is usually limited to the movement of people (no goods) by road, rail and air (no maritime) transport.

Figure 30 elaborates and shows the cross-sectoral value chain of mobility technologies.

Figure 30 – The cross-sectoral value chain of Mobility Technologies industries



Source: EOCIC

According to ACEA (2018b), out of 19.6 million motor vehicles manufactured in the EU in 2017, about 6.2 million were produced in Germany; 2.9 million in Spain and 2.3 million in France, with the Czech Republic and Slovakia rapidly increasing their shares (1.4 million and almost 1 million vehicles respectively).

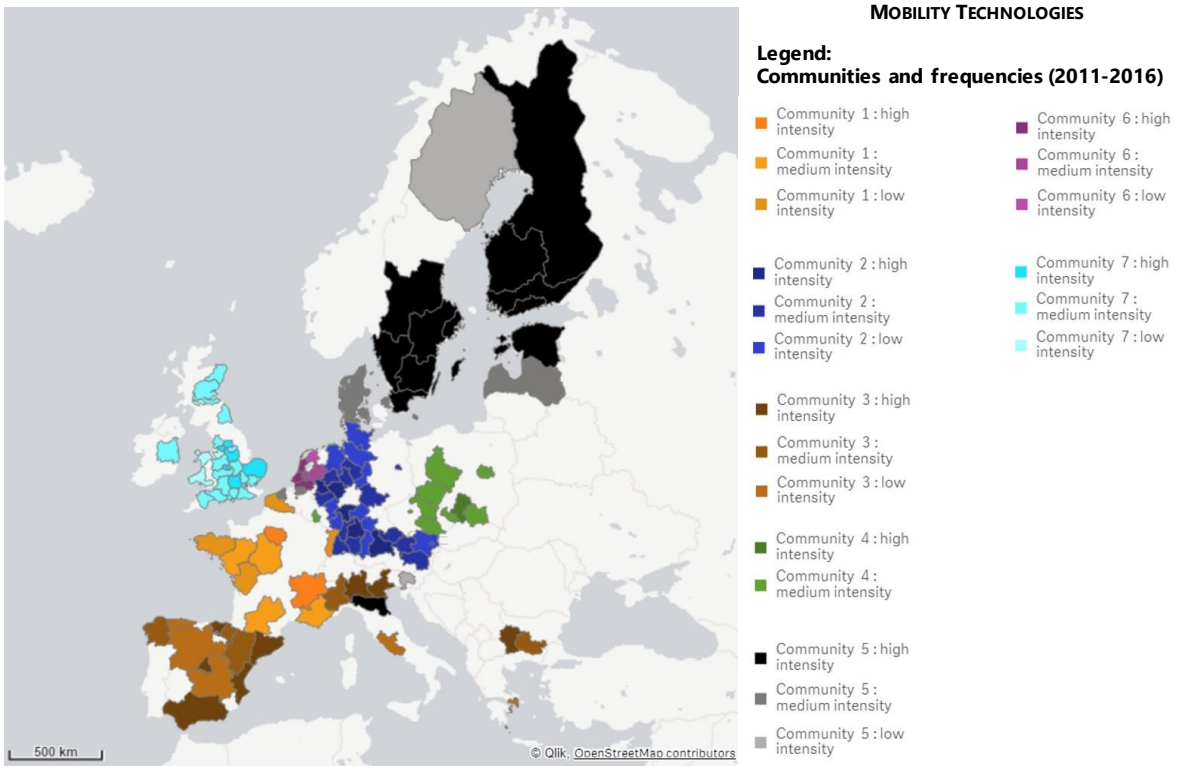
In terms of cross-sectoral linkages, the analysis by the European Cluster Observatory (2015) pinpointed the most dynamic hotspots in Germany, France and the UK. More recent data indicate that the cross-sectoral networks in Spain, Poland and Central Europe, Northern Italy and Sweden are increasing. Ireland and Denmark are significantly integrated with the UK and Sweden, respectively.

The social-network analysis identifies seven communities of regions that were the most closely connected through cross-sectoral linkages in the 2011–2016 period. These communities centre around specific node regions (hotspots):

Community 1: Ile-de-France (France)	Community 5: Helsinki-Uusimaa (Finland)
Community 2: Oberbayern (Germany)	Community 6: Noord-Brabant (Netherlands)
Community 3: Cataluña (Spain)	Community 7: West Midlands (United Kingdom).
Community 4: Śląskie (Poland)	

The number of communities has decreased over time, suggesting a tendency toward concentration of cross-sectoral and cross-regional operations.

Figure 31 – Cross-sectoral communities and hotspots of Mobility Technologies industries in Europe (2011-2016).



Source: EOCIC

4 EU emerging industries in the global economy

Internationalisation provides companies, clusters and regions access to international resources and markets along all parts of the innovation and value chains. This access serves transformation and growth, either to catch up or stay ahead. While in the past clusters have been conceptualised as local, small-scale innovation systems (OECD, 2001) emphasising interactive learning among actors within clusters, the literature has shown the increased importance of internationalisation for the transformation and growth of firms, as well as the value chains and innovation systems they operate in. The international opening of regional industrial basis can fuel the upgrading of product quality, the adoption of more advanced technologies and business models, the accumulation of knowledge and the shift towards more remunerative sectoral specialisations (Rabellotti et al., 2009; Vecciolini, 2018).

This chapter analyses the transformation trends of the ten European emerging industries from a global perspective. It is divided into three sub-sections.

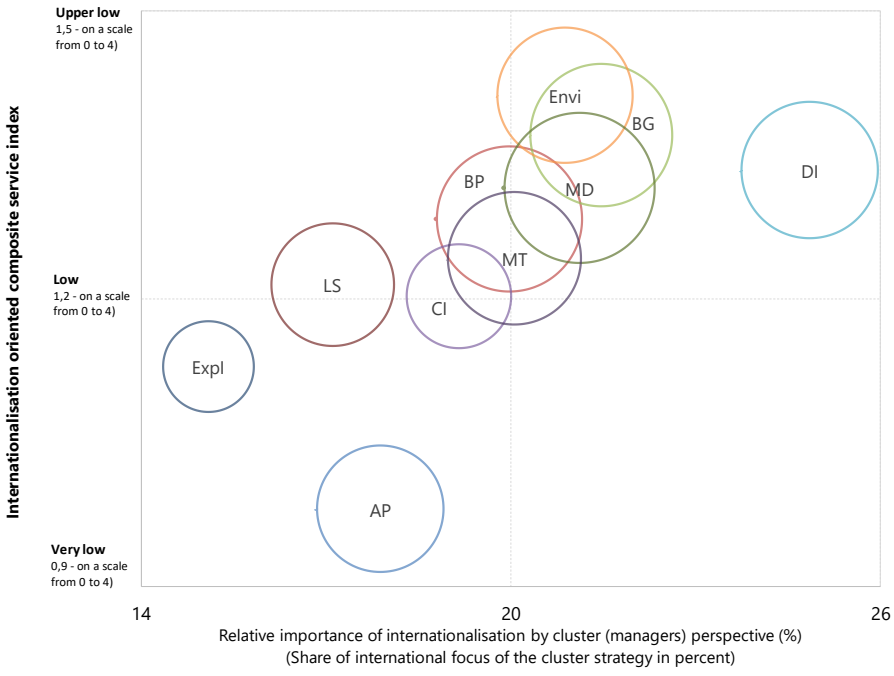
- First, it illustrates and analyses the ESCA data on the international orientation of European clusters in emerging industries.
- Second, it investigates and visualises the intensity and geographical directions in which regions tend to cooperate on the basis of ESCA data.
- Third, it provides a comparative analysis of European emerging industries against a selection of international partner countries. This analysis is mainly qualitative and relies on a review of the briefing reports on international partner countries provided by the European Cluster Collaboration Platform (ECCP) between 2017 and 2018.

4.1 International orientation of emerging industries

To analyse the patterns of internationalisation of European emerging industries, this section relies on the database provided by the European Secretariat for Cluster Analysis (ESCA), including a number of variables on the internationalisation behaviour of a sample of about 100 cluster organisations related to the ten emerging industries[56]. The elaboration of ESCA data focuses on the most recent years (2015-2017) to capture up-to-date levels and patterns of internationalisation. However, a comparison with data presented in the previous European Cluster Trends Report (European Cluster Observatory, 2015) is provided.

By focusing especially on three different aspects of internationalisation, Figure 32 illustrates the strategic importance given by cluster managers and cluster participants[57] to the issue of internationalisation, in combination with an index reflecting the level of a cluster's services oriented towards internationalisation[58]. Table 19 summarises the position of the industry with respect to the three ESCA variables and provides the overall assessment for 2015-2017.

Figure 32 – Analysis of selected internationalisation aspects of European Clusters in Emerging Industries (average 2015-2017)



Notes: AP=Advanced Packaging; BP=Biopharma; BG=Blue Growth; CI=Creative industries; DI=digital based industries; Envi= Environmental industries; Expl=Experience industries; LS=Logistical Services; MD=Medical Devices; MT=Mobility Technologies.

Legend: The size of the bubbles shows the degree of internationalisation per type of cluster participant.

Source: EOCIC

[56] ESCA attributes cluster organisations to specific technological areas. For this study, ESCA has provided information on how to attribute such technology areas to the ten emerging industries. The ESCA database contains data for 115 cluster organisations in 2015, 140 in 2016 and 88 in 2017. For confidentiality reasons, no details are available that would allow the precise identification of cluster organisations included in the database.

[57] The cluster's participants in the survey that was launched to collect the data of the ESCA database are SMEs, non-SMEs, R&D, training providers and other cluster participants.

[58] The index goes from 0 to 4.

Differences can be detected in the level of internationalisation between the ten emerging industries.

- The **relative importance of internationalisation by cluster manager perspective** (reflected in the horizontal axis in Figure 32 and the first column of Table 19) indicates that the international focus is considered particular strategic for the Blue Growth and Digital industries. Clusters related to the Environmental and Mobility Technologies industries also attach a degree of strategic importance to internationalisation above the average observed in all clusters in the ESCA database. Compared to the data included in the previous Cluster Trends Report (European Cluster Observatory, 2015) and referring to the period 2012-2014, the relative importance of internationalisation appears to be increasing for the Biopharmaceuticals, Digital, Environmental, and Medical Devices industries.
- The **current degree of internationalisation of cluster participants** (reflected in the bubble's size in Figure 32 and in the second column of Table 19) is above the average for the Biopharmaceuticals, Blue Growth, Digital, Environmental, Medical Devices and Mobility Technologies industries. The relative importance of internationalisation of cluster participants in the Digital industries has especially increased compared to the previous period.
- The **intensity of international support services for their cluster members** (vertical axis of Figure 32 and third column in Table 19) is particularly high for the Environmental, Blue Growth, Digital and Medical Devices industries. It is also interesting that the internationalisation-oriented service index for clusters related to the Creative industries, while being on the average, has increased compared to 2012-2014.

Three subgroups of emerging industries can be identified by analysing the three variables together.

- Industries in which the level of internationalisation is high with respect to all the three variables (Digital, Environmental and Blue Growth industries) or with respect to the majority of the variables (Biopharmaceuticals, Medical Devices and Mobility Technologies). These industries are characterised by high and growing strategic importance of internationalisation, wide offer of support services and high level of internationalisation exhibited by cluster participants.
- Industries in which the level of internationalisation is close to the average (Creative industries and Logistical services). More specifically, in Logistical Services, although cluster managers seem to attach relatively low strategic importance to internationalisation, the offer of support services to internationalisation and the status of internationalisation of cluster participants is average. On the contrary, in Creative industries, the intensity of support services is in line with the increasing importance given by cluster managers to internationalisation, although the degree of internationalisation of stakeholders is still quite low. This is also due to the high proportion of micro-enterprises in the cultural and creative industries that are often more focused on their home market than on operating internationally. Yet, opportunities still exist for them to target global markets.

- Industries in which the level of internationalisation is relatively low with respect to the majority of the variables considered (Advanced Packaging and Experience industries). The Panorama report (EOCIC, 2019a) highlights that Advanced Packaging has the lowest labour productivity among all emerging industries, while Experience industries are characterised by low digital engagement and small business R&D expenditure. Yet, current transformation trends indicate that both industries are increasing their attention towards innovation (e.g. with the development of intelligent manufacturing, smart packaging, gamification and e-commerce), which will open up opportunities for more international collaboration opportunities in the future. Overall, the geographical analysis of cross-sectoral linkages (see Chapter 3) highlights that these industries have already increased the intensity of cross-regional and cross-sectoral linkages over the 2000-2016 period.

These data indicate a general positive correlation between the relative importance of internationalisation as either declared by the cluster managers or reflected by clusters participants' international orientation and the services offered to support internationalisation. In fact, cluster organisations addressing internationalisation through quite a high intensity of international support services for their cluster participants tend to attach greater strategic importance to internationalisation; in turn, cluster participants tend to display a generally higher degree of international cooperation.

Table 19 – Degree of internationalisation of the ten emerging industries according to the three variables, and overall internationalisation pattern

Emerging industry	Importance of internationalisation according to the cluster managers	International orientation of clusters participants	Availability of Internationalisation-oriented services
Advanced Packaging	🔴	🟡	🔴
Biopharmaceuticals	🟡	🟢	🟢
Blue Growth industries	🟢	🟢	🟢
Creative industries	🟡	🔴	🟡
Digital industries	🟢	🟢	🟢
Environmental industries	🟢	🟢	🟢
Experience industries	🔴	🔴	🟡
Logistical Services	🔴	🟡	🟡
Medical Devices	🟡	🟢	🟢
Mobility Technologies	🟢	🟢	🟡

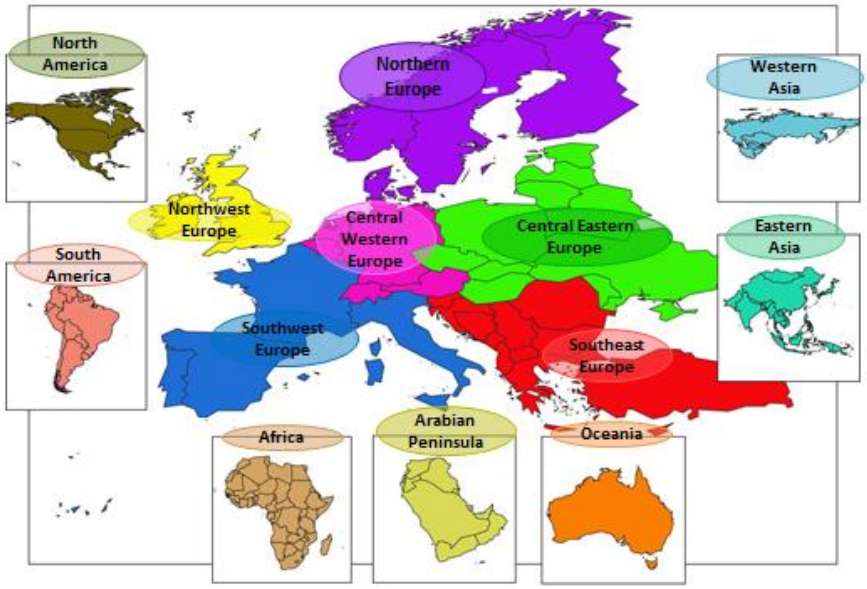
Legend: Green: relatively higher level of internationalisation; orange: relatively medium level of internationalisation; red: relatively lower level of internationalisation (compared to the other emerging industries)
Source: EOCIC elaboration based on ESCA data

4.2 Trans-regional cooperation paths

The geographical analysis of cross-sectoral linkages in Chapter 3 has shown that regions tend to interact within communities that expand beyond national borders. This section analyses the ESCA data of cooperative relationships between cluster organisations in the ten emerging industries and international partners, both in the EU and extra-European countries. The goal is to investigate the intensity and geographical directions in which European emerging industries tend to cooperate with other European or non-European areas to conduct joint R&D or other business activities.

Figure 33 shows the different geographic regions considered for the analysis.

Figure 33 – Geographic regions for the investigation of trans-regional collaboration of European clusters in emerging industries



Source: EOCIC

Figure 34 shows that the highest level of cooperation, measured by the total number of cooperation activities within the same geographical region and towards other European macro-regions, is central Western Europe, followed by Southwest and Northern Europe. The lowest level is detected in southeast and central Eastern Europe. However, in percentage terms, clusters in central Eastern Europe tend to cooperate more with countries beyond the EU borders than within their own region or with other European countries.

Figure 34 – Total number of cooperation activities within the same region and towards other European and non-European regions (2015-2017)

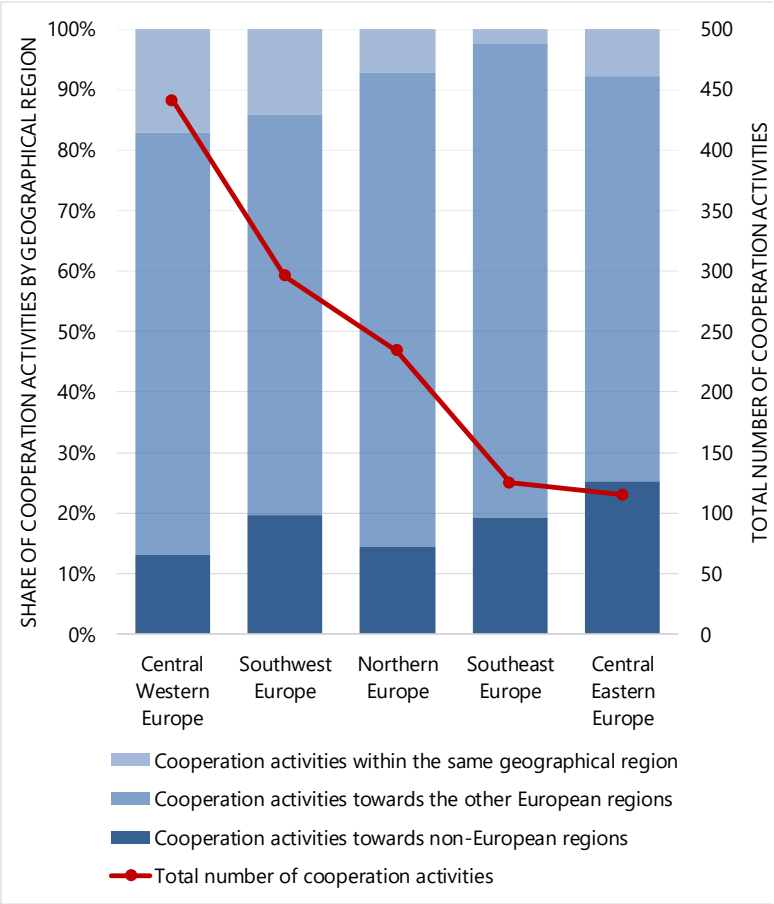
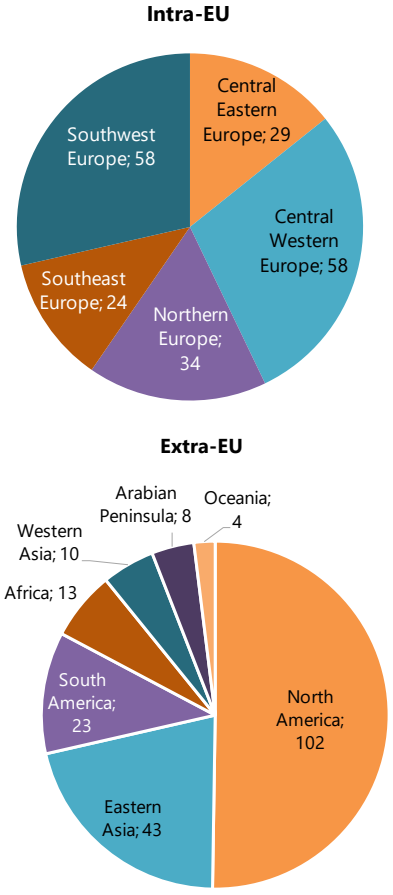


Figure 35 – Total number of cooperation activities towards other macro-regions (2015-2017)



Note: data for the northwest region are missing.
Source: EOCIC elaboration based on ESCA data

Table 20 – Cluster-driven trans-regional cooperation matrix among emerging industries (2015-2017)

	Northern Europe	Northwest Europe	Central Western Europe	Central Eastern Europe	Southwest Europe	Southeast Europe
Northern Europe		-	+	o	o	-
Northwest Europe	-		-	o	-	-
Central Western Europe	+	-		o	++	+
Central Eastern Europe	o	o	o		o	-
Southwest Europe	o	-	++	o		o
Southeast Europe	-	-	+	-	o	

Legend: the relative level of cooperation is identified with ++very strong cooperation, + strong cooperation, o medium strong cooperation, - weak cooperation. The variation with respect to the previous period (2012-2014) is represented by three different colours: green: positive variation; red: negative variation; orange: no variation.
Source: EOCIC elaboration based on ESCA data

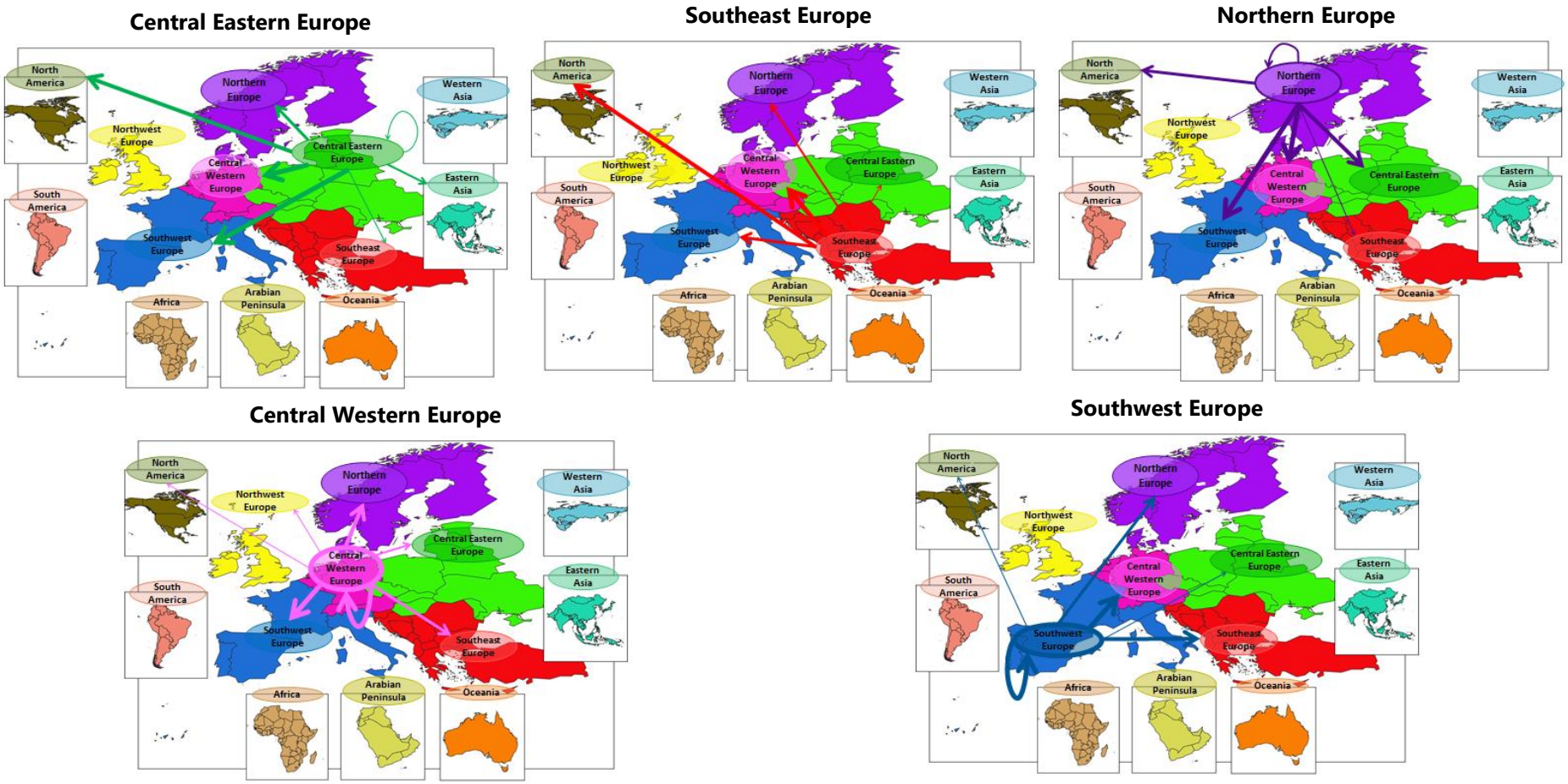
Table 20 summarises the trans-regional cooperation paths of the European clusters in the emerging industries. By focusing on the number of two-way cooperation activities[59], Table 20 shows the different relative levels of cooperation characterising the six European geographical regions, ranging from very strong to weak. In addition, the colours of the cells indicate the variation of the relative levels of cooperation with respect to the previous period 2012-2014. The matrix table shows that the geographical areas of central Eastern, southwest and northern Europe, while characterised by a relatively more limited number of trans-regional cooperation activities, display growing cooperation with some geographical areas in the latest years (2015-2017) compared to the previous period (2012-2014). Central Eastern Europe and northern Europe are increasingly cooperating among each other; southeast Europe is increasingly cooperating with central Western Europe. With respect to the number of external cooperation activities towards non-European regions during the 2015-2017 years (Figure 35), central Western and southwest Europe have the most open regions, recording the highest level of internationalisation not only between European regions but also towards extra-EU regions, followed by northern Europe. Central Eastern and Southeast Europe, in contrast, are still relatively less oriented towards international cooperation.

Among the cooperation activities towards extra-European clusters, the highest numbers concern North America and eastern Asia, respectively, while cooperation targeting South America, Africa, Arabian Peninsula, Oceania and western Asia is, in comparison, quite negligible for all emerging industries.

The intensity and direction of the cooperation activities targeting these extra-EU regions are separately analysed in Figure 36 to explore in relative terms the intensity and geographic priorities of cooperation of each of the European macro-regions for which data are available (thus, excluding the case of northwest Europe). This analysis shows that geographical regions located in the east of Europe tend to record a low level of internal cooperation activities within the same region, but higher towards central Western and southwest Europe. Moreover, internationalisation efforts towards extra-EU regions are relatively higher with respect to the other European areas. An opposite pattern can be highlighted for central Western and southwest Europe, being characterised by stronger cooperation in countries belonging to the same geographical macro-region and a relatively lower internalisation towards other European regions and non-EU regions. Between these two extremes, northern Europe records a medium level of internal cooperation and a relatively strong external cooperation towards both the extra-EU region of North America and all the other European regions, except for northwest Europe and southeast Europe.

[59] An exception is the case of northwest Europe, for which only cooperation activities targeting this macro-region are reported. In fact, data on cooperation activities for northwest Europe and addressed to the other macro-regions were not available.

Figure 36 – Target Cooperation Regions in 2015-17



Note: the thickness of the arrow is proportional to the degree of cooperation (from very high to very low).
Source: EOCIC elaboration based on ESCA data

4.3 Comparison with international partner countries

This section reports and compares the industrial transformation trends observed in the EU with a sample of countries outside the EU. The objective is to assess the positioning of the European emerging industries in the global landscape and, by doing so, to identify opportunities (or competition threats) that could have an impact on cross-sectoral industrial development within the EU. The countries selected for the international comparison are the **US, Canada, Japan, Singapore and the Republic of Korea**. These are all important partners for the EU, having developed strong and long-standing cooperation in trade, investments, science, technology and innovation with EU Member States.

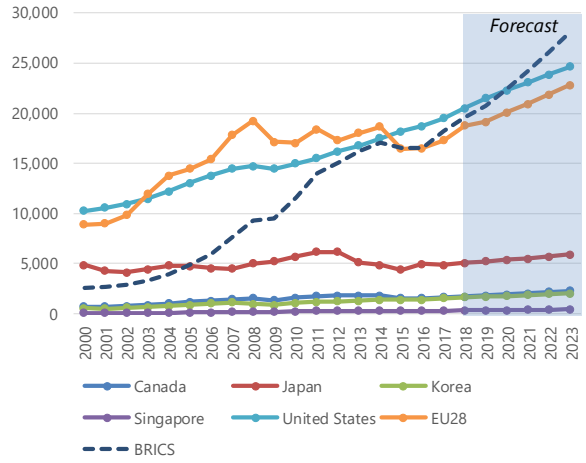
4.3.1 Macro-economic and social trends

Assessing the positioning of the European emerging industries with respect to the five selected international competitors requires a preliminary analysis of the more general global context. In this section, some key macro-economic and social indicators are considered to highlight the opportunities or the challenges the EU faces compared to third countries.

In terms of Gross Domestic Product (GDP), for many years, the EU as a whole had a growing nominal GDP, which was the world's highest between 2003 and 2013 (Figure 37). The prolonged effects of the global recession and the financial and economic crisis in the EU drove economic growth down, while the US economy continued its steady growth. In parallel, the BRIC countries (Brazil, Russia, India and China) have been experiencing an economic boom over the past several years and therefore have seen significant gains in the production of goods and services. In 2017, the GDP of all BRIC countries amounted to approximately 18.25 trillion USD, against a 17.33 trillion USD for the EU and 19.49 trillion for the US. Each of the four BRIC countries saw their GDP rise annually, in particular China, the GDP of which increased by roughly 6 times since 2003. Among the other four countries analysed, Canada, South Korea and Singapore are growing at a faster pace, even if their GDP level is still below those of the overall EU and US economies. Japan, after falling into recession four times since 2008, has a low growth rate compared to other industrial countries.

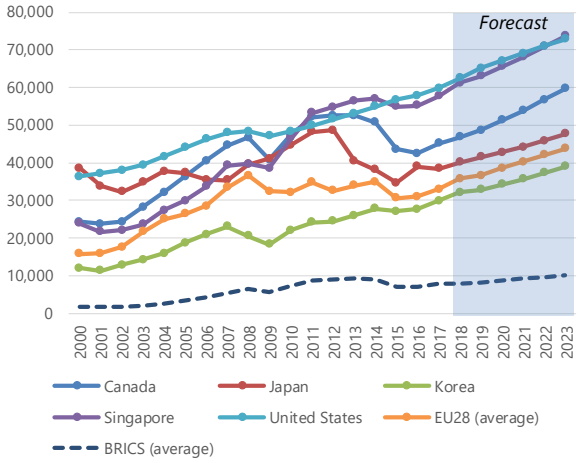
If extra-EU economies, besides the US, rank in lower positions than the EU in terms of current GDP value, when the economic output is considered in per capita terms, they perform better than the EU. The only exception is South Korea, where per capital GDP has rapidly grown over the years but is still below the EU average. The average per capita GDP in the EU is clearly determined by the extremely diversified economic contexts characterising its Member States. Among them, Luxembourg and Ireland have the highest per capita GDP, above the US and the other considered international partners. Denmark, Sweden, Netherlands, Austria, Finland, Germany and France record similar levels of GDP per capita than the US, Singapore, Canada and Japan. In contrast, countries such as Croatia, Romania, Bulgaria, Poland and Hungary rank in much lower positions, with GDP per capita figures similar to those of Russia, Brazil and China.

Figure 37 – GDP, current prices (billions USD)



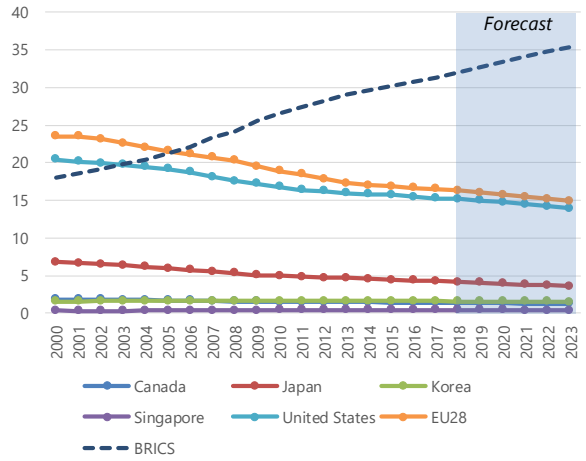
Source: EOCIC elaboration based on IMF World Economic Outlook data

Figure 38 – GDP per capita, current prices (USD)



Source: EOCIC elaboration based on IMF World Economic Outlook data

Figure 39 – GDP based on purchasing-power-parity (PPP) share of world total (per cent)



Source: EOCIC elaboration based on IMF World Economic Outlook data

When one looks at the share of the world total GDP based on purchasing-power-parity (PPP), the exceptionally high growth of the BRICs compared to the EU and other developed economies is evident (Figure 39). The EU28 and the US are the second and third-largest economic blocs globally, with 16.2% and 15.5% of global share, respectively, in 2017. Both their shares and the gap between the two are expected to continue shrinking. If individual EU Member States are considered, Germany, the UK, France and Italy ranked the highest in 2017, after the US and Japan. Other countries like Spain, Poland, Netherland, Belgium, Sweden and Romania have a GDP share of the world that is similar to other international partners like South Korea, Canada and Singapore.

Overall, these figures show the important role that the EU as a whole plays in the global context, despite the considerable differences among the European countries that may affect the general economic trend and the increasing weight that emerging economies are gaining.

The EU position is instead worse if one considers the level of investment over GDP, which is lower than its international partners, except for the US (Figure 40).

Figure 40 – Ratio of total investment over GDP (per cent)

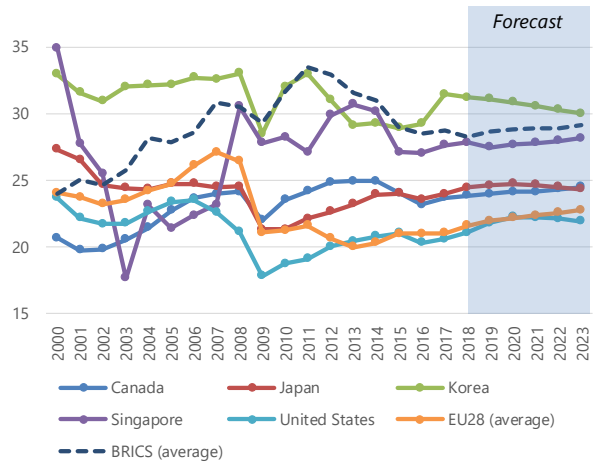


Figure 41 – Volume of exports of goods and services (percentage change)

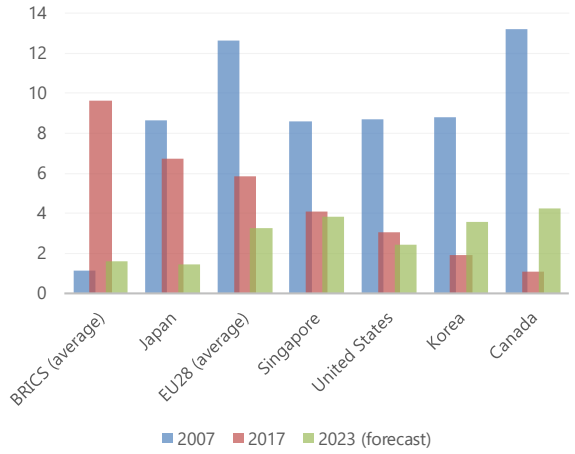
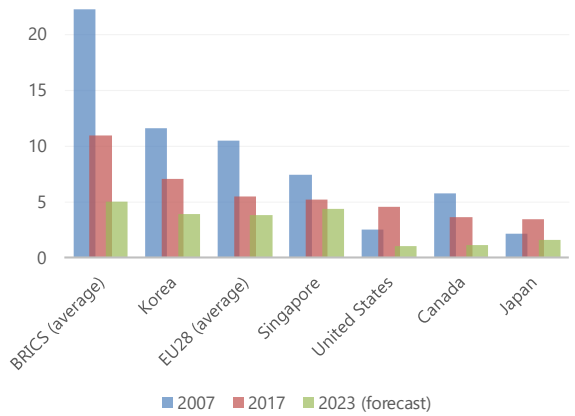


Figure 42 – Volume of imports of goods and services (percentage change)



Source: EOCIC elaboration based on IMF World Economic Outlook data

More specifically, the average EU ratio of gross capital formation over GDP is similar to the US' level (respectively, 22% and 20% in 2017), but falls well behind the share recorded by other international partners. South Korea currently has the highest share (31.5%), higher than the average of the BRICs (28%). It is also interesting that the gap between the EU and Canada and Japan is expected to decline in the next years, thanks to the continuous growth of investments in the EU economy.

All the developed countries in this analysis have strong export-oriented economies. For almost all countries, the largest trade and investment partner is either the EU or the US. Compared to 2007, right before the start of the global economic crisis, the volume of goods and services exported has slowed in the EU and the five international partners. Import growth rates have decreased as well in these countries, except for the US and Japan (Figures 41 and 42). In the future, exports from Korea and Canada are expected to grow faster than they are now. Singapore's economy depends heavily on exports, and these are expected to increase at a rate of around 4% in the next years. The BRICs export at a faster level than in the past, while their import flows are slowing down. As a consequence of the reallocation of global economic activities and global consumption to emerging countries, BRICs economies are highly integrated into international trade and create a strong counter-weight to the already existing world powers of the US, EU and Japan.

Figure 43 – Population (millions) and Dependency ratio (%)

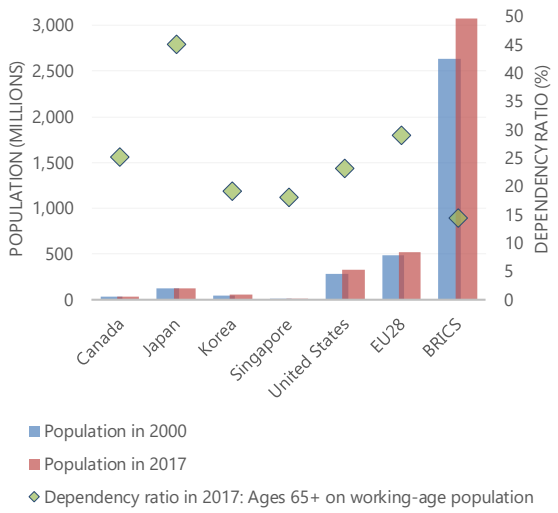


Figure 43 reports on two indicators related to population. Japan and the EU are the economies that recorded the lowest population increase between 2000 and 2017, but are characterised by the largest ageing population. The age dependency ratio in Japan is the highest in the world, closely followed by some European countries: Italy, Finland, Germany, Portugal and Finland. Population growth between 2000 and 2017 has been relatively faster in Singapore (40%), Canada (19%) and the BRICS (17%) and the US (15%).

Figure 44 – Number of researchers and technicians (FTE) per million people

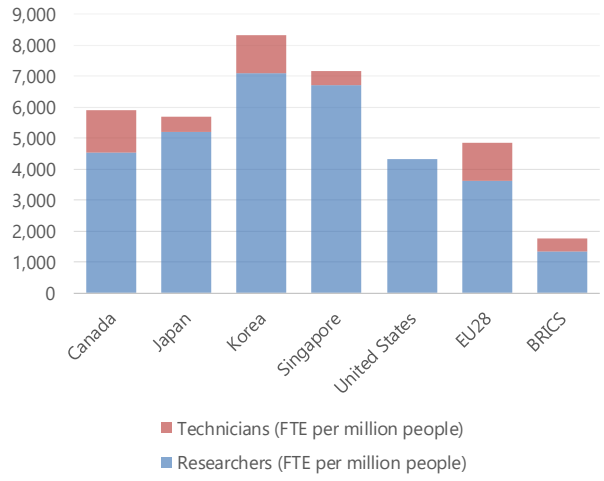
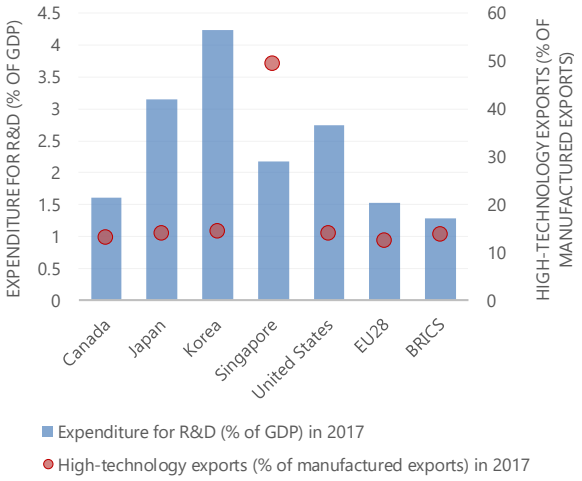


Figure 45 – Expenditure for R&D and high-technology exports



Note: Data on the number of technicians in the US are not available.

Source: EOCIC elaboration based on WB data

The EU and its five international partners share a high reputation for excellence in science and technologies. The aggregate data indicate that on average, the EU has a share of researchers and technicians, R&D expenditure and high-technology exports that are lower than those of its international counterparts, although intra-EU differences are remarkable. Austria, Denmark, Finland, Ireland and Sweden have more than 5,000 researchers per million people, very close to the levels of Japan, Singapore and South Korea. Seven out of ten of the top countries in terms of R&D expenditure over GDP are from the EU: Austria, Belgium, Denmark, Finland, France, Germany and Sweden. Extra-EU countries with a similar share of R&D expenditure are Japan, South Korea and the US. South Korea largely exceeds the other developed economies both in the number of researchers and technicians and share of R&D expenditure.

4.3.2 Industrial strengths of international partner countries and opportunities for the EU industry

The European Cluster Collaboration Platform (ECCP) has released, between 2017 and 2018, a series of analyses of the economy and the cluster landscape in ten strategic third countries, including the US, Canada, Japan, Singapore and South Korea. The ECCP reports provide up-to-date information on the sectoral strengths in each country, i.e. the industries that lead their economies and that are considered of high political importance. This information has been used to determine in which of the European emerging industries those countries have a higher competitive potential, which may determine both potentials for future collaboration between industries and related cluster organisations, but also possible competitive threats to Europe.

Table 21 gives a synthetic picture of the emerging industries where the five extra-EU countries have a greater potential as a consequence of the expansion patterns and levels of innovation and competitiveness currently observed in those industries (or some specific sectors composing them).

Table 21 – Industry strengths of extra-EU countries

Emerging industry	USA	Canada	Japan	Singapore	Rep. Korea
Advanced Packaging					●
Biopharmaceuticals	●	●	●	●	●
Blue Growth industries				●	
Creative industries	●		●		●
Digital industries	●	●	●	●	●
Environmental industries	●	●	●		●
Experience industries	●				●
Logistical Services	●		●	●	
Medical Devices	●	●	●	●	●
Mobility Technologies	●		●		●

Source: EOCIC

In general, the US, as one of the world's largest economies and most technologically advanced countries, enjoys a forefront position in many key sectors that define the ten European emerging industries. Japan is considered one of the most innovative economies in the world, also thanks to its large gross domestic expenditure on R&D (see Figure 45) and has a variety of well-developed sectors, such as automotive and life sciences. Canada has large growth potential in different sectors and is doing relatively well in terms of innovation, although its performance in terms of commercialisation and market deployment of innovation is still substantially lower than the other large economies, including the EU. Singapore and South Korea are still based on strong manufacturing activities, while services are historically less developed, although they have exhibited strong growth during recent years. Both countries aim at becoming hubs for technology and innovation in southeast Asia and attracting major investments in key sectors.

In terms of emerging industries, all these extra-EU countries are acknowledged by the ECCP to have sectoral strengths in Digital, Biopharmaceuticals and Medical Devices industries. In contrast, Advanced Packaging, Blue Growth, Creative and Experience industries are the European emerging industries on which other international partners are relatively less focused.

In what follows, more information on the strengths of these international countries in relation to the ten emerging industries in a global perspective is provided. They are based on the ECCP analysis and additional desk research.

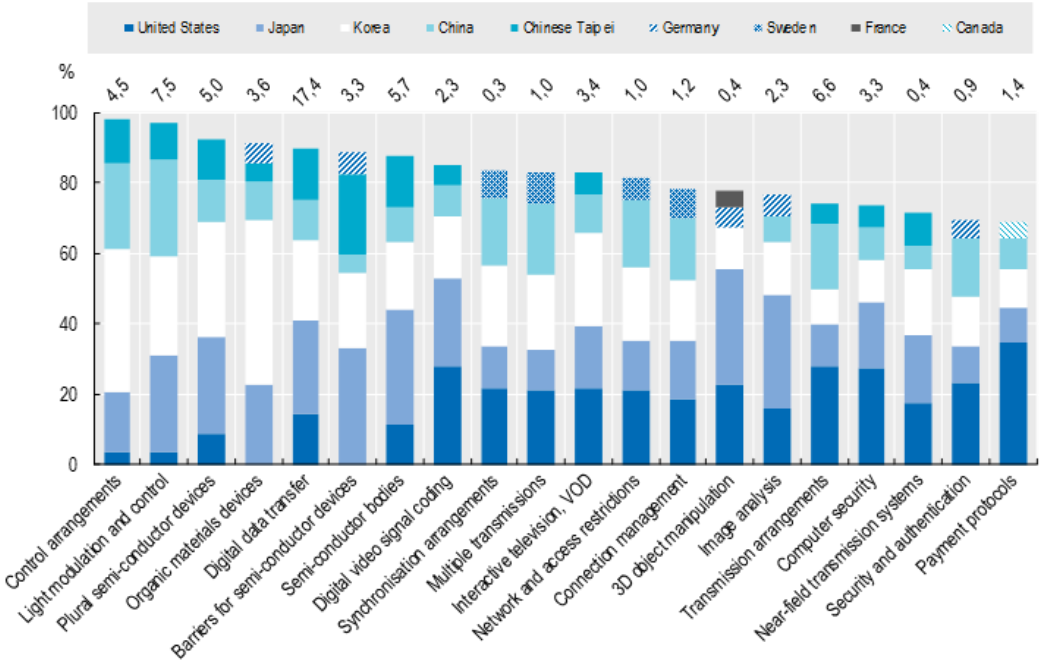
The **Digital industries** represent about 5% of global GDP (around EUR 3,200 billion), employing about 1% of the workforce in developing countries and nearly 4% in developed countries. Considering the size of the digital market and the core activities of the industry, International Monetary Fund (2018) values the digital sector in the US at EUR 1,320 billion, about 8.3% of total GDP. Garcia Herrero and Hu (2017) estimate the industry added value in 2012 (in current values) at about EUR 1,000 billion in the United States; 435 billion in Japan; 360 billion in China; and 102 billion in Korea. EOCIC (2019a) evaluates employment at more than 10 million units in 2018 and argues that the digital industry has grown very fast during the past two decades, having employed 7.3 million in 1996.

Digital industries are unevenly distributed worldwide. Even if they are impressively growing (faster than overall economies), especially in the global South (McKinsey Global Institute, 2016), advanced countries have the lion's share of the digital economy, especially because of the more intense R&D investments and better innovation performance. The US, the EU (especially Germany, Sweden, and France), Japan, South Korea, China and Canada developed the top 20 new technologies between 2012 and 2015 (Figure 46).

Developed countries, including European ones, in the last decade, have recorded high levels of activity and investment in many digital products and services, Big-Data analytics, applications platforms underpinning AI, virtual and augmented reality and many consumer-focused services (Murgia, 2016). New highly dynamic firms have come into this environment. Firms such as Uber (the world's largest 'taxi' company), Facebook (the world's most popular media company), Alibaba (the world's biggest and most valuable retailer), Airbnb (the world's largest 'hotelier') and others have introduced new business models, presumably to dominate the economic scene in the near future, constituting the paradigm of the so-called 'Industry 4.0'.

The US' ICT market represents about 28% of the worldwide total, which makes it the largest ICT market globally. The US is home to many leading and innovative service providers and highly competitive and dynamic start-up ecosystems (Silicon Valley, New York City, Los Angeles, Boston, Chicago and Seattle). The ICT industry includes disruptive sectors such as automotive, health and education through the use of wearable technologies, 3D printing, virtual reality, drones and smartphones.

Figure 46 – Share of top five economies' patents in top 20 new technologies (2012–2015)



Source: OECD, 2017b

In Japan, technological developments have been widely embraced in areas such as mobile telecommunications and multimedia applications. ICT-related services, telecommunications and information services are rapidly increasing. Japanese authorities see the ICT sector as one of the main pillars of future economic growth. Specific attractive market areas are in data centres, cloud, AI technologies, IoT and FinTech market (blockchain).

The digital economy sectors are major contributors to the Canadian economy too. AI is considered a strong area of Canadian expertise. In February 2018, the Canadian government stated that it will spend nearly CAD 1 billion over five years to help firms and research institutes working on AI, advanced manufacturing and digital technologies. It hopes that these projects will lead to the development of Silicon Valley-like "superclusters" (The Economist 3/03/2018, pp. 42).

In Singapore, electronics and ICT are key sectors. In this country, the industry moved away from the labour-intensive assembly of consumer products and positioned itself in the higher stages of the value chain. The industry is driven largely by the semiconductor segments and the emergence of new application areas such as autonomous vehicles, AI and healthcare. Dubbed an IT hub in the Asia Pacific, Singapore is the regional base for most of the world's top ICT multinationals, including Microsoft, Oracle, Amazon Web Services and Google, thanks to an open business environment encouraging competition between foreign and local businesses. This achievement is supported by high-quality skillsets, effective policy-making and high-quality ICT infrastructures. Four key frontier tech capabilities are cybersecurity, IoT, immersive media and AI and data science.

South Korea also has a well-developed ICT sector: the software and ICT service market is strongly growing, driven by well-known brands such as Samsung and LG.

The global market revenues of the **Environmental industries** are estimated at EUR 1,020 billion in 2016, growing at around a 3.5% yearly rate (EBJ, 2018)). The US is the world's largest environmental market with a share of about 32% of the global total. Western Europe follows with a 27% share of the environmental market worldwide. Japan, China and the rest of Asia (India, the Philippines and Indonesia) account for 10%, 6% and 7% of global sales, respectively. Increasing income levels drive the demand for environmental goods and services. Therefore, developed countries are unsurprisingly the main consumers and suppliers of environmental services (OECD, 2005). The US, EU and Japan are also the leading exporters of environmental services, representing together about 90% of total exports. Developed country markets are now considered mature, but they are expected to continue to dominate future exports of environmental services (Dihel, 2010), mainly because industrialisation, urbanisation and demographic growth, as well as consumer pressures for cleaner products, have contributed to increasing the demand for environmental goods and services.

The US and Japan have remarkable strengths in the energy sector. As the world's largest energy consumer and leader in energy production and supply, the US has many companies operating in the energy sector and producing oil, natural gas, coal, renewable fuels and electricity from clean energy sources. The smart grid sector is gaining a renewed focus on investment, pushed by the need to modernise America's electricity infrastructure and enhance reliability.

Since the Japan earthquake in 2011, which caused a series of power plant shutdowns, Japan has invested significantly in developing the renewable energy sector, reduce dependency on petroleum and ensure energy security. The electricity retail, renewable energy and smart metre markets are particularly expanding.

Among the five international partners, South Korea stands out for its focus on environmental industries. Korea is pursuing the objective of becoming a "green nation" and aims to become one of the top 7 renewable energy powerhouses by 2020.

The yearly global turnover of the **Mobility Technologies** industry (i.e. development, manufacturing, maintenance and core services) is currently assessed at between EUR 2,000 and 2,150 billion (Accenture, 2018; McKinsey, 2012). In a dynamic perspective, the last 40 years have witnessed an appreciable worldwide increase in the sales of cars, buses and aeroplanes, which have tripled, thanks especially to the extraordinary expansion of the Chinese market in the last decade. On the other hand, environmental regulation and changes in habits and social norms are casting doubts on the future possibilities of the sector to maintain similar rates of growth. For the next decade, revenues and profits from manufacturing and selling motors and vehicles are forecast to be stable or shrink, while those from mobility services are expected to soar. The European mobility industry is estimated to employ between 10.9 (EOCIC, 2019a) and 13.3 (ACEA, 2018a) million people, with rather high levels of wages, productivity and average value-added. In terms of production, it accounts for 20% of global motor vehicle production and 21% of global passenger car production (ACEA, 2018a). The major competitors are China, the US and Japan, which maintain world market shares of around 30%, 13% and 10%, respectively (Statista, 2018). More specifically, Japan is a world leader in automotive manufacturing and technology and has been one of the worlds' top 3 car-producing countries since the 1960s. The industry has evolved into an integrated supply chain of companies in Japan, which

encompasses great diversity of firms. In the US, the mobility industry is being disrupted by new ICT and aerospace technologies. In particular, the US is at the forefront in the development of self-driving vehicles. The automotive sector in South Korea is also well developed, with strong trade relationships especially with the US, but the degree of innovation and technological advance lag behind those observed in the major economies.

Because the boundaries of **Experience industries** are relatively flexible and their connections with the Creative and Digital industries are very tight, Experience industries offer important business opportunities to all of the five EU international partners. Moreover, the megatrends towards mass customisation, product personalisation and servitisation, driven by the growing middle class, are common to all developed economies. With recent advances in technology, the digital economy is increasingly able to deliver a wider range of services and experiences that people seek. The US is at the forefront of innovation in this field. Platform businesses (e.g. Uber, Airbnb) are cases in point. The South Korean Samsung has been a pioneer in another field of development for the Experience industries, i.e. that of health-based services, having introduced health-related sensors such as pedometers in some of its latest smartphones to help users track exercise schedules, food intake, weight, sleep patterns and heart rate. Canada and Japan are other countries in which the Experience industries may considerably expand in future, thanks to an ICT technological development that is widely embraced in diverse areas such as mobile telecommunications and multimedia applications.

Whereas in 2010 two-thirds of packaging were sold in the established industrialised countries in Western Europe, North America and Japan, currently the biggest potential for growth of the **Advanced Packaging** industries is in the BRICS. Yet, European countries still hold an important market position in the Advanced Packaging industries. According to estimates by Smithers Pira (2018), the total value of the global packaging industry is currently around EUR 746 billion. Interpack Alliance (2016) estimates that Asian-Pacific countries hold the largest market share (about 45%), followed by Western Europe (EU and EFTA, 18%) and North America (USA, Canada and Mexico, 13%, altogether). EOCIC (2019a) evaluates employment in Europe at 4.9 million units. Compared to other emerging industries, productivity and wages are relatively low, but Advanced Packaging industries are expected to steadily grow at 2.9% to reach EUR 859 billion in 2022, with e-commerce being one of the major drivers of the industry's growth. Among the five extra-EU countries, South Korea shows the most significant growth potential in Advanced Packaging industries, being the second-largest market in Asia for processed organic food and beverages.

The Asia-Pacific region is the world's biggest market of the **Creative industries** with EUR 648 billion in revenue (33% of global sales) and 12.7 million jobs (43% of jobs worldwide)[60]. Some industry-leader headquarters are located there, such as Tencent, an internet-based technology and culture enterprise in Shenzhen, China, and the Yomiuri Group, Japan's largest media conglomerate that publishes *Yomiuri Shimbun*, the world's bestselling newspaper (10 million copies a day). The Indian book industry became the 10th largest book market in 2014, showing the fastest growth globally in total book revenue. In the context of Korea's transition to an

[60] Source: EY, 2015.

advanced innovation-driven economy, the creative economy concept is emphasised with the idea of creating new engines of growth and employment through the convergence of science, technology, industry, and culture and specific attention to design. Thanks to its well-structured ecosystem in the cultural and creative sectors, Europe is the second-largest market of the Creative industries, representing EUR 618 billion in revenue (32% of the global total) and 7.7 million jobs (26% of jobs worldwide). The market leaders are the UK, especially due to the contemporary art market, and France, with the company Publicis, a key player in the global advertising industry. Among the 10 most visited museums in the world, 7 are European, while 30 of the 69 UNESCO 'Creative Cities' are European. North America is the third-largest market, generating revenues of EUR 541 billion (28% of global revenues) and 4.7 million jobs (16% of jobs worldwide). Driven by the US, it is also the largest market for TV (EUR 159 billion), movies (EUR 24.4 billion) and radio (EUR 18.3 billion) and is at the forefront of the digital transformation, with the largest number of consumers of digital cultural content (47% of total revenue, compared with 25% in Asia and 24% in Europe).

The **Blue Growth** economy is a field in which Europe exhibits strong competitive advantage. According to the European Panorama of Clusters and Industrial Change (EOCIC, 2019a), in 2017, the EU's Blue Growth industries accounted for 1.3% of total EU GDP, originating 3.5 million jobs, with a turnover of EUR 566 billion and a yearly gross value added of EUR 174 billion. Thanks to net investments of more than EUR 22 billion per year, the sector is likely to grow further in the near future. In other industrialised countries such as the US, investments in water technologies are increasing, and this is generating business opportunities in different related sectors. However, this development is generally connected to the need to rehabilitate ageing water infrastructures, improve service efficiency and reduce pollution. In Singapore, strategic focus is on maritime logistics, with the aim of catalysing enterprise-level efforts to transform and grow the industry through increased productivity and innovation. However, none of the third countries considered has an explicit strategy to support sustainable growth in the marine and maritime sectors as a whole, such as the EU one.

With respect to the global **Logistical Services** industries, Europe is definitely in an important position. The global turnover of the logistical industry is nowadays estimated at between USD 4.3 trillion (Arvis et al., 2018) and 4.8 trillion (Plunkett Research, 2018). According to EOCIC (2019a), the European logistical industry employs 7.9 million people, with an average annual rate of growth of 2.3% in the last five years. Despite the relatively low levels of productivity and wages, the Logistic Performance Index of the World Bank assigns the top-ten world rankings to the European countries traditionally dominating the sector (Germany, Netherlands, Sweden, Belgium, United Kingdom and Austria), with Japan, the United States and China being at the seventh, tenth and twenty-sixth places, respectively. Among the five extra-EU countries, Singapore is focusing the most on the Logistical Services. Thanks to its strategic geographical position, the city-state is home to the world's largest transhipment container port, linked to over 600 ports worldwide. In 2016, the transportation and storage sectors, which include logistics, contributed about 8% to Singapore's GDP and 7% of total employment.

At the global level, the overall turnover of the **Biopharmaceutical industry** in 2017 is estimated between EUR 164 billion (Allied Market Research, 2018) and EUR 192 billion (Mordor

Intelligence, 2018), with an estimated average growth rate for the period 2018-2023 ranging from 8% to 13%. The biopharmaceuticals market is geographically segmented into North America, Europe, Asia-Pacific, the Middle East and Africa and South America. North America owns the highest share of market revenues due to rapid technological advancements and large investments carried out in past years. The US is responsible for 70% of the global research and innovation in biotechnology and has a strong business network with nearly 2,500 companies. These numbers, which are three times higher than the volume of the European industry, place the US far ahead of its competitors. In the near future, the Asia-Pacific area is expected to undergo a significant increase, thanks to factors such as increasing access to healthcare facilities in the region and economic growth. The European biopharmaceutical industry occupies an important position with respect to market share, innovation capability and R&D expenditure. Between 2011 and 2016, the European top five producing countries (Germany, France, Italy, Spain and UK) have launched 17.5% of all medicines and active ingredients that are newly marketed, compared to 64.7% from the US and 7.3% from Japan (EFPIA, 2018).

Medical Devices industries are strongly related to biopharmaceutical industries. The Medical Devices industries are characterised by intense competition and pressure on prices that are also due to reducing government healthcare costs in many parts of the world. Moreover, it has been recently conditioned by important changes in regulation (e.g. by 2020, firms operating in Europe must comply with the Medical Device Regulation and In Vitro Device Regulation that was recently introduced). In addition, the need to continuously innovate leads to a strong commitment to R&D activities (KPGM International, 2016). The global turnover of the Medical Devices industry is assessed at between EUR 288.7 (ReportLinker, 2018) and 325.1 (KPMG International, 2018) billion and is forecast to grow from 2018 to 2023 at an average annual rate between 4.5% (ReportLinker, 2018) and 5.2% (KPMG International, 2018). Using a slightly narrower definition of the industry, Medtech Europe (2018) estimates global revenues at EUR 269 billion. The US produces around 43% of total global turnover, followed by Europe (29%) and, at some distance, Japan (7%), China (6%) and Canada (2%). Europe is a major player for several reasons. EOCIC (2019a) estimates that the European medical device industry employs 4.9 million people, with wages, average value-added and labour productivity higher than in the overall economy. Although eight of the largest companies operating in this industry are headquartered in the US (Medpac, 2017), the role of European firms in innovation is prominent since about 41% of the sector patent applications with the European Patent Office are filed from European countries, compared to 39% from the US (CBI, 2018). The actors of the industry in Europe are a relatively small number of large, diversified companies (e.g. Siemens Healthcare, Philips Healthcare, Fresenius Medical Care, Novozymes) and a large number (around 95% of the total, according to Medtech Europe, 2018) of small and medium-sized enterprises (the majority of which employ less than 50 people) mainly devoted to production of devices for new specific therapeutic areas.

The population ageing phenomenon, which is already particularly critical in Japan, has led authorities to improve the business environment in this particular domain, so that the medical devices, pharmaceutical products, regenerative medicine markets and healthcare services are rapidly expanding.

Canada has many assets in the health/biosciences sectors, including the presence of leading pharmaceutical companies. Health and medical research are extremely strong scientific areas, characterised by strong R&D capacity.

Singapore has Asia's best healthcare system and is strengthening its reputation as the region healthcare hub and centre for healthcare excellence. Having established itself as a leading country in biomedical sciences manufacturing and R&D activities, Singapore is a manufacturing site for many biomedical companies. The presence of skilled talent, strong manufacturing capabilities and a thriving research ecosystem have encouraged companies to set up their operations in Singapore, including some of the top pharmaceutical, biology and medical technology companies.

South Korea is the world leader in the consumption of cosmetics products. The chemical industry is in the process of transforming from a large-scale commodity industry to one producing innovative and high value-added products. Koreas has positioned itself as the hub of global clinical studies, thanks to its infrastructure and rich labour force, in areas such as basic science, life science and clinical research.

5 The role of clusters

This last chapter briefly analyses the role that clusters play in the industrial transformation processes and the development of emerging industries.

Cross-sectoral linkages that characterise the European emerging industries are a key driver of economic development and industrial transformation thanks to the knowledge spillovers, innovation transfers, skill relocation and reconfiguration in industrial leadership patterns that they activate. Cross-sectoral linkages are particularly relevant for clusters, since territorial and cultural proximity amplifies the collective gains they potentially bring about. On the one hand, the clusters' model of governance, based on vertical and horizontal cooperation and embedded in regional business and innovation ecosystems, is distinctively suitable to integrate different industries. On the other hand, ecosystems with a related variety of industries provide the best conditions for the emergence of innovative industrial activity (Trippl et al., 2015).

Substantial theoretical literature and empirical evidence have pointed out the advantages resulting from the multi-sector nature of clusters. The notion of "diversity externalities" dates back at least to Jacobs (1969) and is based on the proposition that knowledge spills over between different industries, causing diversified production structures to be more innovative. The idea of diversity externalities has been generalised by the economic geography literature, which, by developing the concept of agglomeration as a key driver of economic growth, has emphasised the role of "related variety" (Frenken et al., 2007; Boschma and Iammarino, 2009; Boschma et al., 2012). In this view, variety is deemed to be a source of knowledge spillovers and innovation because the proximity between firms operating in different industries offers them valuable opportunities to interact, copy, modify and recombine ideas, practices and technologies across industries. These benefits are larger the more related is variety, i.e. the more complementary the different sectors are, sharing common technologies and/or participating in the same value chain. Diversity externalities and the benefits of related variety are likely to operate mostly at a local level (Frenken et al., 2007; Van Oort, 2004) because spatial proximity, population density and human capital favour information sharing and knowledge diffusion. This enhances the possible role of clusters as "hot spots" of inter-sectoral interaction, locally bounded but deeply integrated within global value chains.

Against this background, this section describes the types of services that are provided by clusters to facilitate industrial transformation (without a specific focus on the ten emerging industries) and highlights whether there is demand for new forms of support services that better fit the opportunities and challenges posed by future industrial development. While the role played by clusters in industrial development is complex and multifaceted, and their support measures numerous and diversified, the analysis especially focuses on selected performance dimensions that are considered key determinants of the European industrial modernisation: cross-sectoral collaboration, internationalisation, innovation, skill development, entrepreneurship and participation in global value chains.

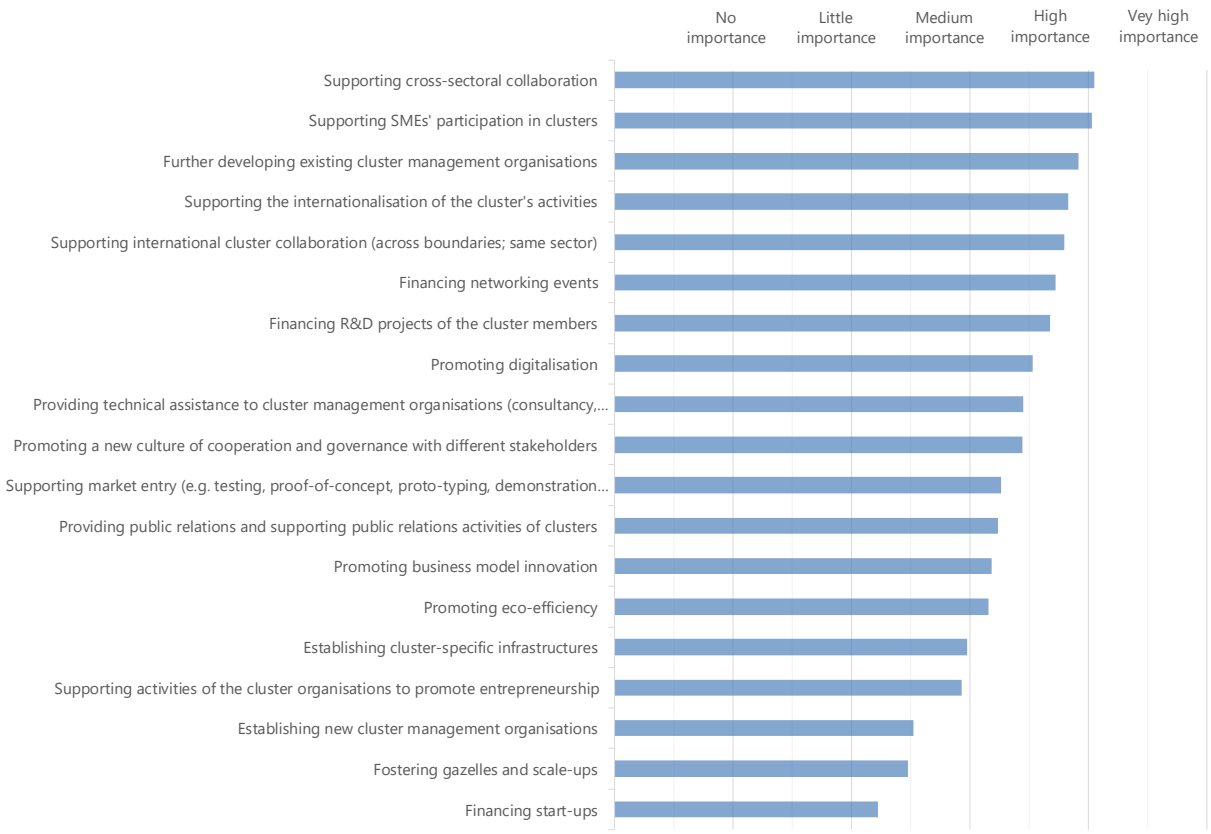
The analysis relies on multiple data sources and information produced by the European Observatory of Clusters and Industrial Change, complemented with external data sources.

5.1 Support services provided by European cluster programmes

5.1.1 General overview

The European Observatory of Clusters and Industrial Change has provided an overview of cluster programmes in the EU Member States and regions. Information was collected through an on-line survey of national and regional actors that are in charge of designing and/or implementing cluster policies in their countries or regions. In total, the exercise collected information for 29 European countries and 49 European regions. The response rate is around 78% for national programmes and 30% for regional programmes. Even if not fully representative of the existing cluster programmes, the survey provides a rich and unique set of information on the type of support available through clusters.

Figure 47 – Average importance of support measures provided by national and regional cluster programmes



Source: EOCIC

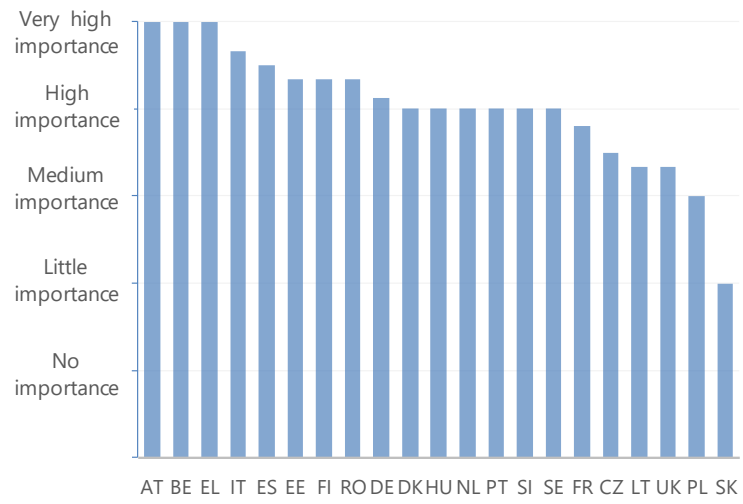
The results show that a variety of initiatives is in place to support clusters across Europe. These activities range from the implementation of dedicated cluster programmes to the integration of cluster support in programmes for business or sectoral support, including in the framework of regional smart specialisation strategies. In this context, although overall specifically oriented towards small and medium-sized enterprises (SMEs), cluster programmes tend to pursue a

mixed strategy addressing both mature industrial activities and new emerging industries and/or emerging technologies. This mixed strategy, whether pursuing a set of several objectives or focusing on a narrower set of targeted objectives, reveals strong attention towards increasing SME competitiveness, collaboration between industry and science/research and internationalisation activities. This is consistent with the fact that the support of SME participation in clusters, the funding of cluster members' R&D projects and support to internationalisation activities and international cluster collaboration are among the most important measures delivered by cluster organisations, as stated by policy-makers and programme managers who participated in the survey (see Figure 47). Relatively less important measures are those relating to entrepreneurship goals, such as measures fostering start-ups, gazelles and scale-ups.

Cluster programmes rely on different funding sources, with national and/or European public sources being the main ones, even if private sector funding (through membership fees and chargeable services) are gaining increasing importance to guarantee the financial sustainability of the cluster organisations. Since the cluster organisations typically channel public funds for SMEs and innovation, grants are the main type of support provided to cluster participants, but training and networking or partnership building measures are gaining momentum.

5.1.2 Support to cross-sectoral linkages

Figure 48 – Average importance of measures supporting cross-sectoral collaboration, by country



Source: EOCIC

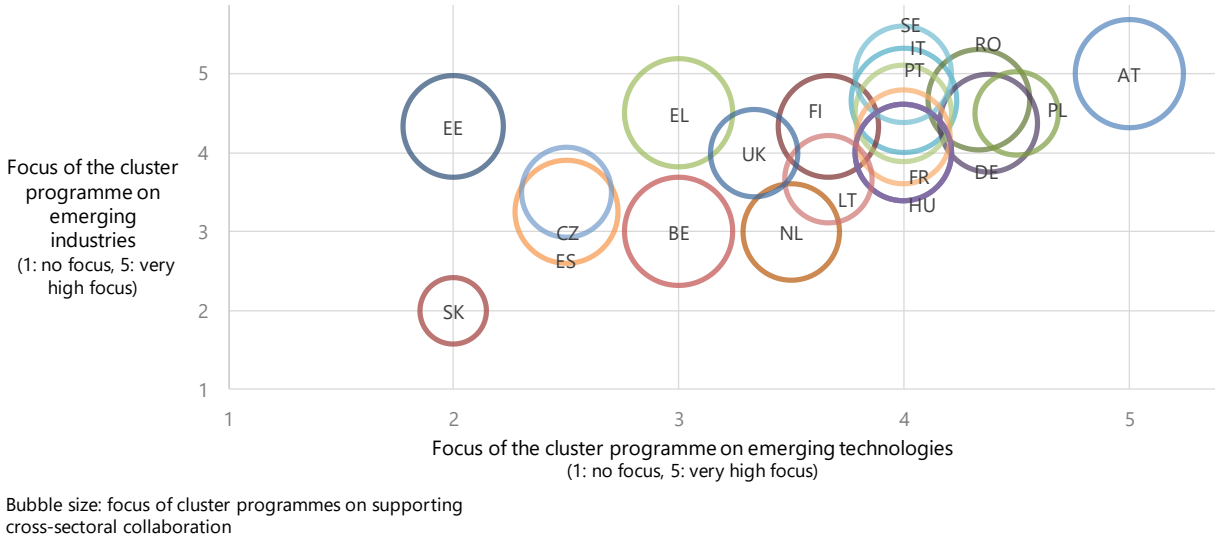
National and regional cluster authorities consider support to cross-sectoral collaboration the most important type of service that cluster organisations deliver. This type of measure is considered highly important for the majority of cluster programmes (Figure 48). National and regional programmes in Austria, Belgium, Greece, Italy and Spain consider this measure as very highly important among their service portfolios.

Within the countries that participated in the survey, the average importance attributed to this measure is relatively low in Slovakia.

Figure 49 combines the information of the importance of this support measure (reflected by the bubble size) with the declared focus of the cluster programmes (on the horizontal and vertical axes). It shows that, in general, higher importance towards cross-sectoral collaboration is combined with a medium, high or very high focus on emerging industries and emerging technologies. In fact, there is a strong direct relationship between these two factors: if the

overall objective of the cluster programme is fostering the development of emerging technologies, it generally targets emerging industries as well.

Figure 49 – Average importance of the focus on emerging industries and emerging technologies in national and regional cluster programmes, by country



Bubble size: focus of cluster programmes on supporting cross-sectoral collaboration

Source: EOCIC

5.1.3 Support of internationalisation

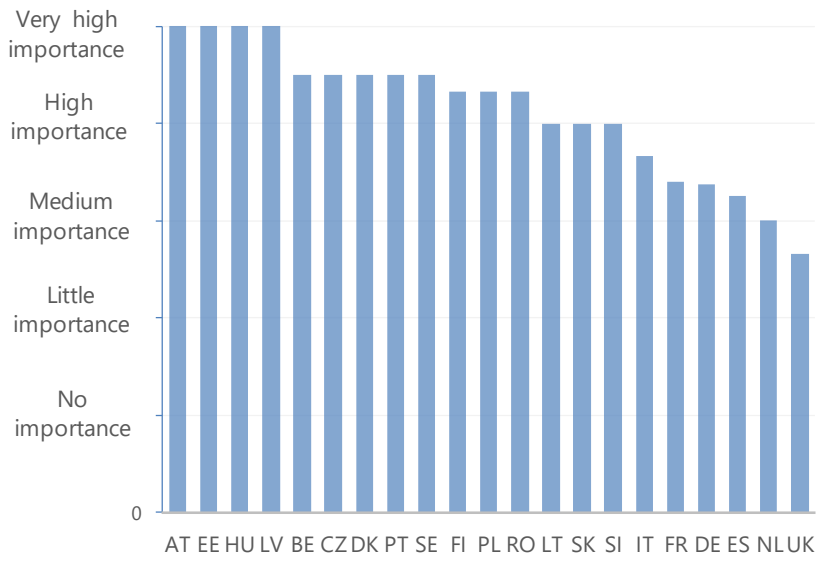
Promoting internationalisation is one of the most frequently mentioned objectives of national cluster policy programmes in Europe. While in the past the focus in the services provided by cluster organisations was merely on promoting cooperation within clusters and regions, promoting a variety of international linkages has become a prominent objective for cluster organisations.

Promoting internationalisation is among the main characteristics of cluster excellence and performance. ESCA data on the relative share of a regional, national or international focus in a cluster's strategy show that on average, the international share in the focus is 20 percent for the clusters that have been awarded one of the ESCA labels (bronze, silver, gold). A higher share of cluster strategies still has a rather national or regional focus.

As revealed by the data from the survey of national and regional cluster programmes across Europe, 'supporting internationalisation activities' is one of the most important objectives (see Figure 50), gaining at least medium importance in all the countries. Interestingly, support for internationalisation is considered of crucial importance by many Eastern European Member States such as Estonia, Hungary, Latvia, Czech Republic, Poland and Romania.

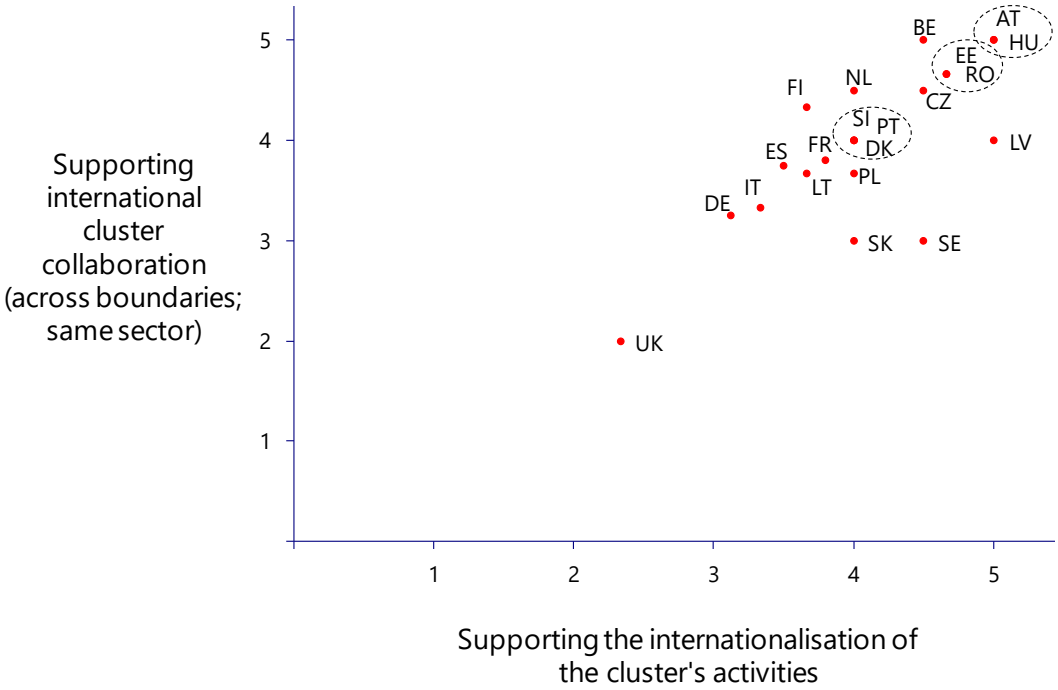
A direct relationship exists between the importance given to supporting internationalisation activities (in a broad sense) and support of collaboration of clusters beyond national borders (Figure 51). The relationship is high in some Eastern European Member States, in particular Hungary, Estonia, Romania and Czech Republic. This finding is in line with the relatively higher collaboration activities of these countries with countries located in other geographical areas of Europe or beyond the EU, as shown by trans-regional cooperation paths in section 4.2.

Figure 50 – Importance of supporting internationalisation activities among cluster programme policy objectives, average by country (1: not at all important, 5; very important)



Source: EOCIC

Figure 51 – Importance of measures supporting cluster internationalisation, by country (1: not at all important, 5: very important)



Source: EOCIC

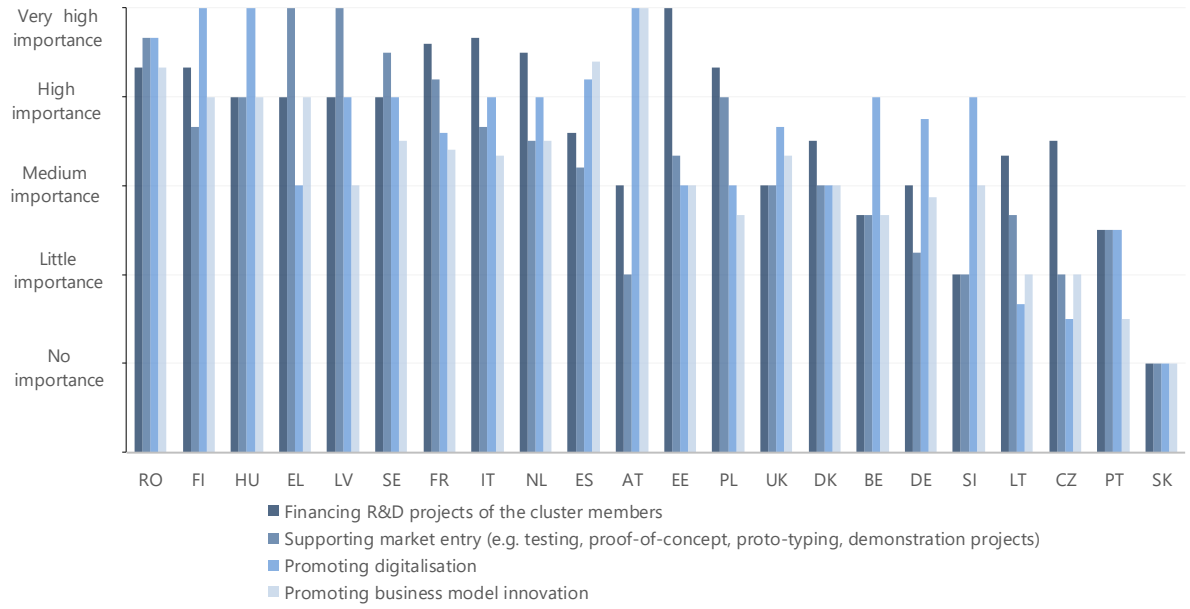
5.1.4 Support of innovation

Greater competition connected to international opening and other challenges posed by global megatrends have spurred greater effort for innovating in clusters. At the same time, production fragmentation has often benefitted innovation by allowing firms to free up resources to be invested in R&D activities (Farrell, 2005; Vivek et al., 2009). Research and innovation activities themselves have undergone a process of worldwide dispersion so that they increasingly take place in global innovation networks in which several firms and other actors participate in different ways to access, generate and combine new knowledge (Levin and Barnard, 2013; Perri et al., 2017; Tzabbar and Vestal, 2015).

European cluster programmes are strongly related to innovation policies. Cluster programmes in the majority of the Member States attach great importance to supporting research and innovation by promoting collaborative R&D projects, the commercialisation of innovation, industry digitalisation and/or business model innovation.

In general, according to the survey, the average degree of importance is higher in the case of measures financing R&D projects, although there are some interesting national differences. Support to R&D is relatively less important in countries like Slovenia, Portugal and Slovakia. Austria is the example of a country where cluster programmes are more focused on promoting innovation by increasing digitalisation of SMEs and favouring the adoption of new business models. Support of market entry looks predominantly important for Greece and Latvia (Figure 52). Romania attaches very high importance to all forms of support to R&D and innovation.

Figure 52 – Degree of importance given to some of the aspects of innovation support, by Member State



Source: EOCIC

5.1.5 Support of skills development

Among the objectives of cluster policy programmes in Europe, upgrading skills does not have a prominent place yet, but there is an emerging need to focus on this specific dimension

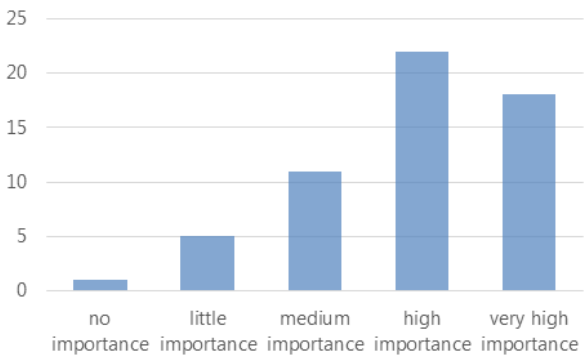
Technological change and decades of increased international integration require adaptation of skills at the level of individual workers, companies, clusters, regions and countries. As described in Chapter 2, global megatrends, particularly automation and the new digital technologies, will pose important challenges. The integration of these technologies into the workflow will alter the skill requirements for several occupations and sectors. In particular, routine tasks will be easily performed by AI and robots. Global competition will contribute to a trend of upskills and trigger global competition for talent. For Europe to fully realise its growth potential in the future, there is a need to align the supply and demand of skills. Besides technological skills, non-technological skills are gaining importance, such as complex problem-solving and adaptation skills, social skills, creativity and multi-disciplinary skills.

Promoting skill development has become more prominent on several EU and national policy agendas involving several policy fields, including education policy, employment policy, digitalisation and industrial policy. However, the survey of national and regional cluster programmes indicates that cluster organisations are generally not focused on upgrading skills. This is because this is generally perceived as part of the mission of educational institutions (university, vocational schools). While most of the policy attention in skill development has gone to general skill development, e.g. of the unemployed to help them get back into the labour market, skill development by cluster organisations could focus on specific skill shortages and on new skills that are expected to become more important in the future for firms (mainly SMEs) that are part of the cluster.

The European Cluster Observatory (2016) identified the following roles of cluster organisations in skill development:

- offering qualification and training schemes developed jointly with the cluster actors;
- pursuit of advocacy efforts by promoting the need for skill development with industry, academia and policy;
- monitoring and evaluating the progress and impact made in the field of skill development as a result of the common efforts within the cluster; and
- "clearing house" functions by moderating processes between industry, academia and policy with regards to skill development.

Figure 53 – Degree of importance to develop skills and human resources through the cluster programmes



Source: EOCIC

Even if promoting workforce skill development has not been among the priority objectives of EU cluster policy nor addressed with a dedicated programme, except for development of cluster management skills (see Figure 47), the survey identified that for many respondents, it will be very important to use clusters for this purpose (Figure 53).

The use of clusters for skill upgrading has been included in the new EU cluster policy on Joint Cluster Initiatives in the Single Market Programme (2021-2027). This is expected to increase the future attention of cluster organisations to skill development as a strategic objective.

5.1.6 Support of entrepreneurship

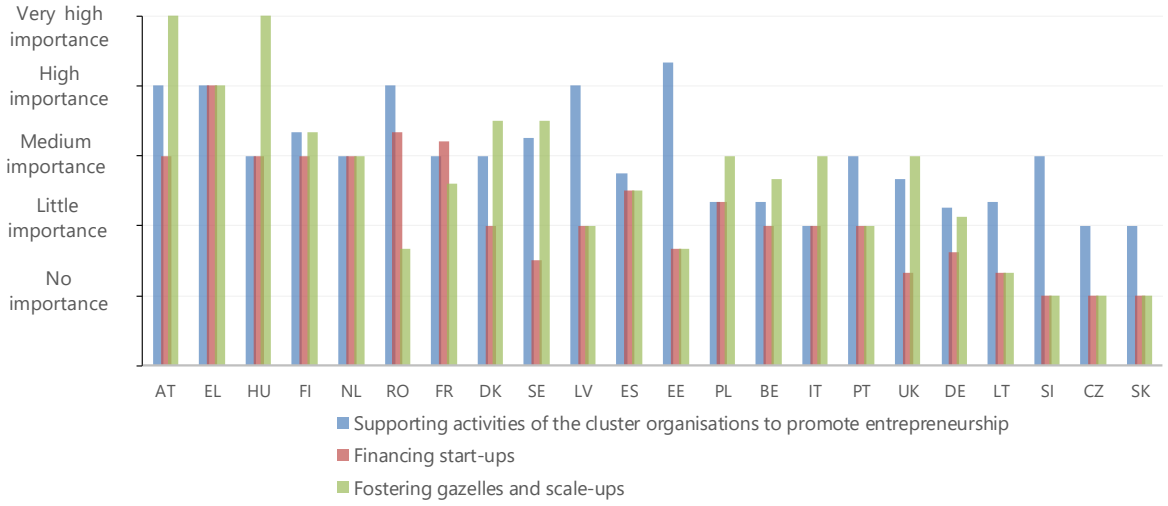
The promotion of entrepreneurship is among the most important objectives of the European Union policy agenda. However, the survey of national and regional cluster programmes reveals that initiatives related to entrepreneurship/start-ups/spin-offs and scale-ups are considered less central by cluster organisations than other support measures. Cluster programmes seem largely focused on supporting innovation and competitiveness in established firms (i.e. the growth phase) and increasing SME participation in clusters, whereas they devote limited attention to the promotion of early-stage entrepreneurship and the support to start-ups within specific industries. StartUp Europe[61], an initiative supported by the European Commission, has mapped start-up ecosystems in Europe. It found that many EU and national initiatives are in place to support start-up creation and establish sound foundations for their growth, but also that these are generally not delivered through the cluster organisations.

The "Smart Guide to entrepreneurship support through clusters" (EOCIC, 2019e) highlights that cluster organisations are not yet perceived as key actors in national or regional entrepreneurship support service infrastructure and, in some cases, do not perceive entrepreneurship promotion as part of their core mission. In fact, start-up and scale-up support through clusters is a more recent policy objective. Nevertheless, evidence indicates that cluster policies and initiatives can be effective instruments for organising and delivering entrepreneurship policies thanks to their bottom-up dynamics, also in partnership with other entities (e.g. universities, incubator centres, and public agencies).

Figure 54 shows the degree of importance given to support the promotion of entrepreneurship in general and, more particularly, to finance start-ups and foster gazelles and scale-ups. All three objectives, clearly interlinked to each other, receive high importance by cluster organisations in Greece. In contrast, the data suggest that other countries attach greater priority on one specific objective: for instance, support for scale-ups and gazelles is perceived as more of a priority for Austria, Hungary, Sweden and Denmark. Financing of start-ups is instead relatively more important in Romania.

[61] http://startupeuropemap.eu/map/; http://startupeuropeclub.eu/eu-funds-and-support/.

Figure 54 – Degree of importance given to some of the aspects of support for entrepreneurship, by Member State



Source: EOCIC

5.1.7 Support for increased participation in global value chains

The full array of services provided by cluster organisations can foster participation of SMEs in global value chains, particularly through the promotion of internationalisation activities, innovation and entrepreneurship.

A growing number of studies has recently focused on the issue of clusters' integration in global value chains (Cainelli et al., 2018; De Marchi et al., 2018; Giuliani et al., 2005). The literature has made it clear that the traditional productivity advantages of clusters, deriving from a system of interconnected firms operating in related industries within the same supply chain and embedded into a favourable institutional context, have been challenged by the new wave of globalisation of the 2000s (engendered by the development of communication technologies and reduction in trade costs), the establishment of global value chains and the increased fragmentation of production (Bellandi and De Propris, 2015; Belussi and De Propris, 2013). However, at the same time, cluster organisations can play a decisive role in facilitating the development of new industrial value chains, participation in global value chain and positioning in the most lucrative segments. Involvement of clusters into global value chain is a driver to access a source of knowledge and a set of resources otherwise unavailable, which could allow cluster firms to upgrade and achieve relevant gains in productivity and value added.

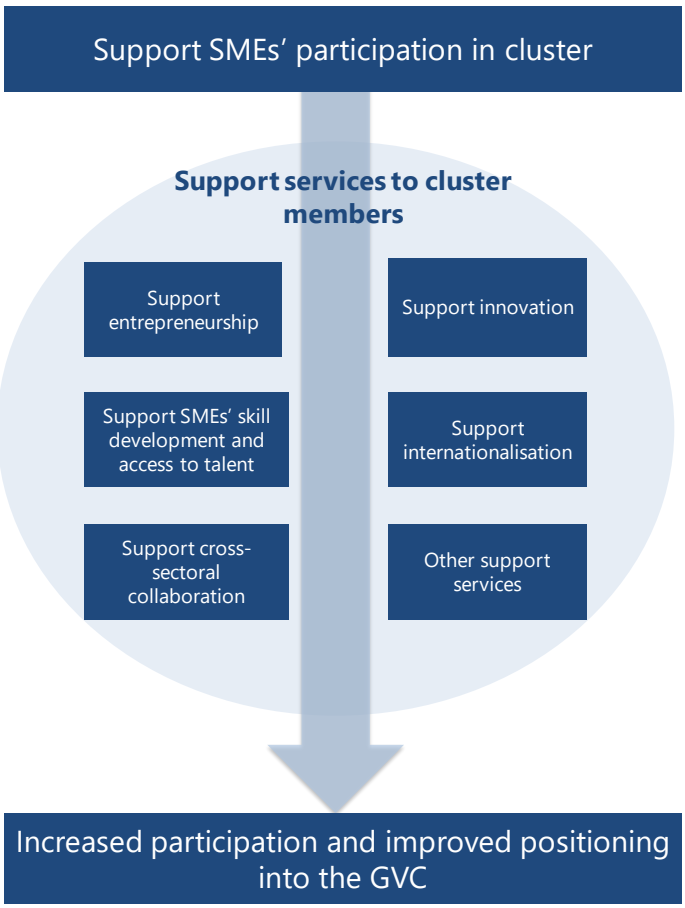
In this dynamic process of change, the economic literature has largely analysed the role of lead firms as key agents to favour and develop connections between cluster firms, global value chains and global innovation networks. Leading firms may be either home-grown or foreign global firms, provided that they are embedded in the local context to take full advantage of the "collective efficiency" (Schmitz, 1995) derived from external economies and joint action. Clusters' foreign lead firms are often Multi-National Enterprises (MNEs) and global lead firms in global value chains: large manufacturers, giant retailers or global brands. Local lead firms are relatively smaller; their evolution is characterised by a long-standing dimensional growth

with increasing vertical integration and a shift from manufacturing to pre- and post-production activities.

Global and local lead firms are fundamental vehicles for clusters to enter and position in global value chains, since on the one hand, they are able to develop the external linkages and connections with global actors in international networks, and on the other hand, they keep strict relationships with cluster SMEs. This allows obtaining gains from integration in global value chains while enjoying the comparative advantages of geographical agglomeration and local know-how and helps clusters compete successfully in the global production arena.

To make the most of opportunities supplied by global value chains, it is important that the leader efficiently coordinate cluster firms, and the latter – original equipment manufacturers, original design manufacturers and highly specialised suppliers – are sufficiently capable and dynamic, which implies an adequate and continuous upgrading. Even local institutions and cluster managers are required to properly evolve to fulfil the more demanding requirements of global competition in global value chains, for example, by supporting rapid diffusion of knowledge, expanding infrastructure and strengthening training, testing and certification facilities.

Figure 55 – How clusters can increase participation into global value chains: a simplified intervention logic



Source: EOCIC

It is therefore clear that cluster organisations could effectively influence the degree of participation in global value chains, first by increasing participation of SMEs in clusters, and then by supporting internationalisation activities, cross-sectoral linkages and innovation and skill development of SMEs and stimulating entrepreneurship among cluster members.

All these support measures contribute to an economic upgrading process by which cluster firms move up in the value chain to deal with more lucrative activities, either upstream (design, product development, R&D, manufacturing of key components) or downstream (marketing, branding and customer service).

The business and innovation ecosystem and the cluster management skills are important enabling conditions that could support (or slow down) the economic upgrade process.

5.2 Main findings on extra-EU cluster programmes

With the objective of comparing European cluster programmes with different cluster approaches beyond Europe, the European Observatory of Cluster and Industrial Change has also surveyed the cluster programmes in place in ten non-European countries. In this section, the main findings related to the US, Canada, Japan, South Korea and Singapore, the five countries addressed also in Chapter 4, are highlighted, focusing on the similarities and differences between the European and extra-European cluster programmes. A more extensive assessment is provided by the report "Cluster programmes in Europe and beyond" (EOCIC, 2019f).

As in the EU, cluster support is delivered in all the selected non-European countries and is generally embedded in the specific national framework conditions and government policy. Overall, cluster support programmes in these countries have undergone certain developments over time, and some trends can be detected such as promoting industrial to innovation clusters—as the Japanese example shows through the introduction of knowledge clusters

complementary to the approach of industrial clusters—or clusters to superclusters, as the launch of the Canadian Innovation Superclusters Initiative testifies.

The strong presence of cluster support programmes within government policy may be due to the fact that in these countries, cluster support is not a recent approach, but rather a long and strong tradition that characterises most of them, with only the US being an exception. Among the early adopters, Singapore has followed a policy of designating specific areas to host knowledge clusters and identifying special areas of research and development to set up knowledge hubs since its independence in 1963. Japan introduced cluster policy in the 1980s through a joint approach of the ministries in charge of economic development and of education. In a similar vein, Canada has a long tradition in cluster policies and South Korea, since the mid-1990s, has given high priority to industrial agglomerations, and innovation clusters in its economic and territorial development.

Mostly delivered in the frame of dedicated cluster programmes and to a lower extent also through other programmes that also cover support for cluster activities, the five countries support cluster activities either pursuing broad objectives such as competitiveness, innovation, entrepreneurship, and/ or specific sectoral or technological goals, in line with the European cluster programmes. In total, the number of objectives pursued by clusters is quite varied, showing their high importance in terms of achieving political goals and their pertinence as vehicles for economic development and growth. Innovation receives particularly high attention in the innovation policy of the US federal government and especially in its Innovative Economy Clusters programme, which, with the main focus on small and medium-sized enterprises to boost competitiveness and growth, addressees a total of 18 clusters. On the contrary, broader clusters strategies jointly targeting R&D activities, technology leadership, commercialisation, start-up creation, collaboration and growth that ultimately build significant competitive advantages by attracting research, competences and investment can be found in Canada, Japan, South Korea and Singapore. However, with respect to the latter, a new focus has been recently put especially on emerging industries and/or start-ups, through various initiatives promoting these objectives, including institutional support, business funding, knowledge and technology transfer and education.

In contrast with European cluster programmes, internationalisation and cluster collaboration beyond national borders are not one of the main priorities in the five selected countries, except for the case of South Korea, where, since 2010, the additional objective of inter-regional cooperation and integration in global networks has been added. Some countries reveal higher attention towards the local or regional dimension, mostly with the aim of strengthening a more balanced economic development, ultimately leading to increased competitiveness on the national level. This is the case, for instance, of Japan and of South Korea with its Industrial Complex Cluster Programme aimed at establishing regional ecosystems with collaborating actors.

Despite the similarities and differences between European and extra-European cluster programmes as well as the different contexts in which cluster policies are implemented, several achievements of the cluster programmes of these countries can be identified: the establishment and further development of networks and collaboration structures, bringing

together different types of public and private actors and strengthening cooperation between public and private stakeholders, establishing research actors, research partnerships, and new actors, mostly businesses, but also intermediaries that improve coordination of governance levels. Establishing efficient ecosystems, often with a particular focus on innovation, specialisation and economic development, and support to advancing specific sectors and technologies are further achievements displayed by the international partner countries.

6 Conclusions

The analysis presented in this report confirms the high dynamism characterising emerging European industries. In a global context influenced by different prevailing megatrends and increasing competition, emerging industries are undergoing profound transformations that reflect the need to address the new challenges posed by disruptive technological changes, demographic shifts, environmental sustainability issues and the emergence of new global economic powers, but also the ambition to exploit the opportunities that these changes could trigger for the competitiveness of the European industry. The fast development of the pharma food industry, autonomous driving boats and cars and the application of virtual reality technologies for medical purposes are only a few examples of the undergoing transformation processes driven by stronger linkages among different sectors.

Industrial transformation trends are not only reflected in the reinforcement or emergence of new cross-sectoral interlinkages, but also in new inter-regional collaboration patterns. Overall, the analysis of the geographical configuration of the ten emerging industries in Europe over a medium-long time period (2000-2016) indicates that the European regions are increasingly collaborating and establishing cross-sectoral relationships, as reflected by patent, M&A and JV&A indicators. Stronger cross-sectoral and inter-regional collaboration is particularly evident for Spain and Eastern European countries such as Poland, Romania and Bulgaria.

Data from the ESCA indicate that collaboration across sectors and industries is reinforcing not only in the EU, within and between different Member States, but also with extra-European countries. Cross-country and extra-EU cooperation is increasing particularly for European Eastern Member States. The number of cooperation activities between clusters operating in any of the emerging industries in these countries and other geographical areas of Europe and the rest of the world has increased faster than cooperation activities taking place within the same country. This confirms how important internationalisation is to stimulate and push cross-sectoral industrial development and innovation. Overall, North America and, to a less extent, Eastern Asia are the extra-EU areas with which European clusters have activated the greatest number of collaborations.

The ECCP briefing reports on international partner countries show that the collaboration is particularly high when both European and extra-European actors have distinguishing strengths to exploit in common sectors in terms of growing levels of innovation, competitiveness and political priority attached to those sectors. The European Union maintains a prominent position in the value chain of all emerging industries, with a focus especially on R&D and innovation activities and, more downstream, the value chain, marketing and customer service activities. In spite of its good research and innovation capabilities, the EU generally lags behind the US and Japan in some emerging industries, such as Digital industries, Mobility industries and Biopharmaceuticals, and is called to face the increasing competition from other countries in particular fields (such as Canada on AI, Singapore on Logistical Services and South Korea on

Environmental and Experience industries). Yet, the EU appears to be relatively stronger in industries like Blue Growth industries, Creative industries and Advanced Packaging, in which the EU is showing large growth potential, but the main international partners analysed appear to be less focused on, compared to other sectors that receive most of their political attention and investment efforts.

The position of European emerging industries in global value chains is expected to change in the future, as a consequence of three main factors.

- First, the catching-up process of the BRIC countries, but also some more developed countries with traditional manufacturing capabilities and increasing levels of servitisation and innovation such as South Korea and Singapore, are increasing the level of competition worldwide, but also potentially bringing new opportunities for collaboration with European industries and cluster organisations.
- Second, some global value chains are expected to be severely disrupted by global megatrends, particularly mass customisation and servitisation, green and circular economy and automation. All these trends may contribute to favouring the participation of EU industries at different stages of the value chains, thanks to a reorganisation of the production process, reshoring of manufacturing activities and shortening of value chains to respond more quickly to changing markets and cut logistics costs.
- Third, while the engine of European economic growth and competitiveness still relies on its traditionally larger and most industrialised economies, data of cross-sectoral linkages show that some new regions, especially from the eastern Member States, are quickly emerging as new relevant players for some industries. The increase of European economic cohesion and smart specialisation strategies could help the EU as a whole further improve its overall competitiveness on a global scale.

Against this background, clusters already play a propulsive role for industrial modernisation. The European Observatory of Clusters and Industrial Change has provided customised expert analysis and policy advice to selected European regions in economic transition, demonstrating how modern cluster policies can provide adequate support to drive industrial transformation and growth. As the ESCA data on a sample of European cluster organisations show, support services for the development of cross-sectoral collaboration, research and innovation capabilities and outputs and internationalisation of cluster members, primarily SMEs, are already the top priorities of cluster organisations. Compared to the cluster programmes implemented in the US, Canada, Japan, Singapore and South Korea, support for internationalisation and the establishment of trans-regional collaboration networks are given higher importance by European cluster organisations.

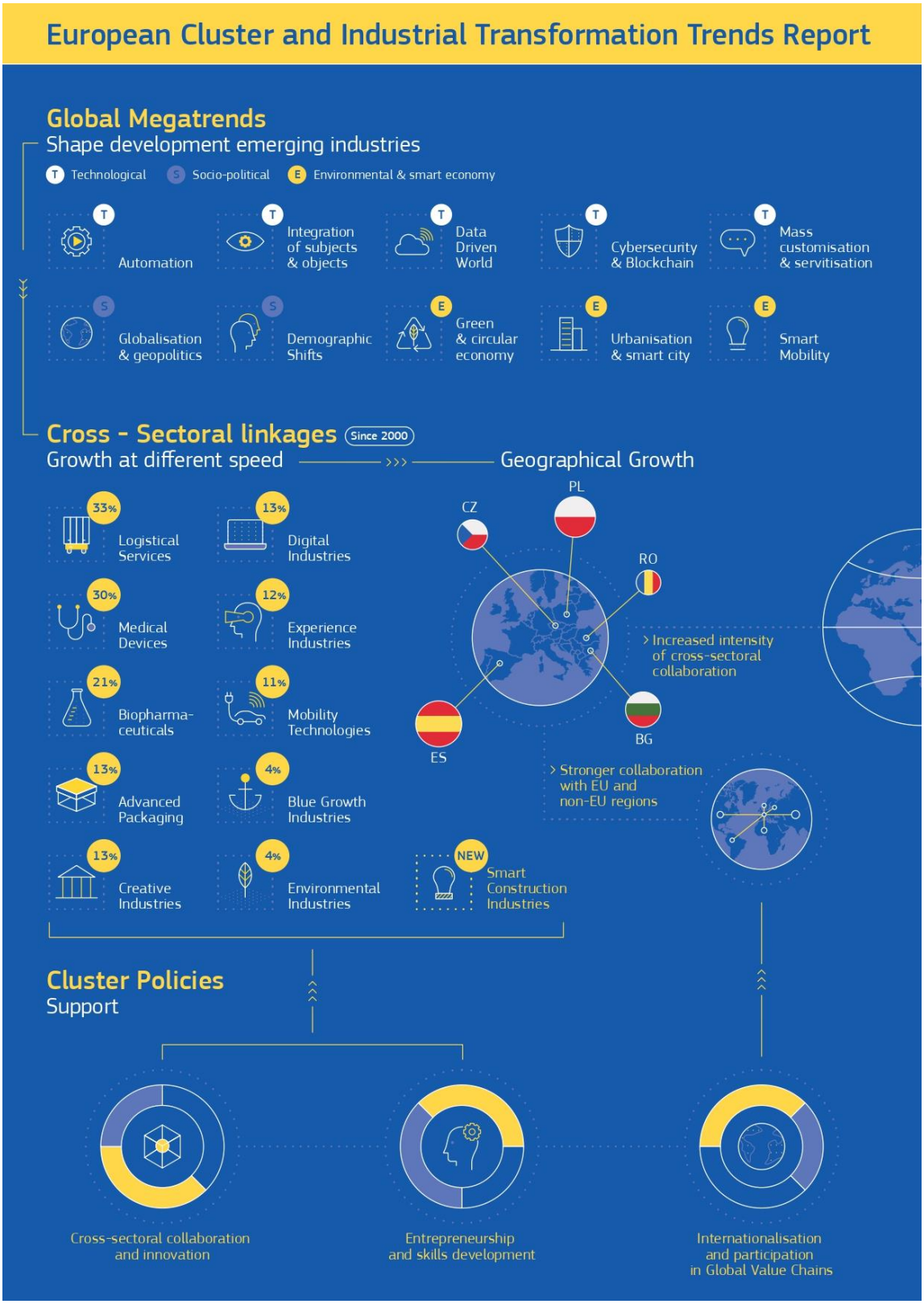
The analysis of national and regional cluster programmes, combined with the analysis of challenges and the possible impact of global megatrends on emerging industries, highlight the need for European clusters to play a more prominent role in other two key areas, skill development and entrepreneurship. Currently, these fields of interventions are not systematically targeted by cluster organisations because they often fall into the mandate of other organisations that are part of regional innovation and business ecosystems (e.g. universities, regional agencies, incubator centres). Nevertheless, consistent evidence deriving

from the direct assistance to regions in industrial transitions and targeted research conducted by the Observatory (see, for instance, the "Smart Guide to entrepreneurship support through clusters", EOCIC, 2019e) highlights that the cluster policies and initiatives can be effective instruments for organising and delivering skill development and entrepreneurship policies thanks to their bottom-up dynamics and possibility to exploit synergies with other support services provided.

In view of the fast changes occurring in the emerging industries and observed in the global context, constant monitoring of the transformation process of these industries is needed. First, the statistical definition of the emerging industries should be reconsidered to take into account the most recent cross-sectoral transformation processes and improve the accuracy of analysis when forecasting future trends. The methodology to re-define the European emerging industries could follow the same approach adopted by the European Cluster Observatory in 2012, when the 10 emerging industries were originally identified.[62] Second, the patterns of transformation and internationalisation of industries located in the newly emerging European regions should receive special attention by virtue of their high growth potential and possible important role to drive cross-sectoral transformation and competitiveness of the overall EU industry. To this end, the next European Cluster Panorama report or other dedicated reports by the European Commission could dig into the factors that explain the growing innovative potential and ongoing industrial transformations in some regions of Poland, Bulgaria, Romania, Czech Republic and Spain.

[62] European Cluster Observatory (2012): https://ec.europa.eu/research/industrial_technologies/pdf/emerging-industries-report_en.pdf

Annex A - Main facts and figures



Annex B - Data of cross-sectoral linkages by emerging industry

Advanced Packaging

Table 22 – Emerging cross-sectoral linkages related to Advanced Packaging industry

Core industry under analysis	Link to other industries showing positive dynamics related to the core industry	Total period 2000-2004	Total period 2005-2010 [% Growth rate (2000/04)–(2005/10)]	Total period 2011-16 [Growth rate (2005/10)–(2011/16)]
Patent data				
Advanced packaging	Materials, metallurgy	1276	993 -22%	1790 80%
Advanced packaging	Measurement	1277	1277 0%	1726 35%
Advanced packaging	Electrical machinery, apparatus, energy	1227	924 -25%	1180 28%
Advanced packaging	Mechanical elements	3026	2923 -3%	3560 22%
Advanced packaging	Transport	3122	3330 7%	3548 7%
M&A data				
Advanced packaging acquired	Power	3	15 400%	53 253%
Advanced packaging acquired	Professional services	14	16 14%	46 188%
Advanced packaging acquired	Other industrials	15	20 33%	48 140%
Advanced packaging acquired	Chemicals	26	29 12%	59 103%
Advanced packaging acquired	Construction materials	25	45 80%	76 69%
Advanced packaging was a target	Transportation & infrastructure	11	5 -55%	36 620%
Advanced packaging was a target	Automobiles & Components	37	22 -41%	59 168%
Advanced packaging was a target	Chemicals	35	31 -11%	77 148%
Advanced packaging was a target	Professional services	4	22 450%	52 136%
Advanced packaging was a target	Electronics	80	100 25%	197 97%
JV&A data				
Advanced packaging	Construction Firms	7	3 -57%	8 167%
Advanced packaging	Miscellaneous Manufacturing	8	4 -50%	8 100%

Advanced packaging	Electric, Gas, and Water Distribution	4	5 25%	8 60%
Advanced packaging	Wholesale Trade-Durable Goods	5	8 60%	12 50%
Advanced packaging	Metal and Metal Products	15	13 46%	19 46%

Table 23 – Top and emerging regions related to Advanced Packaging industry (2011-2016)

Top region		**Frequency (2011-2016)**	**Emerging region**		**Frequency (2011-2016)**
DE11	Stuttgart	209	**BG41**	Yugozapaden	29
DE21	Oberbayern	267	**BG42**	Yuzhen tsentraien	22
DE71	Darmstadt	155	**CZ05**	Severovýchod	22
DEA1	Düsseldorf	140	**DE22**	Niederbayern	23
DEA2	Köln	141	**DE40**	Brandenburg	30
FI19	Länsi-Suomi	261	**DE80**	Mecklenburg-Vorpommern	24
FI1B	Helsinki-Uusimaa	385	**DEB2**	Trier	41
FI1C	Etelä-Suomi	167	**ES11**	Galicia	24
FI1D	Pohjois- ja Itä-Suomi	145	**ES22**	Comunidad Foral de Navarra	31
FR10	Ile-de-France	187	**ES24**	Aragón	37
FRK2	Rhône-Alpes	102	**ES61**	Andalucía	37
ITC4	Lombardia	147	**PL22**	Śląskie	77
ITH5	Emilia-Romagna	141	**PL41**	Wielkopolskie	40
NL33	Zuid-Holland	129	**PL42**	Zachodniopomorskie	22
NL41	Noord-Brabant	147	**PL51**	Dolnośląskie	40
SE11	Stockholm	121	**PL61**	Kujawsko-pomorskie	32
SE23	Västsverige	125	**PL63**	Pomorskie	33
			PL82	Podkarpackie	28
			PL91	Warszawski stołeczny	89
			PL92	Mazowiecki regionalny	39

Biopharmaceuticals

Table 24 – Emerging cross-sectoral linkages related to Biopharmaceuticals industry

Core industry under analysis	Link to other industries showing positive dynamics related to the core industry	Total period 2000-2004	Total period 2005-2010 [% Growth rate (2000/04)–(2005/10)]	Total period 2011-16 [Growth rate (2005/10)–(2011/16)]
Patent data				
Biopharmaceuticals	Micro-structural and nano-technology	14	94 571%	237 152%
Biopharmaceuticals	Measurement	100	58 -42%	78 34%
Biopharmaceuticals	Food chemistry	2371	1686 -29%	1611 -4%
Biopharmaceuticals	Materials, metallurgy	325	227 -30%	180 -21%
Biopharmaceuticals	Basic materials chemistry	1029	735 -29%	561 -24%
M&A data				
Biopharmaceuticals acquired	Metals & Mining	9	9 0%	30 233%
Biopharmaceuticals acquired	Construction materials	14	10 -29%	24 140%
Biopharmaceuticals acquired	Chemicals	49	38 -22%	90 137%
Biopharmaceuticals acquired	Healthcare Equipment	18	26 44%	60 131%
Biopharmaceuticals acquired	Healthcare Providers	4	11 175%	22 100%
Biopharmaceuticals was a target	Insurance	12	18 50%	52 189%
Biopharmaceuticals was a target	Food & Beverage	24	23 -4%	48 109%
Biopharmaceuticals was a target	Other Materials	9	15 67%	26 73%
Biopharmaceuticals was a target	Machinery	31	42 35%	71 69%
Biopharmaceuticals was a target	Water & waste management	0	12 n.a.	19 58%
JV&A data				
Biopharmaceuticals	Transportation and Shipping (except air)	15	6 -60%	13 117%
Biopharmaceuticals	Wholesale Trade-Durable Goods	8	6 -25%	12 100%
Biopharmaceuticals	Metal and Metal Products	15	8 -47%	16 100%
Biopharmaceuticals	Oil and Gas; Petroleum Refining	6	5 -17%	10 100%
Biopharmaceuticals	Investment & Commodity Firms,Dealers,Exchanges	14	10 -29%	14 40%
Biopharmaceuticals	Business Services	95	57 -40%	75 32%
Biopharmaceuticals	Measuring, Medical, Photo Equipment; Clocks	28	22 -21%	25 14%

Table 25 – Top and emerging regions related to Biopharmaceuticals industry (2011-2016)

Top region		Frequency (2011-2016)	Emerging region		Frequency (2011-2016)
AT13	Wien	69	**BG41**	Yugozapaden	15
DE12	Karlsruhe	129	**CZ06**	Jihovýchod	13
DE13	Freiburg	70	**DE73**	Kassel	15
DE21	Oberbayern	163	**DE93**	Lüneburg	18
DE30	Berlin	120	**ES24**	Aragón	15
DE71	Darmstadt	137	**ES41**	Castilla y León	14
DEA1	Düsseldorf	74	**ES52**	Comunidad Valenciana	40
DEA2	Köln	86	**ES70**	Canarias	15
DEB3	Rheinhessen-Pfalz	81	**FRC1**	Bourgogne	18
ES30	Comunidad de Madrid	153	**FRE2**	Picardie	18
ES51	Cataluña	433	**LV00**	Latvija	127
FI1B	Helsinki-Uusimaa	123	**PL21**	Małopolskie	96
FR10	Ile-de-France	626	**PL22**	Śląskie	30
FRK2	Rhône-Alpes	139	**PL41**	Wielkopolskie	58
ITC4	Lombardia	135	**PL51**	Dolnośląskie	100
NL32	Noord-Holland	68	**PL63**	Pomorskie	46
NL33	Zuid-Holland	84	**PL71**	Łódzkie	29
SE11	Stockholm	84	**PL72**	Świętokrzyskie	15
			PL81	Lubelskie	20
			PL92	Mazowiecki regionalny	16
			RO32	Bucureşti-Ilfov	40
			UKE3	South Yorkshire	14

Blue Growth Industry

Table 26 – Emerging cross-sectoral linkages related to Blue Growth industries

Core industry under analysis	Link to other industries showing positive dynamics related to the core industry	Total period 2000-2004	Total period 2005-2010 [% Growth rate (2000/04)–(2005/10)]	Total period 2011-16 [Growth rate (2005/10)–(2011/16)]
Patent data				
Blue growth industries	Measurement	679	786 16%	1152 47%
Blue growth industries	Electrical machinery, apparatus, energy	945	885 -6%	1230 39%
Blue growth industries	Mechanical elements	2154	2277 6%	2905 28%
Blue growth industries	Machine tools	1150	903 -21%	1059 17%
Blue growth industries	Transport	3229	3282 2%	3769 15%
M&A data				
Blue growth industries acquired	Electronics	81	109 35%	198 82%
Blue growth industries acquired	Power	57	89 56%	160 80%
Blue growth industries acquired	Other industrials	50	86 72%	141 64%
Blue growth industries acquired	Professional services	173	281 62%	439 56%
Blue growth industries acquired	Construction & Engineering	72	187 160%	275 47%
Blue growth industries was a target	Insurance	56	106 89%	451 325%
Blue growth industries was a target	Automobiles & Components	41	36 -12%	94 161%
Blue growth industries was a target	Contruction & Engineering	86	165 92%	293 78%
Blue growth industries was a target	Power	38	79 108%	135 71%
Blue growth industries was a target	Other industrials	34	61 79%	84 38%
JV&A data				
Blue growth industries	Construction Firms	33	22 -33%	56 155%
Blue growth industries	Investment & Commodity Firms,Dealers,Exchanges	37	27 -27%	39 44%
Blue growth industries	Metal and Metal Products	21	16 -24%	23 44%
Blue growth industries	Transportation and Shipping (except air)	77	36 -53%	45 25%
Blue growth industries	Business Services	178	95 -47%	111 17%

Table 27 – Top and emerging regions related to Blue Growth industries (2011-2016)

Top region		Frequency (2011-2016)	Emerging region		Frequency (2011-2016)
DE11	Stuttgart	117	**BG32**	Severen tsentraien	30
DE21	Oberbayern	323	**BG33**	Severoiztochen	46
DE71	Darmstadt	106	**BG34**	Yugoiztochen	52
DEA1	Düsseldorf	184	**BG42**	Yuzhen tsentraien	51
DEA2	Köln	114	**CZ06**	Jihovýchod	34
DK01	Hovedstaden	150	**DE26**	Unterfranken	25
ES30	Comunidad de Madrid	492	**DEG0**	Thüringen	26
ES51	Cataluña	323	**ES22**	Comunidad Foral de Navarra	47
FI19	Länsi-Suomi	241	**ES24**	Aragón	39
FI1B	Helsinki-Uusimaa	519	**ES41**	Castilla y León	54
FI1C	Etelä-Suomi	162	**ES53**	Illes Balears	38
FI1D	Pohjois- ja Itä-Suomi	128	**ES62**	Región de Murcia	24
FR10	Ile-de-France	489	**ES70**	Canarias	33
FRK2	Rhône-Alpes	80	**PL21**	Małopolskie	55
ITC4	Lombardia	156	**PL41**	Wielkopolskie	69
NL32	Noord-Holland	132	**PL51**	Dolnośląskie	43
NL33	Zuid-Holland	216	**PL63**	Pomorskie	41
SE11	Stockholm	263	**PL92**	Mazowiecki regionalny	43
SE22	Sydsverige	108	**SE33**	Övre Norrland	30
UKD3	Greater Manchester	79			
UKE4	West Yorkshire	87			
UKG3	West Midlands	79			
UKI3	Inner London — West	312			
UKI4	Inner London — East	136			
UKJ1	Berkshire, Buckinghamshire and Oxfordshire	121			
UKJ2	Surrey, East and West Sussex	101			
UKK1	Gloucestershire, Wiltshire and Bristol/Bath area	79			

Creative Industry

Table 28 – Emerging cross-sectoral linkages related to Creative industries

Core industry under analysis	Link to other industries showing positive dynamics related to the core industry	Total period 2000-2004	Total period 2005-2010 [% Growth rate (2000/04)–(2005/10)]	Total period 2011-16 [Growth rate (2005/10)–(2011/16)]
Patent data				
Creative industries	Electrical machinery, apparatus, energy	15	64 327%	289 352%
Creative industries	Transport	49	127 159%	281 121%
Creative industries	Measurement	110	288 162%	480 67%
Creative industries	Other special machines	34	44 29%	73 66%
Creative industries	Civil engineering	12	30 150%	48 60%
M&A data				
Creative industries acquired	Power	51	100 96%	378 278%
Creative industries acquired	Automobiles & Components	56	110 96%	229 108%
Creative industries acquired	Contruction & Engineering	45	120 167%	242 102%
Creative industries acquired	Electronics	180	200 11%	351 76%
Creative industries acquired	Publishing	331	498 50%	814 63%
Creative industries was a target	Contruction & Engineering	47	80 70%	196 145%
Creative industries was a target	Power	19	66 247%	134 103%
Creative industries was a target	Transportation & infrastructure	49	73 49%	148 103%
Creative industries was a target	Construction materials	37	79 114%	144 82%
Creative industries was a target	Machinery	121	271 124%	397 46%
JV&A data				
Creative industries	Construction Firms	19	9 -53%	34 278%
Creative industries	Health Services	4	7 75%	15 114%
Creative industries	Transportation and Shipping (except air)	53	28 -47%	38 36%
Creative industries	Commercial Banks, Bank Holding Companies	46	13 -72%	17 31%
Creative industries	Machinery	7	12 71%	15 25%

Table 29 – Top and emerging regions related to Creative industries (2011-2016)

Top region		Frequency (2011-2016)	Emerging region		Frequency (2011-2016)
DE12	Karlsruhe	327	**BG31**	Severozapaden	96
DE21	Oberbayern	322	**BG32**	Severen tsentraien	40
DE30	Berlin	155	**BG33**	Severoiztochen	67
DEA1	Düsseldorf	145	**BG34**	Yugoiztochen	46
DEA2	Köln	147	**BG42**	Yuzhen tsentraien	55
DK01	Hovedstaden	195	**CZ08**	Moravskoslezsko	28
ES30	Comunidad de Madrid	896	**ES11**	Galicia	92
FI19	Länsi-Suomi	304	**ES12**	Principado de Asturias	65
FI1B	Helsinki-Uusimaa	735	**ES24**	Aragón	43
FR10	Ile-de-France	1124	**ES41**	Castilla y León	55
FRK2	Rhône-Alpes	170	**ES53**	Illes Balears	47
IE06	Eastern and Midland	241	**ES70**	Canarias	57
ITC4	Lombardia	225	**FRB0**	Centre — Val de Loire	30
NL32	Noord-Holland	409	**IE04**	Northern and Western	34
NL33	Zuid-Holland	246	**MT00**	Malta	44
NL41	Noord-Brabant	232	**PL63**	Pomorskie	59
SE11	Stockholm	516	**PL71**	Łódzkie	33
UKE4	West Yorkshire	136	**PL92**	Mazowiecki regionalny	36
UKG3	West Midlands	149			
UKH1	East Anglia	142			
UKI3	Inner London — West	841			
UKI4	Inner London — East	356			
UKJ1	Berkshire, Buckinghamshire and Oxfordshire	244			
UKJ2	Surrey, East and West Sussex	154			

Digital Industry

Table 30 – Emerging cross-sectoral linkages related to Digital industries

Core industry under analysis	Link to other industries showing positive dynamics related to the core industry	Total period 2000-2004	Total period 2005-2010 [% Growth rate (2000/04)–(2005/10)]	Total period 2011-16 [Growth rate (2005/10)–(2011/16)]
Patent data				
Digital industries	Audio-visual technology	9828	11234 14%	16491 47%
Digital industries	Machine tools	15778	16990 8%	22980 35%
Digital industries	Materials, metallurgy	2332	3956 70%	4696 19%
Digital industries	Analysis of biological materials	4249	3402 -20%	4030 18%
Digital industries	Civil engineering	8950	8841 -1%	9989 13%
M&A data				
Digital industries acquired	Chemicals	62	60 -3%	124 107%
Digital industries acquired	Power	19	54 184%	93 72%
Digital industries acquired	Machinery	298	392 32%	666 70%
Digital industries acquired	Automobiles & Components	25	55 120%	91 65%
Digital industries acquired	Construction materials	53	110 108%	169 54%
Digital industries was a target	Chemicals	57	46 -19%	127 176%
Digital industries was a target	Transportation & infrastructure	36	44 22%	103 134%
Digital industries was a target	Machinery	341	452 33%	668 48%
Digital industries was a target	Professional services	119	219 84%	289 32%
Digital industries was a target	Construction materials	75	124 65%	151 22%
JV&A data				
Digital industries	Electric, Gas, and Water Distribution	28	14 -50%	28 100%
Digital industries	Construction Firms	17	8 -53%	15 88%
Digital industries	Metal and Metal Products	20	13 -35%	21 62%
Digital industries	Transportation and Shipping (except air)	36	12 -67%	19 58%
Digital industries	Amusement and Recreation Services	33	11 -67%	14 27%

Table 31 – Top and emerging regions related to Digital industries (2011-2016)

Top region		Frequency (2011-2016)	Emerging region		Frequency (2011-2016)
DE11	Stuttgart	513	**CY00**	Cyprus	55
DE12	Karlsruhe	701	**CZ05**	Severovýchod	61
DE13	Freiburg	339	**DE22**	Niederbayern	91
DE21	Oberbayern	1618	**DE80**	Mecklenburg-Vorpommern	54
DE30	Berlin	363	**ES11**	Galicia	82
DE71	Darmstadt	599	**ES22**	Comunidad Foral de Navarra	52
DEA1	Düsseldorf	413	**ES61**	Andalucía	100
DEA2	Köln	354	**FRJ1**	Languedoc-Roussillon	55
DK01	Hovedstaden	318	**HR04**	Kontinentalna Hrvatska	76
ES30	Comunidad de Madrid	614	**NL23**	Flevoland	59
ES51	Cataluña	574	**PL21**	Małopolskie	167
FI19	Länsi-Suomi	707	**PL22**	Śląskie	207
FI1B	Helsinki-Uusimaa	1642	**PL41**	Wielkopolskie	93
FI1C	Etelä-Suomi	384	**PL51**	Dolnośląskie	123
FI1D	Pohjois- ja Itä-Suomi	443	**PL63**	Pomorskie	90
FR10	Ile-de-France	1647	**PL71**	Łódzkie	96
FRK2	Rhône-Alpes	429	**PL81**	Lubelskie	65
IE06	Eastern and Midland	366	**PL82**	Podkarpackie	56
ITC4	Lombardia	352	**RO11**	Nord-Vest	61
NL32	Noord-Holland	401	**RO21**	Nord-Est	58
NL33	Zuid-Holland	467			
NL41	Noord-Brabant	699			
SE11	Stockholm	607			
SE22	Sydsverige	411			
UKH1	East Anglia	356			
UKI3	Inner London — West	468			
UKI4	Inner London — East	263			
UKJ1	Berkshire, Buckinghamshire and Oxfordshire	357			
UKJ2	Surrey, East and West Sussex	247			

Environmental Industry

Table 32 – Emerging cross-sectoral linkages related to Environmental industries

Core industry under analysis	Link to other industries showing positive dynamics related to the core industry	Total period 2000-2004	Total period 2005-2010 [% Growth rate (2000/04)–(2005/10)]	Total period 2011-16 [Growth rate (2005/10)–(2011/16)]
Patent data				
Environmental industries	Measurement	4557	4233 -7%	5676 34%
Environmental industries	Electrical machinery, apparatus, energy	6171	4940 -20%	6593 33%
Environmental industries	Transport	5659	5783 2%	6620 14%
Environmental industries	Mechanical elements	3645	4028 11%	4589 14%
Environmental industries	Thermal processes and apparatus	2812	2507 -11%	2715 8%
M&A data				
Environmental industries acquired	Chemicals	126	110 -13%	208 89%
Environmental industries acquired	Power	62	113 82%	205 81%
Environmental industries acquired	Other industrials	39	87 123%	138 59%
Environmental industries acquired	Professional services	110	172 56%	254 48%
Environmental industries acquired	Electronics	166	201 21%	294 46%
Environmental industries was a target	Chemicals	130	102 -22%	240 135%
Environmental industries was a target	Automobiles & Components	45	54 20%	103 91%
Environmental industries was a target	Construction & Engineering	93	179 92%	298 66%
Environmental industries was a target	Machinery	334	405 21%	659 63%
Environmental industries was a target	Electronics	127	245 93%	383 56%
JV&A data				
Environmental industries	Construction Firms	22	15 -32%	36 140%
Environmental industries	Transportation and Shipping (except air)	55	25 -55%	36 44%
Environmental industries	Metal and Metal Products	23	17 -26%	22 29%
Environmental industries	Investment & Commodity Firms, Dealers, Exchanges	26	22 -15%	28 27%
Environmental industries	Business Services	173	94 -46%	116 23%

Table 33 – Top and emerging regions related to Environmental industries (2011-2016)

Top region		Frequency (2011-2016)	Emerging region		Frequency (2011-2016)
BE21	Prov. Antwerpen	194	**BG41**	Yugozapaden	236
DE11	Stuttgart	357	**BG42**	Yuzhen tsentraien	51
DE12	Karlsruhe	444	**CZ05**	Severovýchod	49
DE21	Oberbayern	1264	**CZ06**	Jihovýchod	50
DE30	Berlin	241	**DE22**	Niederbayern	66
DE71	Darmstadt	602	**DE73**	Kassel	58
DEA1	Düsseldorf	902	**DE80**	Mecklenburg-Vorpommern	69
DEA2	Köln	468	**ES12**	Principado de Asturias	50
DEB3	Rheinhessen-Pfalz	363	**ES22**	Comunidad Foral de Navarra	75
DK01	Hovedstaden	256	**ES24**	Aragón	65
ES30	Comunidad de Madrid	591	**ES41**	Castilla y León	63
ES51	Cataluña	561	**LV00**	Latvija	221
FI19	Länsi-Suomi	534	**PL21**	Małopolskie	170
FI1B	Helsinki-Uusimaa	1330	**PL41**	Wielkopolskie	199
FI1C	Etelä-Suomi	437	**PL42**	Zachodniopomorskie	131
FI1D	Pohjois- ja Itä-Suomi	304	**PL51**	Dolnośląskie	238
FR10	Ile-de-France	1019	**PL52**	Opolskie	59
FRK2	Rhône-Alpes	251	**PL61**	Kujawsko-pomorskie	69
ITC4	Lombardia	391	**PL63**	Pomorskie	82
ITH5	Emilia-Romagna	194	**PL71**	Łódzkie	109
NL32	Noord-Holland	288	**PL81**	Lubelskie	57
NL33	Zuid-Holland	486	**PL82**	Podkarpackie	61
NL41	Noord-Brabant	331	**PL92**	Mazowiecki regionalny	66
SE11	Stockholm	330			
SE23	Västsverige	290			
UKI3	Inner London — West	266			
UKJ1	Berkshire, Buckinghamshire and Oxfordshire	196			

Experience Industry

Table 34 – Emerging cross-sectoral linkages related to Experience industries

Core industry under analysis	Link to other industries showing positive dynamics related to the core industry	Total period 2000-2004	Total period 2005-2010 [% Growth rate (2000/04)–(2005/10)]	Total period 2011-16 [Growth rate (2005/10)–(2011/16)]
Patent data				
	not applicable			
M&A data				
Experience industries acquired	Power	8	12 50%	66 450%
Experience industries acquired	Educational Services	31	25 -19%	53 112%
Experience industries acquired	Food & Beverage Retailing	11	35 218%	68 94%
Experience industries acquired	Machinery	56	70 25%	111 59%
Experience industries acquired	Other Retailing	33	56 70%	87 55%
Experience industries was a target	Contruction & Engineering	13	17 31%	64 276%
Experience industries was a target	Food & Beverage Retailing	27	30 11%	78 160%
Experience industries was a target	Professional services	130	202 55%	351 74%
Experience industries was a target	Other Retailing	41	59 44%	98 66%
Experience industries was a target	IT Consulting & Services	337	402 19%	622 55%
JV&A data				
Experience industries	Construction Firms	13	9 -31%	22 144%
Experience industries	Metal and Metal Products	9	9 0%	14 56%
Experience industries	Electric, Gas, and Water Distribution	22	12 -45%	17 42%
Experience industries	Wholesale Trade-Nondurable Goods	13	13 0%	17 31%
Experience industries	Transportation and Shipping (except air)	59	26 -56%	32 23%

Table 35 – Top and emerging regions related to Experience industries (2011-2016)

Top region		Frequency (2011-2016)	Emerging region		Frequency (2011-2016)
DE21	Oberbayern	130	**BG31**	Severozapaden	62
DE30	Berlin	98	**BG32**	Severen tsentraien	22
DE71	Darmstadt	70	**BG33**	Severoiztochen	61
DK01	Hovedstaden	117	**BG34**	Yugoiztochen	36
ES30	Comunidad de Madrid	446	**BG42**	Yuzhen tsentraien	39
ES51	Cataluña	338	**CZ05**	Severovýchod	41
FI1B	Helsinki-Uusimaa	363	**CZ06**	Jihovýchod	29
FR10	Ile-de-France	608	**DEB1**	Koblenz	20
IE06	Eastern and Midland	74	**ES11**	Galicia	35
ITC4	Lombardia	102	**ES12**	Principado de Asturias	26
NL32	Noord-Holland	228	**ES22**	Comunidad Foral de Navarra	23
NL33	Zuid-Holland	112	**ES41**	Castilla y León	35
SE11	Stockholm	294	**ES52**	Comunidad Valenciana	75
UKD3	Greater Manchester	96	**ES62**	Región de Murcia	19
UKE4	West Yorkshire	96	**ES70**	Canarias	42
UKG3	West Midlands	72	**MT00**	Malta	21
UKH1	East Anglia	87	**PL21**	Małopolskie	46
UKI3	Inner London — West	522	**PL41**	Wielkopolskie	39
UKI4	Inner London — East	228	**PL63**	Pomorskie	29
UKJ1	Berkshire, Buckinghamshire and Oxfordshire	171			
UKJ2	Surrey, East and West Sussex	85			
UKK1	Gloucestershire, Wiltshire and Bristol/Bath area	82			

Logistical Services

Table 36 – Emerging cross-sectoral linkages related to Logistical Services

Core industry under analysis	Link to other industries showing positive dynamics related to the core industry	Total period 2000-2004	Total period 2005-2010 [% Growth rate (2000/04)–(2005/10)]	Total period 2011-16 [Growth rate (2005/10)–(2011/16)]
Patent data				
Logistical services	IT methods for management	3	1 -67%	5 400%
Logistical services	Transport	1	3 200%	8 167%
Logistical services	Telecommunications	1	3 200%	6 100%
Logistical services	Medical technology	6	4 -33%	7 75%
Logistical services	Civil engineering	7	12 71%	18 50%
M&A data				
Logistical services acquired	Contruction & Engineering	2	1 -50%	17 1600%
Logistical services acquired	Automobiles & Components	8	5 -38%	26 420%
Logistical services acquired	Machinery	5	11 120%	26 136%
Logistical services acquired	Professional services	14	21 50%	36 71%
Logistical services acquired	Building/Construction	0	13 n.a.	18 38%
Logistical services was a target	Paper & Forest Products	2	1 -50%	11 1000%
Logistical services was a target	Other Consumer Products	1	3 200%	12 300%
Logistical services was a target	Automobiles & Components	8	9 13%	21 133%
Logistical services was a target	Construction materials	2	11 450%	19 73%
Logistical services was a target	Transportation & infrastructure	84	82 -2%	139 70%
JV&A data				
Logistical services	Real Estate; Mortgage Bankers and Brokers	9	3 -67%	7 133%
Logistical services	Advertising Services	10	3 -70%	7 133%
Logistical services	Oil and Gas; Petroleum Refining	4	4 0%	8 100%
Logistical services	Transportation and Shipping (except air)	67	28 -58%	42 50%
Logistical services	Electric, Gas, and Water Distribution	23	8 -65%	12 50%
Logistical services	Construction Firms	14	6 -57%	8 33%
Logistical services	Amusement and Recreation Services	32	10 -69%	13 30%

Table 37 – Top and emerging regions related to Logistical Services (2011-2016)

Top region		Frequency (2011-2016)	Emerging region		Frequency (2011-2016)
DE21	Oberbayern	23	**BG31**	Severozapaden	9
DEA1	Düsseldorf	17	**BG32**	Severen tsentraien	10
ES30	Comunidad de Madrid	108	**BG33**	Severoiztochen	13
ES51	Cataluña	92	**BG34**	Yugoiztochen	17
FI1B	Helsinki-Uusimaa	81	**BG42**	Yuzhen tsentraien	7
FR10	Ile-de-France	95	**CZ05**	Severovýchod	10
ITC4	Lombardia	25	**CZ06**	Jihovýchod	12
NL32	Noord-Holland	27	**DE94**	Weser-Ems	6
NL33	Zuid-Holland	28	**ES22**	Comunidad Foral de Navarra	16
SE11	Stockholm	54	**ES24**	Aragón	14
UKI4	Inner London — East	58	**ES41**	Castilla y León	16
UKI7	Outer London — West and North West	17	**ES42**	Castilla-La Mancha	9
UKJ1	Berkshire, Buckinghamshire and Oxfordshire	28	**ES53**	Illes Balears	13
			ES61	Andalucía	28
			ES62	Región de Murcia	9
			ES70	Canarias	9
			FRE1	Nord-Pas de Calais	5
			MT00	Malta	6
			PL21	Małopolskie	7
			PL22	Śląskie	19
			PL41	Wielkopolskie	5
			PL42	Zachodniopomorskie	6
			PL51	Dolnośląskie	15
			PL63	Pomorskie	9
			PL91	Warszawski stołeczny	22
			PL92	Mazowiecki regionalny	9
			SK01	Bratislavský kraj	5
			UKD6	Cheshire	6
			UKF2	Leicestershire, Rutland and Northamptonshire	7

Medical Devices

Table 38 – Emerging cross-sectoral linkages related to Medical Devices industries

Core industry under analysis	Link to other industries showing positive dynamics related to the core industry	Total period 2000-2004	Total period 2005-2010 [% Growth rate (2000/04)–(2005/10)]	Total period 2011-16 [Growth rate (2005/10)–(2011/16)]
Patent data				
Medical devices	Transport	11439	13083 14%	18367 40%
Medical devices	Electrical machinery, apparatus, energy	7598	7083 -7%	9184 30%
Medical devices	Control	3279	3761 15%	4395 17%
Medical devices	Materials, metallurgy	4652	3320 -29%	3853 16%
Medical devices	Surface technology, coating	4900	4062 -17%	4585 13%
M&A data				
Medical devices acquired	Contruction & Engineering	5	12 140%	28 133%
Medical devices acquired	Other industrials	15	24 60%	54 125%
Medical devices acquired	Chemicals	43	34 -21%	71 109%
Medical devices acquired	Healthcare Equipment	28	17 -39%	29 71%
Medical devices acquired	Machinery	231	295 28%	502 70%
Medical devices was a target	Chemicals	27	20 -26%	64 220%
Medical devices was a target	Healthcare Equipment	28	17 -39%	44 159%
Medical devices was a target	Other industrials	8	16 100%	40 150%
Medical devices was a target	Machinery	244	212 -13%	359 69%
Medical devices was a target	Power	12	26 117%	44 69%
JV&A data				
Medical devices	Electric, Gas, and Water Distribution	9	9 0%	20 122%
Medical devices	Transportation and Shipping (except air)	15	6 -60%	10 67%
Medical devices	Wholesale Trade-Durable Goods	15	11 -27%	17 55%
Medical devices	Metal and Metal Products	22	18 -18%	24 33%
Medical devices	Investment & Commodity Firms,Dealers,Exchanges	17	12 -29%	13 8%

Table 39 – Top and emerging regions related to Medical Devices industries (2011-2016)

Top region		Frequency (2011-2016)	Emerging region		Frequency (2011-2016)
DE11	Stuttgart	469	**DE22**	Niederbayern	79
DE12	Karlsruhe	437	**DE80**	Mecklenburg-Vorpommern	43
DE13	Freiburg	309	**ES11**	Galicia	89
DE21	Oberbayern	1595	**ES61**	Andalucía	59
DE25	Mittelfranken	404	**FRC2**	Franche-Comté	49
DE30	Berlin	247	**FRH0**	Bretagne	101
DE60	Hamburg	250	**FRI1**	Aquitaine	56
DE71	Darmstadt	576	**FRJ1**	Languedoc-Roussillon	46
DEA1	Düsseldorf	396	**HR04**	Kontinentalna Hrvatska	48
DEA2	Köln	313	**HU11**	Budapest	114
DEB3	Rheinhessen-Pfalz	205	**PL21**	Małopolskie	173
FI19	Länsi-Suomi	738	**PL22**	Śląskie	232
FI1B	Helsinki-Uusimaa	1424	**PL41**	Wielkopolskie	103
FI1C	Etelä-Suomi	368	**PL42**	Zachodniopomorskie	77
FI1D	Pohjois- ja Itä-Suomi	425	**PL51**	Dolnośląskie	191
FR10	Ile-de-France	1172	**PL61**	Kujawsko-pomorskie	45
FRK2	Rhône-Alpes	327	**PL63**	Pomorskie	88
ITC4	Lombardia	323	**PL71**	Łódzkie	94
NL32	Noord-Holland	274	**PL81**	Lubelskie	57
NL33	Zuid-Holland	442	**PL82**	Podkarpackie	70
NL41	Noord-Brabant	596	**PL91**	Warszawski stołeczny	267
SE11	Stockholm	308	**RO21**	Nord-Est	64
SE23	Västsverige	434	**RO32**	Bucureşti-Ilfov	213
UKH1	East Anglia	227	**SE31**	Norra Mellansverige	60
			UKG2	Shropshire and Staffordshire	43

Mobility Technologies

Table 40 – Emerging cross-sectoral linkages related to Mobility Technologies industries

Core industry under analysis	Link to other industries showing positive dynamics related to the core industry	Total period 2000-2004	Total period 2005-2010 [% Growth rate (2000/04)–(2005/10)]	Total period 2011-16 [Growth rate (2005/10)–(2011/16)]
Patent data: not applicable				
M&A data				
Mobility technology acquired	Chemicals	4	7 75%	21 200%
Mobility technology acquired	Other Retailing	0	3 n.a.	8 167%
Mobility technology acquired	Contruction & Engineering	1	5 400%	10 100%
Mobility technology acquired	Machinery	24	25 4%	44 76%
Mobility technology acquired	Construction materials	10	20 100%	34 70%
Mobility technology was a target	Chemicals	55	44 -20%	160 264%
Mobility technology was a target	Transportation & infrastructure	23	23 0%	62 170%
Mobility technology was a target	Professional services	26	53 104%	97 83%
Mobility technology was a target	Machinery	386	509 32%	847 66%
Mobility technology was a target	Electronics	160	199 24%	298 50%
JV&A data				
Mobility technology	Construction Firms	13	6 -54%	12 100%
Mobility technology	Electric, Gas, and Water Distribution	13	12 -8%	22 83%
Mobility technology	Business Services	53	22 -58%	37 68%
Mobility technology	Transportation and Shipping (except air)	16	8 -50%	12 50%
Mobility technology	Investment & Commodity Firms,Dealers,Exchanges	19	12 -37%	16 33%

Table 41 – Top and emerging regions related to Mobility Technologies industries (2011-2016)

Top region		Frequency (2011-2016)	Emerging region		Frequency (2011-2016)
DE11	Stuttgart	106	**BG42**	Yuzhen tsentraien	20
DE21	Oberbayern	117	**DE22**	Niederbayern	22
DE71	Darmstadt	60	**ES11**	Galicia	30
DEA1	Düsseldorf	102	**ES12**	Principado de Asturias	17
ES30	Comunidad de Madrid	186	**ES22**	Comunidad Foral de Navarra	36
ES51	Cataluña	235	**ES24**	Aragón	37
FI19	Länsi-Suomi	157	**ES41**	Castilla y León	18
FI1B	Helsinki-Uusimaa	184	**ES42**	Castilla-La Mancha	15
FI1C	Etelä-Suomi	100	**FRI3**	Poitou-Charentes	16
FI1D	Pohjois- ja Itä-Suomi	71	**LV00**	Latvija	29
FR10	Ile-de-France	204	**PL41**	Wielkopolskie	26
FRK2	Rhône-Alpes	93	**SI04**	Zahodna Slovenija	16
ITC4	Lombardia	100	**UKK4**	Devon	21
ITH5	Emilia-Romagna	75	**UKL1**	West Wales and The Valleys	19
NL32	Noord-Holland	64			
NL33	Zuid-Holland	75			
NL41	Noord-Brabant	83			
SE11	Stockholm	217			
SE22	Sydsverige	107			
SE23	Västsverige	108			
UKD3	Greater Manchester	52			
UKE4	West Yorkshire	66			
UKF1	Derbyshire and Nottinghamshire	44			
UKG3	West Midlands	88			
UKI3	Inner London — West	65			
UKI4	Inner London — East	50			
UKJ1	Berkshire, Buckinghamshire and Oxfordshire	57			

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European Observatory for Clusters and Industrial Change

The European Observatory for Clusters and Industrial Change (#EOCIC) is an initiative of the European Commission's Internal Market, Industry, Entrepreneurship and SMEs Directorate-General. The Observatory provides a single access point for statistical information, analysis and mapping of clusters and cluster policy in Europe, aimed at European, national, regional and local policy-makers, as well as cluster managers and representatives of SME intermediaries.

The aim of the Observatory is to help Europe's regions and countries design better and more evidence-based cluster policies and initiatives that help countries participating in the COSME programme to:

- develop world-class clusters with competitive industrial value chains that cut across sectors;
- support Industrial modernisation;
- foster Entrepreneurship in emerging industries with growth potential;
- improve SMEs' access to clusters and internationalisation activities; and
- enable more strategic inter-regional collaboration and investments in the implementation of smart specialisation strategies.

In order to address these goals, the Observatory provides an Europe-wide comparative cluster mapping with sectoral and cross-sectoral statistical analysis of the geographical concentration of economic activities and performance, made available on the website of the European Cluster Collaboration Platform (ECCP) [63]. The Observatory provides the following services:

- **Bi-annual "European Panorama of Clusters and Industrial Change"** that analyses cluster strengths and development trends across 51 cluster sectors and 10 emerging industries, and investigates the linkages between clusters and industrial change, entrepreneurship, growth, innovation, internationalisation and economic development;
- "**Cluster and Industrial Transformation Trends Report**" which investigates the transformation of clusters, new specialisation patterns and emerging industries;
- **Cluster policy mapping** in European countries and regions as well as in selected non-European countries;

[63] https://www.clustercollaboration.eu/

- "**Regional Eco-system Scoreboard for Clusters and Industrial Change"** that identifies and captures favourable framework conditions for industrial change, innovation, entrepreneurship and cluster development;
- **Updated European Service Innovation Scoreboard**[64], that provides scorecards on service innovation for European regions;
- **"European Stress Test for Cluster Policy",** including a self-assessment tool targeted at cross-sectoral collaboration, innovation and entrepreneurships with a view to boosting industrial change;
- **Customised advisory support services** to twelve selected model demonstrator regions, including expert analysis, regional survey and benchmarking report, peer-review meeting, and policy briefings in support of industrial modernisation;
- **Advisory support service to European Strategic Cluster Partnerships**, in order to support networking between the partnerships and to support exchanges of successful practices for cross-regional collaborations and joint innovation investments;
- **Smart Guides** for cluster policy monitoring and evaluation, and for entrepreneurship support through clusters that provide guidance for policy-makers; and
- **Brings together Europe's cluster policy-makers and stakeholders** at four European Cluster Policy Forum events, the EU Cluster Weeks, and at the European Cluster Conference In order to facilitate high-level cluster policy dialogues, exchanges with experts and mutual cluster policy learning. Four European Cluster Policy Forums took place in February, April, November 2018 and March 2019 in Brussels. The European Cluster Conference took place from 14 to 16 May 2019 in Bucharest (Romania) with support of the Romanian Presidency to the EU.
- Online presentations and publications, discussion papers, newsletters, videos and further promotional material accompany and support information exchanges and policy learning on cluster development, cluster policies and industrial change.

More information about the European Observatory for Clusters and Industrial Change is available at: https://www.clustercollaboration.eu/eu-initiatives/european-cluster-observatory

[64] Previous versions for 2014 and 2015 were developed by the European Service Innovation Centre (ESIC), see http://ec.europa.eu/growth/tools-databases/esic/index_en.htm

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