BLUEAIR PROJECT

BLUE GROWTH SMART ADRIATIC IONIAN S3

D.T.2.1.4.

Position Paper on Key Common Technologies

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Contents

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List of Abbreviations

ADRION	Adriatic and Ionian region
AR	Average Relatedness Index
EPO	European Patent Office
EU	European Union
EUIPO	European Union Intellectual Property Office
EUSAIR	European Union Strategy for the Adriatic and Ionian Region
FICCI	Federation of Indian Chambers of Commerce & Industry
IPC	International Patent Classification
KAS	Konrad-Adenauer-Stiftung
NACE	Nomenclature statistique des activités économiques dans la Communauté européenne (Statistical classification of economic activities in the European Community)
NUTS	Nomenclature of Territorial Units for Statistics
R&D	Research and development
RTA	Revealed Technological Advantage
S3	Smart specialisation strategy
STEM	Science, technology, engineering and mathematics
U.S.	United States of America
UN	United Nations
WB	World Bank

1. BACKGROUND INFORMATION

1.1. Blue Economy/Growth importance

In the second decade of the 21st century, Blue Economy has emerged as an exceedingly important, multidimensional concept. Blue Economy effects are relevant not only in terms of wealth but also for their impact in the work market, labour and organization of the territory, especially in coastal regions. The Blue Economy concept is still evolving, and different stakeholders have adopted its varying definitions based on their own visions and priorities. However, there exists a broad consensus that with the diminishing land resources, there will be a much greater pressure on the oceans for more resources to feed faster growth to meet the demands of a growing population (KAS and FICCI, 2019). The Blue Economy concept seeks to promote economic growth, social inclusion, and the preservation or improvement of livelihoods while at the same time ensuring environmental sustainability of the oceans and coastal areas (WB and UN, 2017).

These elements attract an increasing attention from market and public institutions to create a correct framework to develop Blue Economy and to boost potentialities for their activities. Realizing the full potential of the Blue Economy also requires the effective inclusion and active participation of all societal groups. The private sector can and must play a key role in the Blue Economy.

1.2. BLUEAIR project

BLUEAIR project aims to enhance institutional capacity of ADRION countries/regions in the definition of a common approach towards the implementation of the smart specialisation strategy (S3) by developing an innovation strategy and accompanying action plan in the field of Blue Growth at the macro-regional level.

The BLUEAIR project intends to achieve this main goal by focusing on the following specific objectives:

1. Improving the competencies of quadruple-helix stakeholders in the area of Blue Growth
2. Identifying Blue Growth sectors of macro-regional interest and exploiting the potential for transnational cooperation
3. Development of macro-regional smart specialization in the area of Blue Growth of the Adriatic-Ionian macro-region.
4.

The BLUEAIR project aims to improve the competencies of quadruple helix stakeholders in the Adriatic-Ionian macro-region in the field of Blue Growth through capacity building, cross-fertilization and mutual learning activities. Development of a new entrepreneurial discovery process model/approach/guideline, as well as development of reports on forecasting processes/tools/technologies to improve competitive advantages and take advantage of new opportunities within the Blue Growth will empower ADRION countries/regions in achieving BLUEAIR project objectives.

1.3. Strategic framework

Strategic framework of the Position Paper refers to all strategic documents related to the scope of the BLUEAIR project, like the following:

- The EU Blue Economy Report 2021
- A new approach for a sustainable blue economy in the EU Transforming the EU's Blue Economy for a Sustainable Future (2021)
- EU Biodiversity Strategy for 2030 (2021)
- A New Industrial Strategy for Europe (2020) and Updating the 2020 New Industrial Strategy: Building a stronger Single Market for Europe's recovery (2021)
- Proposal on the use of renewable and low-carbon fuels in maritime transport and amending Directive 2009/16/EC (2021)
- Fostering a European approach to Artificial Intelligence (2021)
- European Union Strategy for the Adriatic and Ionian Region (EUSAIR) Flagships 2021-2027 (2020)
- Addendum concerning the European Union Strategy for the Adriatic and Ionian Region (2020)
- Action Plan concerning the European Union Strategy for the Adriatic and Ionian Region (2020)
- A European Strategy for Data (2020)
- Farm to Fork Strategy (2020)
- Making the most of the EU's innovative potential, An intellectual property action plan to support the EU's recovery and resilience (2020)
- The European Green Deal (2019)
- Council conclusions on the implementation of EU macro-regional strategies (2019) and Corrigendum (2019)
- Study on macro-regional strategies and their links with Cohesion Policy (2017)
- MedFish4Ever Declaration (2017)
- Report on the implementation of EU macro-regional strategies (2016)
- Action Plan concerning the European Union Strategy for the Adriatic and Ionian Region (2014)
- Communication concerning the European Union Strategy for the Adriatic and Ionian Region (2014).

However, the basis of the Position Paper is the EUSAIR framework, besides smart specialisation concept. This strategy for the macro-region is positioned between national and regional smart specialisation strategies (S3) where resources and potentials for innovations are already identified. It acts as a bridge between EU and local policymaking. EU macro-regional strategy is a policy framework which allows countries located in the same region to jointly tackle and find solutions to problems or to better use the potential they have in common (European Commission, 2017). These strategies are purely intergovernmental initiatives and their implementation relies heavily on the commitment and goodwill of the participating countries. It is imperative for them to be inclusive and bottom-up to ensure ownership. Also, important to mention, cooperation and coordination between different macro-regional strategies is of key importance with a view to maximising mutual co-benefits and impact. This is even more important where there is a geographical overlap between the strategies, for example between EUSAIR and EUSDR.

The EUSAIR defined concrete priorities for the macro-region through its four pillars. Through the Action plan, these priorities were shaped by a bottom-up approach and extensive consultations into actions/projects that appeared promising to respond to the key challenges as well as key opportunities in the region.

Blue Growth represents the first pillar of the EUSAIR with three specific objectives:

1. To promote research, innovation and business opportunities in blue economy sectors, by facilitating the brain circulation between research and business communities and increasing their networking and clustering capacity.
2. To adapt to sustainable seafood production and consumption, by developing common standards and approaches for strengthening these two sectors and providing a level playing field in the macro-region.
3. To improve sea basin governance, by enhancing administrative and institutional capacities in the area of maritime governance and services.

EUSAIR flagships 2021-2027 adopted in 2020, related to this pillar of Blue Growth are as following:

- Fostering quadruple helix ties in the fields of marine technologies and blue biotechnologies for advancing innovation, business development and business adaptation in Blue bio-economy
- Promoting sustainability, diversification and competitiveness in the fisheries and aquaculture sectors through education, research and development, administrative, technological and marketing actions, including the promotion of initiatives on marketing standards and healthy nutritional habits
- Bolstering capacity building and efficient coordination of planning and local development activities for improving marine and maritime governance and blue growth services.

For the above-mentioned flagships, all challenges/needs/strategic importance, overall goals and expected outcomes as well as remarks on proposed projects and actions are taken into account within the Position Paper. The added value of EUSAIR is characterised by its cross-sectoral approach, its transnational dimension (including the participation of non-EU countries) and its contribution to better multi-level governance (European Commission, 2017). However, in terms of innovation and smart specialisation strategies, which is the main outcome of the BLUEAIR project, there is a challenge regarding the depth and width of the scope and the level of the macro-regional framework.

All deliverables within the BLUEAIR project are considered too.

1.4. The purpose and the scope of the Position Paper

The fast-emerging paradigm of Blue Economy primarily seeks to harness the ocean/sea resources for sustainable development.

Position Paper on Key Common Technologies in the ARION macro region is one of the bases in the process of developing a macro-regional innovation strategy. It was designed by the Croatian Chamber of Commerce in cooperation with project partners on the BLUEAIR project.

The key purposes of the Position Paper is: (1) to propose and (2) implement a methodological approach to detect key common technologies in ADRION macro region and (3) detection of key common technologies in in order to support development of the common innovation strategy in the ADRION region.

The paper also emphasizes conviction about the desirability of ADRION adopting a holistic innovation strategy which is anchored in the results of the BLUEAIR project. This should be designed to accelerate growth, while at the same time ensuring sustainable development.

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To fulfil its purpose, the Position Paper is divided into following parts:

- Background information
- Patents
- Methodology
- Main findings and discussion
- Key common technologies in ADRION macro region – the justification and recommendations.

This Position Paper aims to provide an empirical validation of the knowledge relatedness concept in ADRION. Following the results of the defined methodological approach and conducted analysis, potential key common technologies are highlighted, as well as opportunities to enhance the effectiveness of the innovation system, thereby contributing to faster technological progress, sustainable economic growth and consequently the increase of the living standard in the ADRION region.

2. PATENTS

Innovations are considered as source of comparative and competitive advantages of both countries and companies. Since innovation is an important driver of the world economy, but also of social life, it is necessary to create such an environment that will stimulate the creation and dissemination of innovation. Protection of the intellectual property rights is proven to be one of the important stimulants for innovations. It follows that one of the most important arguments for explaining the importance of an intellectual property protection system is that the absence of such a system would leave private market agents unprotected, i.e. there would be no incentive to undertake expensive and risky investments that could result in new ideas and technologies, which are today considered a source of economic growth (Breitweiser and Foster, 2012).

A subject matter of patents are industrially applicable invention in all fields of technology (WIPO, 2021). Patents enable exclusive right to make, use and sell the patented invention, typically maximum 20 years from filing.

Patents count as one way to measure innovation. They represent incentive for innovation, protection of knowledge and full technical disclosure of invention. However, they do not represent a perfect measure, because they vary in importance and in the level of quality (Shambaugh et al., 2017). It is proven that companies which own at least one patent, registered design or trade mark generate on average 20% higher revenues per employee than companies which do not own any of those intellectual property rights (EPO and EUIPO, 2021).

Due to, to some extent, varying standards, it can be difficult to make cross-national/cross-regional comparisons, but still these comparisons can have high informative value, especially in terms of innovation and for the purpose of creating common actions.

One has to bear in mind that also increase in the patents applications can be misleading, because the quality of the application is unknown, and even if approved, some patents will not have impact on a greater scale. Also, the other important thing is to be aware on the effects of patents system. From one, and very important view, this system spurs innovations and help innovators to have higher returns on their innovations. It is of great importance since research, development and innovation activities cost a lot. But, patents a way limit competition, and for a certain period of time give monopoly power to the owners. Accumulation of patents of lower quality can be even discouraging for the innovation (Shambaugh et al., 2017). From this point of view, it is important to insist, within the patent system, on granting patents only when they meet certain standards in terms of novelty and usefulness. Granting a monopoly to innovators, while not a perfect solution, nevertheless provides incentives to create innovation, which in turn should result in long-term productivity growth and improved product quality. Stronger patent systems increase the propensity to patent, but this does not necessarily lead to greater innovation efforts. Moreover, it can lead to increased efforts to create those innovations that are easier to patent (Sakakibara and Branstetter, 2001).

However, it has to be acknowledged that researches found that patents are closely linked to innovation and innovative activities and usually are used as a proxy for innovation (Shambaugh et al., 2017). Usually, patenting is highly concentrated in metropolitan areas and near research universities.

Patent statistics provide a unique insight into the sector's past and future innovation dynamics. As such, patent studies can help us understand where the sector came from, and what to expect for the years to come (Van Balen et al., 2021).

It is inevitable fact that countries/regions which invest more in R&D produce more high-quality patents. Also researches have shown that industries which employ more STEM workers produce more patents (Shambaugh et al., 2017).

Since Blue Economy is considered to require unified efforts, like it is the case in ADRION region too, there are some arguments in favour of common management of the intellectual property right (Karnik, 2019). As the main argument for this thesis, an example of IP rights in cleantech has been mentioning. Smaller number of corporations holding the patents will not achieve common objectives, which do not rest solely on profiteering. Patent system which allows similar use for the benefit of the Blue Economy is consider to lead to a greater overall benefit on ocean bodies (Karnik, 2019). There are some proposals that the use of IP and innovation strategies in the Blue Economy should, where possible, be integrated with other forms of international law instruments and that finding synergies between IP and the United Nations Convention on the Law of the Sea may assist in creating an integrated legal framework for sustainable development in the Blue Economy (Cadogan, 2019).

Patent data, capturing the development of novel products and processes of economic value, are particularly useful to observe and implement the concept of smart specialization (Kogler et al., 2017).

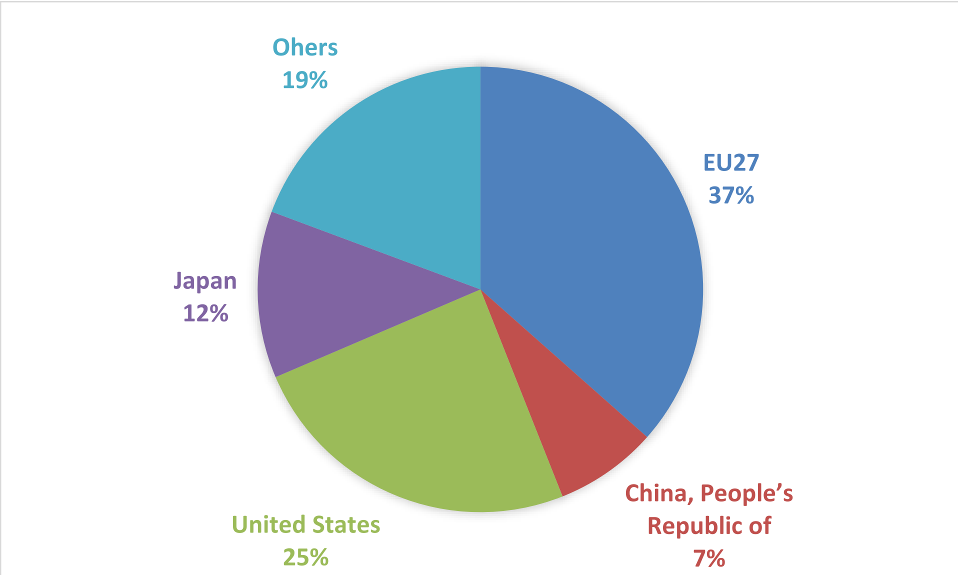
2.1. Patenting performance of the European Union

When assessing patenting performance in the world, different sourced of data, and different methodologies can be used. In further text, different sources and foundations will be presented.

Despite the COVID-19 pandemic, innovators around the world managed to file what, given the circumstances, is a total of 3,276,700 patents applications in the world, which makes an increase of 1.6% to 2019 (WIPO, 2021). China was the biggest source of applications for international patents in the world in 2020 for the second consecutive year (Farge, 2021). In 2020, it reached 45.7% of total patent applications in the world, with the increase of almost 7% to 2019. On the second place was U.S. with 18.2% and decrease of almost 4% to 2019, and on the third place was Japan with 8.8% and decrease higher than 6% to 2019. These three countries made 72.7% of total world patent applications in 2020 (WIPO, 2021). Total Europe had 357,900 patent applications in 2020, which is around 11% of the total share in the world (WIPO, 2021).

The biggest patent applicant to the EPO within the European Union is Germany (EPO, 2020) (see Annexes 1 and 2). On the second place is France, followed by Netherlands, Italy, Sweden, Belgium, Denmark and Austria. In comparison to the rest of the world, EU27 stands for 37% of total applications filed with the EPO in 2020 (Figure 1).

Figure 1. Applications filed with the EPO, 2020



Source: EPO.

It is interesting to see who is applying for patents where, because it indicates where investors believe are greatest market opportunities (Van Balen et al., 2021). On the below figure, the origin is shown on the left, and the destination on the right. According to patent applications, U.S. is most desirable office, followed by EPO on the second place and China on the third place.

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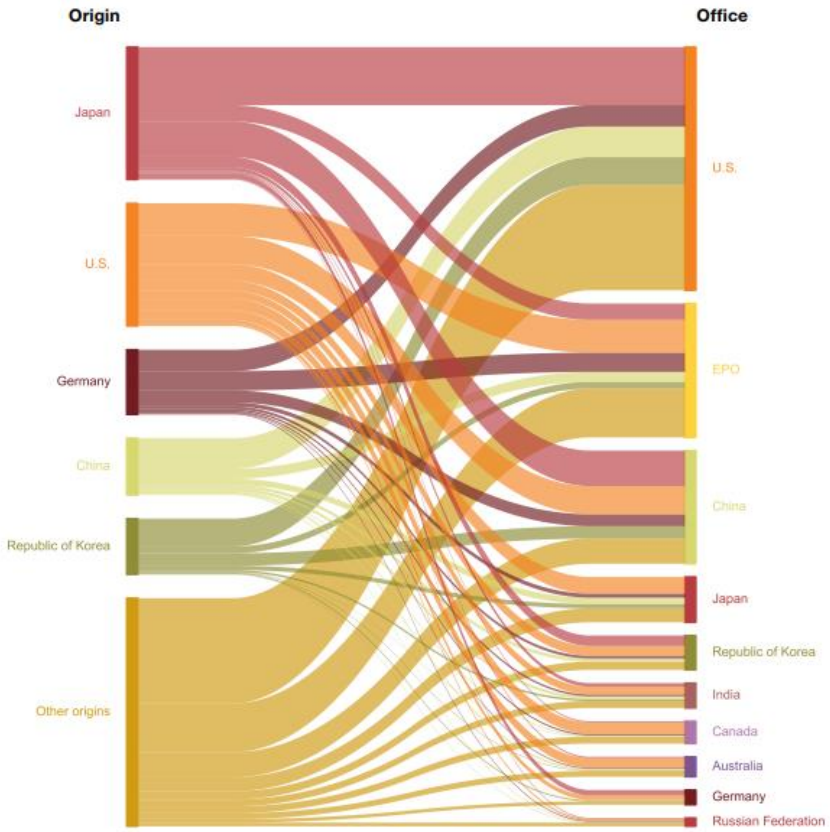
Figure 2. Flows of non-resident patent applications between the top five origins and the top 10 offices, 2020



Source: WIPO (2021).

2.2. Patenting performance and blue inventions in the Adriatic-Ionian region

Established and emerging sectors and subsectors, as well as related NACE codes of the Blue Economy, defined in the EU Blue Economy Report 2020, are given in the Annex 3.

Innovation activity is spread unevenly and it is one of the most geographically-concentrated economic activities (Vlčkova et al., 2018).

Opportunities for sustainable innovations are evident for green shipping, sustainable aquaculture and fisheries, as well as maritime and coastal tourism in the region (UfM, 2021).

3. METHODOLOGY

3.1. Approach and key concepts

There is a consensus in a vast literature that innovations positively influence on prosperity and economic growth. In order to develop a competitive innovation strategy, it is suggested that regions identify their core competencies, as well as the potential for complementarities within their respective knowledge base (Kogler et al., 2017).

Smart specialisation is an innovative policy approach. It combines industrial and innovation policy. The key characteristics of this approach are (Gómez Prieto et al., 2019): territorial dimension, bottom-up approach fostered via quadruple helix, entrepreneurial discovery process and flexibility which allows modifications and improvements throughout the intervention process. Smart specialisation methodology consists of six steps (Sörvik, 2012; Gómez Prieto et al., 2019; Bilas, 2020): (1) the analysis of the potential for innovation through an entrepreneurial discovery process, (2) the establishment of the governance system, (3) the design of a strategic territorial vision, (4) the identification of selected priorities, (5) the definition of a policy mix and implementation mechanisms, and (6) the establishment of monitoring and evaluation system.

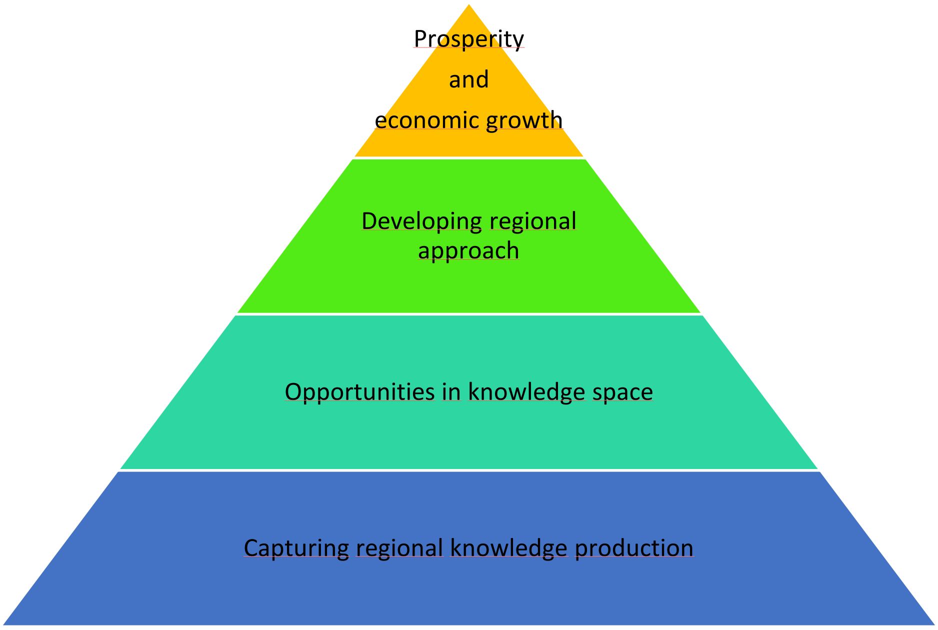
Consequently, the innovation process is a complex social activity that includes various types of knowledge and actors, and the regions differ significantly in their innovation characteristics. Evolutionary economic geography explores the role of knowledge connectivity in regional development and is based on the fact that knowledge production stems from specific patterns in the region, patterns that have evolved over time. Tangible and intangible assets that are present in companies, over time, expand into the region. Therefore, identifying the links between technologies/products/industries and existing opportunities in the region can help predict future potential technological directions. Furthermore, smart specialization policy requires new measures to identify the main competencies of the regions, which are usually a combination of qualitative and quantitative data. Measuring the connection of knowledge and its visualization in the knowledge space will enable the assessment of the specialization of the Adriatic-Ionian macro-region and the identification of potential industries in accordance with the concept of smart specialization.

Regional knowledge is the foundation of the regional competitive advantage and despite this fact, a little attention has been given to the actual type of knowledge produced by the variety of actors within specific places (Kogler, 2018). Knowledge production is a cumulative, path-dependent and interactive process. When we discuss on the knowledge space, we discuss knowledge accumulation and relatedness.

Knowledge relatedness and knowledge complexity could be used as methodological tools for selecting prospective industries in smart specialisation strategies (Vlčkova et al., 2018).

Based on these statements, the core of the analysis of the Position Paper relies on knowledge space theory. It is used to show the specialization of a region and the evolution of its technological specialization (entry and exit into certain technological sectors), based on the visualization of the relationship between certain categories of patents (knowledge). The level of technological specialisation in the ADRION region is assessed, using bottom-up approach.

Figure 3. Bottom-up approach



Source: adapted according to Kogler (2018).

Investment in, and use of the best available science, data, and technology is critical to underpinning governance reforms and shaping management decisions to enact long-term change (WB and UN, 2017).

Emerging evolutionary economic geography attempts to explain the change in spatial and regional structures through endogenous technological innovation. This concept of knowledge relatedness focuses on the types of knowledge in specific locations and how existing capabilities affect future technology trajectories (Vlčkova et al., 2018).

Patents reflect the knowledge base of the region. Patent data have been used to explore patterns of specialization in invention and innovation using the technology codes within which patents are classified (Kogler et al., 2017). According to Kogler et al. (2017), the patent class distance data are combined with counts of patents by categories to measure the average relatedness (specialization) of knowledge produced within each region.

Besides scanning the literature and projects running on this topic, based on the analysis and projections, recommendations are made.

Following steps are conducted in order to conduct analysis within the Position Paper:

1. Review of the literature and projects on knowledge space
2. Data collection
3. Data analysis
4. Interpretation of results and discussion
5. Recommendations.

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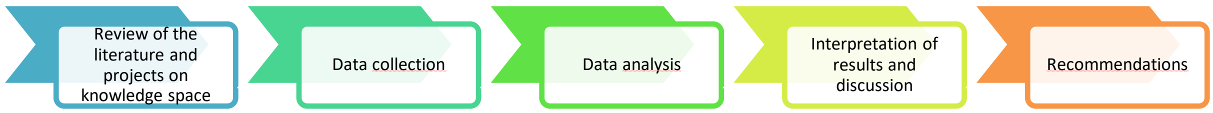
Figure 4. Position Paper construction



Geographical scope of the document refers to nine countries of the Adriatic-Ionian region, as follows:

- EU Member States: Croatia, Greece, Italy, Slovenia
- Non-EU Countries: Albania, Bosnia and Herzegovina, Montenegro, Serbia, North Macedonia.

Detailed methodology of the conducted analysis is given in the following sections. Measuring knowledge relatedness and its visualisation in knowledge space will enable to assess the specialisation of ADRION regions and the identification of prospective industries in line with the concept of smart specialisation as a basis for ADRION innovation strategy.

3.2. Knowledge space analysis

The concept of knowledge space is used to present the specialization of the Adriatic-Ionian region and the evolution of its technological specialization (entry and exit into certain technological sectors), based on the visualization of relations between individual patent categories.

The measurement of knowledge space is carried out on patent documentation. The main assumption is that patents reflect the knowledge base from the macro-region and are unique in their scope and in their geographical and historical coverage.

For the purpose of analysis, the patent application date (priority date) is used, not the patent grant date, as the priority date is closest to the inventive activity. Furthermore, the country of the inventor is used for the geographical determination, not the country of the patent owner, because the main interest is in the innovation possibilities of the region. In case the inventors are assigned to a larger number of countries (or regions), the patent is divided among the inventors.

Technological connectivity is measured based on the categories of patents to which each patent belongs (co-classification).

In the following text, the explanation of used knowledge space indicators is given, as well as methodological approach/process.

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First of all, patents are selected into two basic subsets according to:

1. Location of the innovator /patent-owned organization (Adriatic-Ionian macro-region)
2. According to the citizenship of the innovator (in addition to the above subset by location, it also includes those patents that are not located in the Adriatic-Ionian region, but are innovators from the Adriatic-Ionian macro-region).

In both cases, patents should have these six attributes:

1. International Patent Classification (IPC, all patent denominations up to 4 digits, e.g. A01B)
2. Year of patent application
3. NACE classification
4. Location (NUTS2 region from the Adriatic-Ionian macro-region)

Following text explains used measurement of technological relatedness on basis of patent documentation

3.2.1. Technological connection of patents

The connection of individual categories of patents measures the simultaneous occurrence of these categories in certain patents. The assumption is that the more often a patent belongs to two different categories of patents, the more likely these categories of patents share a similar knowledge base.

The knowledge space maps the connection of individual categories through the construction of a symmetric matrix that includes the number of patents belonging to certain categories. This matrix of simultaneous phenomena can then be used to derive a measure of the connectivity between technological fields and to provide a visualization of the relationship between patent classes in networks.

With above mentioned data on patents, technological connection of patents is assessed. Firstly, symmetric matrix involving the number of patents belonging to certain categories is constructed as follows:

- Let *P* be the number of granted patents, *p* the particular patent, and *i* and *j* represent the category of patents. If the patent belongs to category *i*, then *Fip = 1*. If the patent does not belong to category *i*, then *Fip = 0*. The number of patents for category *i* is *Ni = ∑p Fip*.
- *Nij = ∑p Fip Fjp* denotes the number of patents belonging to both categories: *i* and *j*.

In total, there are more than 120 patent classes belonging to 8 different areas.

This needs to be done for all 120+ classes of patents (three digits, e.g. A01 - Agriculture; forestry; animal husbandry; hunting; trapping; fishing) which results in a matrix of *12x × 12x*, which denotes patents belonging to both categories. The knowledge space is also affected by the total number of patents that belong to a certain category. Thus, a standardized matrix of common occurrence (*S*) is created with the elements, which indicates the technological connection of two different categories in the year:

$$S_{ij} = \frac{N_{ij}}{\sqrt{N_i * N_j}}$$

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Once standardized matrix of co-occurrence is developed, it need to be visualized in form of network graph to be analyzed.

3.3. Limitations

There are few limitations of the applied methodology, and still not managed to be avoided in scientific literature:

- Regional comparability of the level of patenting
- The fact that not all inventions are patented which makes patent statistic an incomplete insight into innovation activities
- Applied methodology is primarily quantitative.

4. MAIN FINDINGS AND DISCUSSION

4.1. Knowledge space

For quite some time, knowledge production and technological innovations have been viewed as dominant force sustaining rise in productivity and enabling growth in the long run (Sollow, 1956; Romer, 1990). On the other hand, insights on where, what and how knowledge is produced were being scarce and not explored thoroughly. However, with the ever-rising importance of knowledge production and technological innovations, inquiries into what, where and how of knowledge production became more important. Economic geography and especially concept of knowledge space, shed some light on where, what and how of knowledge production.

Concept of Knowledge space, as it is understood in this document, follows on Kogler et all (2013) and defines knowledge space as based "on the proximity of technology classes, utilizing measures derived from co-classification information contained in patent documents." Knowledge space of ADRION macro-region is developed from information contained in patent application from ADRION macro-region.

Each patent application contains several information that allow us to build knowledge space. Most important information contained in patent application is patent classification. Patent are classified according to IPC (International patent classification) classification. Each patent is associated with at least on patent classification. IPC classification system was "established by the Strasbourg Agreement 1971", and it allows "classification of patents and utility models according to the different areas of technology to which they pertain (WIPO 2020). In building knowledge space of ADRION macro-region, we rely on relations between different patent classifications on patent application. Patent classification used in this analysis is International patent classification (IPC) that is used by EPO (European patent office). IPC denotes technological area(s) that certain patent relates to.

Beside IPC classification, secondary classifications used in building and evaluating Knowledge space of ADRION macro-region are: NACE v.2 codes (3- and 4-digit codes) and broad technology areas devised by World intellectual property organization (WIPO)[1].

It needs to be noticed that NACE v.2 codes are assigned to patent application on basis of probability function, and do not serve as a completely accurate denotation.

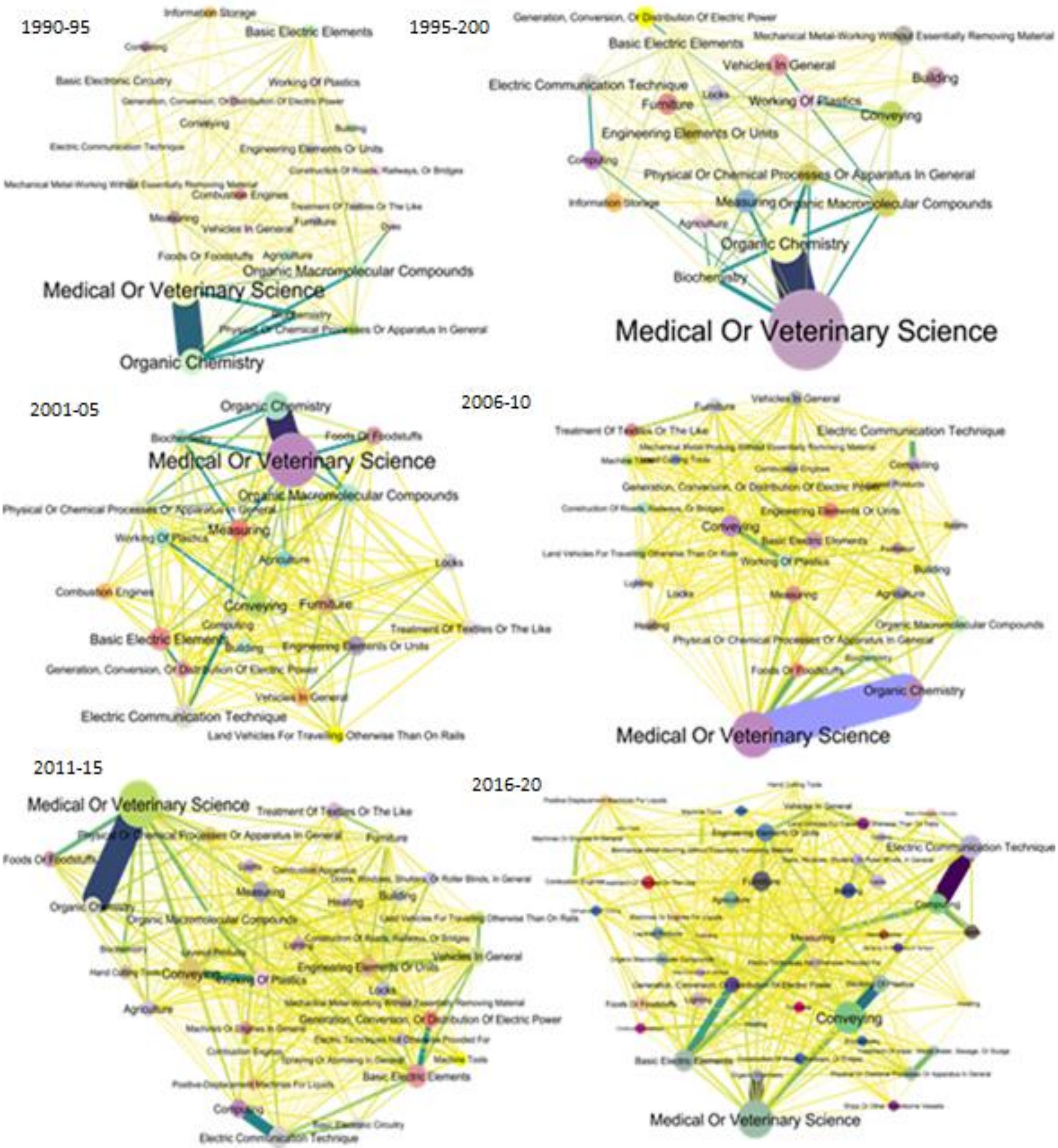
In the following paragraphs, we describe Knowledge space in general, and later we turn to analysing ICT and Environmental technologies as separate larger technological areas of interest for ADRION macro-region.But before we start with laying out insights derived from analysis, some general points on concept of knowledge space and its impact on understanding how innovation and knowledge production processes work.

Knowledge space as a concept was derived from product space developed by Hidalgo et al. (2007). Therefore, the product space is defined as "network-based representation that captures the levels of cognitive proximity based on how often two specific products are co-exported by each country" (Hidalgo et al., 2007). Building on this idea, Kogler et al. (2013), developed knowledge space as an analytical tool, that instead of focusing

[1] https://www.wipo.int/export/sites/www/ipstats/en/statistics/patents/pdf/wipo_ipc_technology.pdf

on products and their relatedness, focuses on co-occurrence of patent classification codes found on patent documents. The knowledge space is an “intuitive way to model the processes of technological specialization/diversification of a regional economy” (Whittle, 2020). As a analytical tool, knowledge space is based on path-dependent logic, meaning that “it argues that technological change is strongly biased towards related activities, whereby regions are more likely to adopt technologies that are related to their existing technological portfolio” (Whittle & Kogler, 2019).

Figure 5 – Development of knowledge space and technological relatedness in ADRION macro-region from 1990 through 2020 (IPC 3-digit classification)



Source: Authors own calculation; EPO PATSTAT

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Figure 5 illustrates developments of ADRION macro-region knowledge space throughout last 30 years. Linkages in network, as it is already explained, represent co-occurrence of different IPC classes in patent application. Each network represents five-year period from 1990 to 2020.

Networks (Knowledge space visual representations) illustrated in Figure 5 are made using software package *Cytoscape 3.9.0*[2]. Furthermore, networks representation of knowledge space is visualized on basis of several assumptions.

First, size of the bubble represents number of the IPC classes that are found in patent applications. Roughly, size of the bubbles approximately represents the number of patents in certain technological area. Size of the bubbles is not transitive between pictures of different five-year periods, since it is automated visualisation option of software itself, and therefore different for each period.

Second, since complete networks of each five-year period are way to massive to be presented in full, some reduction must be put in place. So, the first step is to lower the number of possible nodes (IPC classes) and edges (connections), in order to get a clear picture. This is done by omitting nodes (IPC classes) that amount to less than 5% of the most represented node (IPC class) in the period. For example, if in five-year period IPC class denoting Medical or Veterinary Science appears 6789 times across different patent application. IPC classes that appear less than 339,5 times across different patent application are omitted. In that way we can get clearer picture and illustrate only IPC classes that represent majority of IPC classes appearing in patent applications.

Third, edges (linkages between different IPC classes) connecting different nodes (IPC classes), are weighted, so that thickness of the line represents size of co-occurrence of IPC classes in patent applications. The edges are color-coded as well, with darker colours representing IPC classes that are co-occurring the most. Cut-off point being set at 10% of thickest edge or 10% of most repeated linkages connecting two nodes. For example, in first five-year period, weighted edge (linkage) between Medical and Veterinary Sciences and Organic Chemistry amounts to 2706 points. Therefore, cut-off point, from where linkages start to appear in darker colours is set at 270 points. Networks for all five-year periods of IPC classes representing Knowledge spaces of ADRION macro-region are visualized using above mentioned parameters.

First insight that comes to mind is the size of the nodes throughout network representations of the ADRION macro-region knowledge space. It is obvious that Medical and Veterinary science is by far most important field of Knowledge space in ADRION macro-region in the last decade of the 20th century, and that it still being the largest area of knowledge production in ADRION macro region.

Therefore, from figure 5, we see that in in first five-year period starting in 1990, Knowledge space of ADRION macro-region is characterized by Medical and Veterinary Science technology area and fields closely related to it, such as Organic Chemistry, Biochemistry and Organic Macromolecular Compounds. Moreover, sheer size of the bubbles indicates that majority of new knowledge production was concentrated within and around Medical and Veterinary Science technology area.

Moving on from first 5-year period, onto second period (from 1996 to 2000), we see slightly more diversified knowledge space, as Measuring, Vehicles in General and Conveying are becoming more prominent in ADRION macro-region knowledge space (increased size of bubble in comparison to Medical and Veterinary science technology area), regarding the size of the knowledge space they occupy and number of linkages that they

[2] Shannon P, Markiel A, Ozier O, et al. Cytoscape: a software environment for integrated models of biomolecular interaction networks. Genome Res. 2003;13(11):2498-2504.

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share. Besides Vehicles in General and related areas, we see that Electric communication technique and Computing are becoming prosperous knowledge generating area.

As we move on to third five-year period (2001-2005), Electric communication Technique, Computing and related areas are becoming even more prominent knowledge production areas, together with already mentioned Medical and Veterinary science complex. Technology area connected with Vehicles in general is becoming slightly less knowledge productive technology area (bubble size and connection strength) in comparison to already mentioned technology areas, but area still relevant in knowledge production in ADRION macro region. Conveying and Working of plastics are now well established technology area with good measure of relatedness between them.

Fourth five-year period is characterized again with Medical and Veterinary science and related fields as largest knowledge producing technology areas, but technology areas of Electric communication technique and Conveying are becoming more prominent.

Last two five-year periods bring full diversification to knowledge space of ADRION macro region, with technology areas of Medical and Veterinary science, Conveying, Measuring, Computing, Electric Communication technique and Basic electric elements taking up of over 30% of patenting activity.

Figure 6 – Summary network statistics for knowledge space representation of ADRION macro region

Summary statistics						
	1990-1995	**1996-2000**	**2001-2005**	**2006-2010**	**2011-2015**	**2016-2020**
Network density	0,173	0,198	0,213	0,227	0,243	0,153*
Avg. number of neighbours	20,4	23,9	25,7	27,5	29,6	17,8*

Source: Authors own calculation; EPO PATSTAT

* statistics for last period are not complete as many patents are still in approval phase. According to EPO, for patent to be granted by EPO takes between 3 to 5 years[3]

Figure 6 provides general metrics of network representation of knowledge space of ADRION region.

Metrics used for description of networks are: network density and average number of neighbours.

Network density is calculated in following way:

$$D = \frac{N_c}{N_t}$$

where

D represents density,

N_c represents number of connections in a network and

N_t represent total possible connections in network

Density is expressed as number between 0 and 1, or percentage between 0 and 100%

[3] https://www.epo.org/service-support/faq/procedure-law.html

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Average number of neighbours is calculated in following way:

$$ANN = \frac{\sum_{i=1,2..n}^{n} N_i}{NN_t}$$

where

ANN represents average number of neighbours

$\sum_{i=1,2..n}^{n} N_i$ represents sum of number of neighbours for each node

NN_t represents total number of nodes in network

As it is visible from figure 6, density of network is constantly rising, going from 0,173 in period form 1990 to 1995, to 0,243 in period from 2011 to 2015, which represents an increase of around 40% Although numbers for the final period of analysis (2016-2020) are lower than in first period of analysis, they should be taken as temporary results. Since patenting process can last between three to five years, and in analysis only granted patents are used, in following years many more patents will be available, thus bringing these numbers closer to previous period.

Ever higher density of network, points toward conclusion of more connected Knowledge space, where knowledge production is combination of more different technological areas. Even a brief view of network development in Figure 5 shows how much more connected knowledge space of ADRION macro region has become over last three decades.

Furthermore, such assumption is corroborated by average number of neighbours' metrics, which is constantly on the rise, going from 20,4 to 29,6, which represents an increase of 45%. Rise in average number of neighbours' metrics denotes knowledge creation as a result of combining more technology areas through patenting activity and creating opportunity for technology innovations of wider scope and use.

In general, knowledge production within knowledge space of ADRION macro region is becoming more and more result of combination and cooperation between various technological areas.

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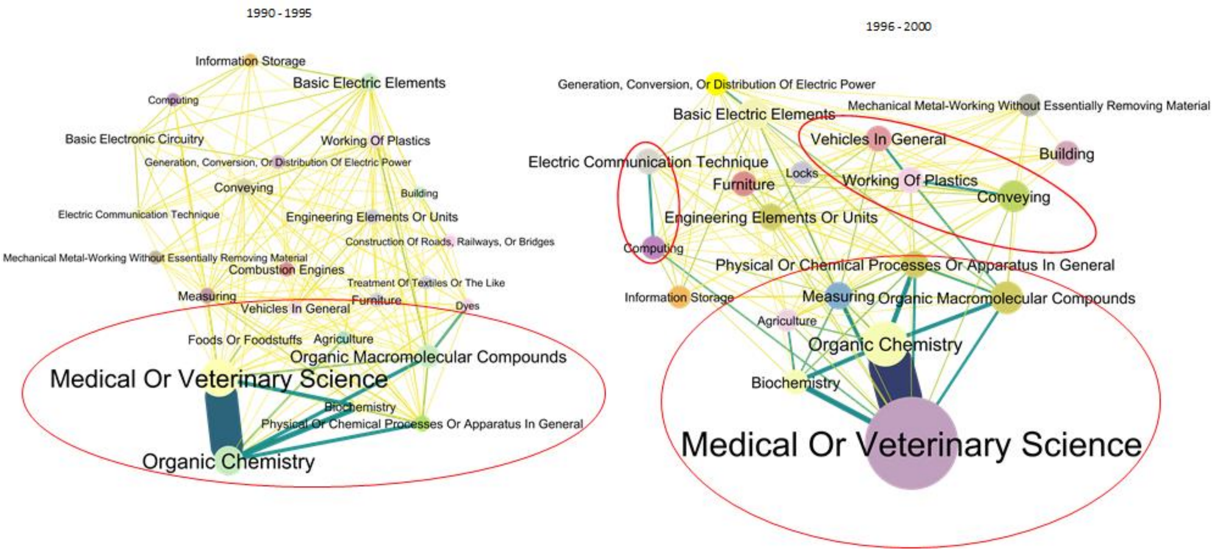
Taking in consideration that knowledge space framework builds on already mentioned path dependence and technological relatedness, meaning that, production of new knowledge is more likely to take place in related technological areas (those IPC classes that are more linked – thicker and darker linkages visible in Figure 5) rather than in technological areas less related (narrow and lighter coloured linkages).

In following pages, we will bring our attention to visual analysis of clustering of different technological areas and their development through time.

Figure 7 illustrates first two five-year periods and development of knowledge space in ADRION macro region and highlights crucial developments in knowledge production.

Figure 7 – Knowledge space and technological relatedness in ADRION macro-region from 1990 to 2000 (IPC 3-digit classification)



Source: Authors own calculation; EPO PATSTAT

Whereas first five-year period is clearly dominated by knowledge production in the technology area of Medical and Veterinary science and related fields: Organic chemistry, Biochemistry, Organic macromolecular compounds, Foods or Foodstuffs and Physical or Chemical Processes or Apparatus in general, in the second five-year period (1996-2000), two more "clusters" start to appear: First, there is grouping around Working of plastics that is above average connected with Vehicles in general and Conveying and "cluster" consisting of Electric communication technique and Computing. On the other hand, "cluster" around Medical and Veterinary Science has broadened and now includes technology area – Measuring.

Figure 8 highlights crucial development of knowledge space of ADRION macro region in the first decade of 21st century. As it is visible form the illustration, in five-year period from 2001 to 2005, largest cluster remains "cluster" around Medical and Veterinary Science, which is now even more connected with technology area - Measuring. Furthermore, "cluster" made of technology areas of Conveying and Working of plastics on one hand, becomes even tighter connected and on the other hand less connected with technology area Vehicles in general. Third "cluster" is one between Computing and Electric communication technique, with relatively strong ties toward "cluster" around Medical and Veterinary Science. Link between these two clusters is mainly due to technology area of Measuring.

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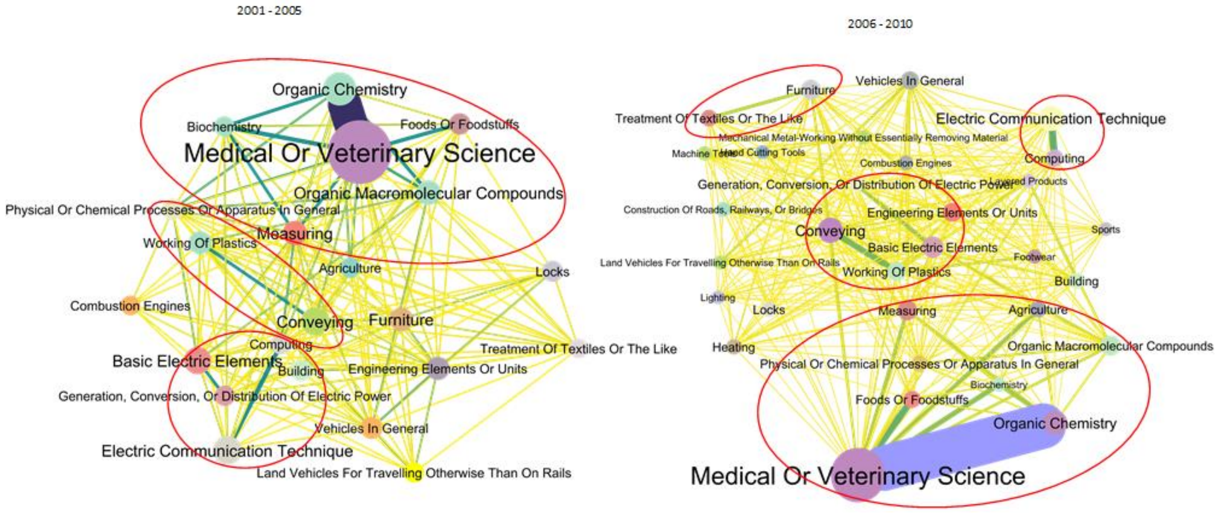
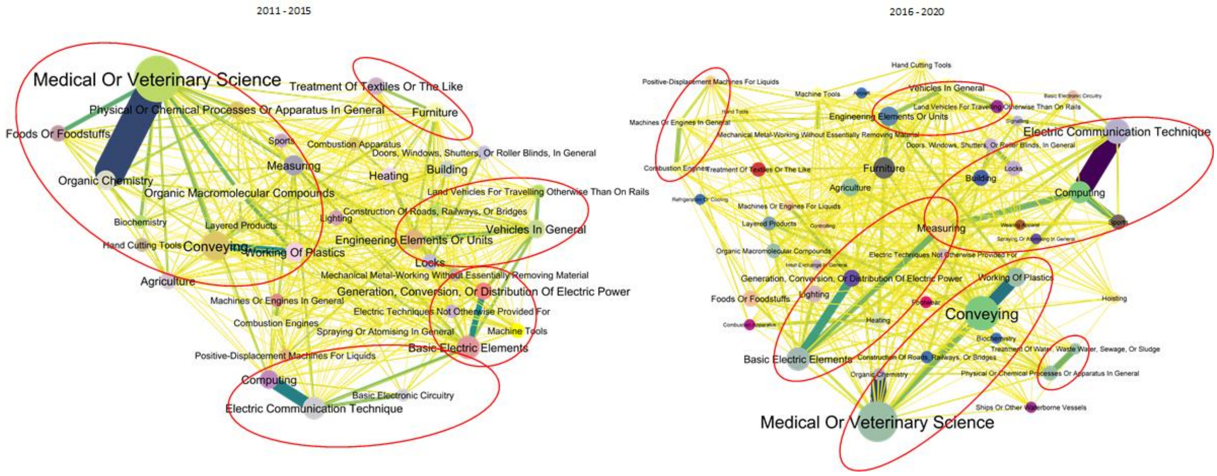
Figure 8 – Knowledge space and technological relatedness in ADRION macro-region from 2001 to 2010 (IPC 3-digit classification)



Source: Authors own calculation; EPO PATSTAT

Moving on to five-year period from 2006 to 2010, again largest "cluster" remains grouping around Medical and Veterinary science, with addition of Agriculture as technology area with high connectedness to Medical and Veterinary science. Electric communication technique and computing remains closely connected "cluster" with ties to other technology areas, but of not such intensity. Furthermore, Treatment of textile and Furniture are forming a new cluster that has not been connected on that level in previous five-year periods. Conveying and Working of plastics remain mutually strongly connected "cluster" with relatively strong ties to Medical and Veterinary science "cluster" and Textile and Furniture "cluster".

Figure 9 – Knowledge space and technological relatedness in ADRION macro-region from 2011 to 2020 (IPC 3-digit classification)



Source: Authors own calculation; EPO PATSTAT

Figure 9 highlights crucial developments in network representation of knowledge space of ADRION macro region in the last decade. In five-year period from 2011 to 2015, five different "clusters" can be visually identified. Again, "cluster" around Medical and Veterinary science is the largest one. Another interesting development is that "cluster" around Medical and Veterinary science has incorporated previously independent "cluster" of conveying and Working of plastics. Besides that, new "clusters" that are visually identifiable are "cluster" around Computing and Electric communication technique, but which now incorporates Basic electronic circuitry and has strong ties to new "cluster" that consists of technology areas

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Generation, Conversion or Distribution of electric power and Basic electric elements. Furthermore, “cluster” around Vehicles in general surfaces again and is made up of following technology areas: Land vehicles for travelling otherwise than on rails and Engineering Elements or units. Also, cluster around vehicles in general has strong connections with “cluster” around Basic electric elements. Fifth “cluster” that can be identified in the five-year period from 2011 to 2015 is “cluster” consisting of technology areas Furniture and Treatment of textiles.

In last five-year period (2016-2020), six “cluster” can be visually identified. One notable big difference is that largest knowledge production area in ADRION region, “cluster” around Medical and Veterinary science is not as dominant as in previous periods. “Cluster” around Electric communication technique and Computing has connected through technology area Measuring with “cluster” around Basic electric elements and Generation, Conversion and distribution of electric power. Two new “clusters” have emerged in las five years. First one is built around Treatment of waste, wastewater, sewage or sludge and Physical or Chemical processes and Apparatus in general. Second one is built around Combustion engines and Machines in general with strong ties to Positive-displacement machines for liquids.

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Summary findings

Development of knowledge space of ADRION macro region points toward creation of multi-clustered knowledge space at which core lay Information and communication technologies. Since 1990, knowledge production in ADRION macro-region was heavily impacted by Medical and Veterinary science and technological areas closely related to it: Organic chemistry and Biochemistry. In the first five-year period, only Medical and Veterinary Science technology area was related enough to form a “cluster”. Since then, development path of the knowledge space of ADRION macro region has been diversified by development of several “clusters” encompassing various technology areas. For example, technology area described as Conveying that deals with handling, packaging and local transportation of materials or products in an industrial process and is closely related to technology area denoted as Working of plastics that primarily deals with knowledge related to moulding , casting and other types of material transformation. Another “cluster” formed on development path of ADRION macro region knowledge space is “cluster” that relates to automotive industry, although knowledge creation in this cluster is not consistent through time, but rather characterized by high or low production in various periods. Third “cluster”, which exerts most influence on shaping knowledge space of ADRION macro region, is “cluster” around ICT technology area, which is encompassing technology areas: Computing and Electric communication technique. In latter stages of knowledge space development, “ICT cluster” heavily relates to “cluster” that have emerged around Basic electric elements and Generation, Distribution or Conversion of electric power. In the final stages of development of Knowledge space in ADRION macro region, these two “clusters” have a point of contact in technology area denoted as Measuring which primarily deals with production of knowledge regarding different instruments used for measuring. Interesting fact is that, technology area of Measuring was until recently, very much related to “cluster” around Medical and Veterinary science, and in present days is becoming focal point of Knowledge space of ADRION macro region by connecting two most propulsive “clusters” in ADRION macro region. Finally, we can assert that ADRION macro region knowledge space, at the moment encompasses several clusters of closely related technological areas: Medical and Veterinary Science “cluster”, ICT “cluster”, Basic electric elements “cluster”, Vehicles in general “cluster” and two “clusters” that became visible in the last stage of development of knowledge space of ADRION macro region: “cluster” that encompasses technology areas of Combustion engines and Machine and engines in general and “cluster” that deals with environmental technology areas: Treatment of water, waste water, sewage and sludge and Physical and Chemical processes and Apparatus in general.

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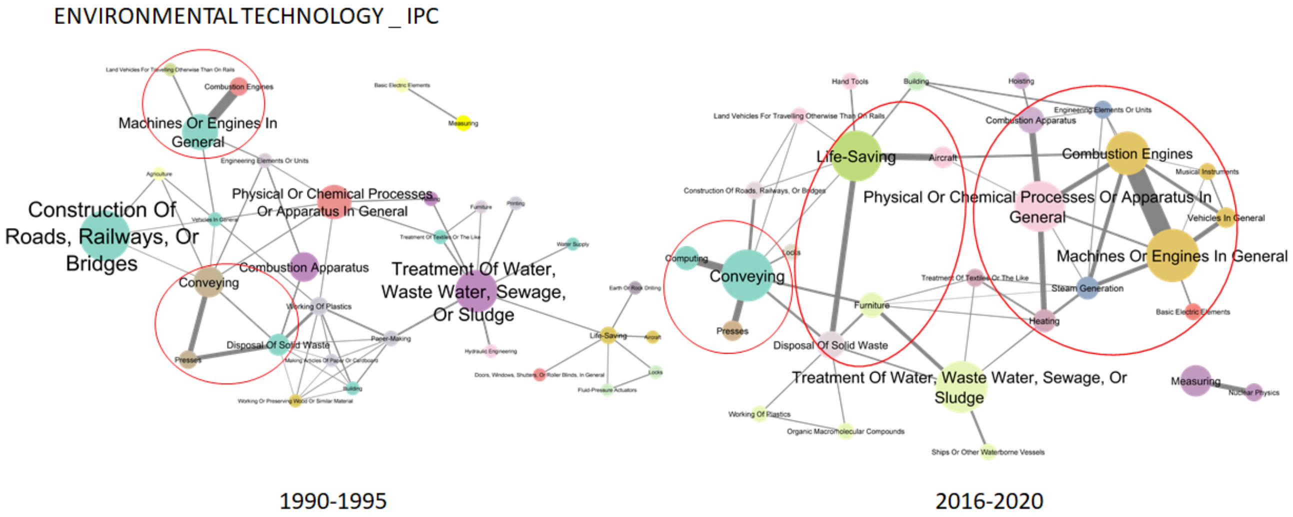
4.2 Environmental technology

Following part is dedicated to Environmental technology as a subnetwork of knowledge space of ADRION macro region. Environmental technology draws its importance from European New green deal[4] and is recognized as technology area with transformational promise regarding both, society and economy, in line with the strategic directions of new European Industrial strategy[5].

Figure 10 – Knowledge space and relatedness in Environmental technology in five-year periods 1990-1995 and 2016-2020 (IPC 3-digit classification)



Source: Authors own calculation; EPO PATSTAT

Figure 10 illustrates development of environmental technology in last 30 years in ADRION macro region. As it is visible from picture, in five-year period from 1990 to 1995, different technological areas that constitute environmental technologies domain were relatively seldom related. Most prominent areas were: Construction of Roads, Railways or Bridges, Treatment of water, wastewater, sewage and sludge, "cluster" around what could be called automotive industry, encompassing following technology areas: Machines or engines in general, Combustion engines and Land vehicles for transportation other than on rails. And finally, "cluster" around technology areas of Conveying, Presses and Disposal of Solid waste. Development path of Environmental technology knowledge space brings us to right side of the Figure 10, and as it is visible from the picture, in last five-year period is clustered around 4 themes: Life-saving technologies in connection with Aircraft technology area and Disposal of solid waste technology area, "cluster" of technologies related to automotive industry encompassing Combustion engines, Machines or engines in general, Vehicles in general, Heating and Combustion apparatus technology areas, "cluster" of technologies around Conveying technology area including Presses and Disposal of solid waste technology areas and finally technology area of Treatment of Water, Wastewater, sewage and sludge.

[4] https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/delivering-european-green-deal_en
[5] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0102&from=HR

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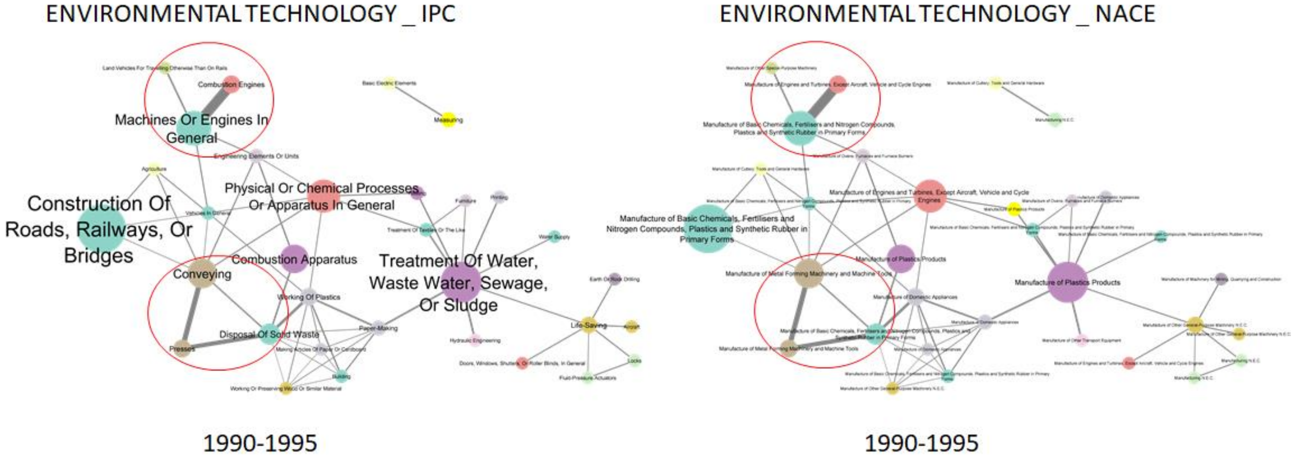
Figure 11 – Knowledge space and relatedness in Environmental technology in five-year periods 1990-1995 (IPC 3-digit classification and NACE v.2 classification)



Source: Authors own calculation; EPO PATSTAT

Figure 11 and Figure 12 illustrate linkages between manufacturing activities defined by NACE v.2 codes (4-digit) and technology areas regarding environmental technology domain in five-year periods from 1990 to 1995 and 2016 to 2020. As it is already mentioned, NACE v.2 codes are assigned to certain patent applications according to probability function, therefore they are not exclusive designators of patenting in certain technology area but provide us with insight on stakeholders in environmental technology domain. In first five-year period, firms under NACE v.2 code - Manufacture of plastic products (C22.2) are linked with technology area of Treatment of water, wastewater, sewage and sludge. Manufacture of metal forming machinery and machine tools (C28.4) have a connection with technology areas of Conveying and Presses. In what is defined as automotive "cluster" within Environmental technology domain, technology area Machines or engines in general is connected to Manufacture of Basic Chemicals, Fertilisers and Nitrogen Compounds, Plastics and Synthetic Rubber in Primary Forms (C20.1), and technology area Combustion engines is linked to Manufacture of Engines and Turbines, Except Aircraft, Vehicle and Cycle Engines (C28.11). Furthermore, technology areas denoted as Construction of roads, railways or bridges is connected to Manufacture of Basic Chemicals, Fertilisers and Nitrogen Compounds, Plastics and Synthetic Rubber in Primary Forms (C20.1).

In five-year period from 2016 to 2020, as it is visible in figure 12, linkages between environmental technology domain and manufacturing activities according to NACE v.2 classification are broadly divided into three "clusters". First "cluster" dealing with technology areas of Computing, Conveying and Presses, is connected to Computer programming, consultancy and related activities (J62) and Manufacture of metal forming machinery and machine tools (C28.4). Technology "cluster" around Life-saving technology area is linked to Manufacture of other chemical products (C20,5), Manufacture of Other General-Purpose Machinery N.E.C. (C28.29) and Manufacture of Other Special-Purpose Machinery (C28.9). Technology "cluster" around automotive industry is linked to following manufacturing activities: Manufacture of Other General-Purpose Machinery N.E.C. (C28.29), Manufacture of Motor Vehicles (C29.1), Manufacture of domestic appliances (C27.5) and Manufacture of Ovens, Furnaces and Furnace Burners (C28.21).

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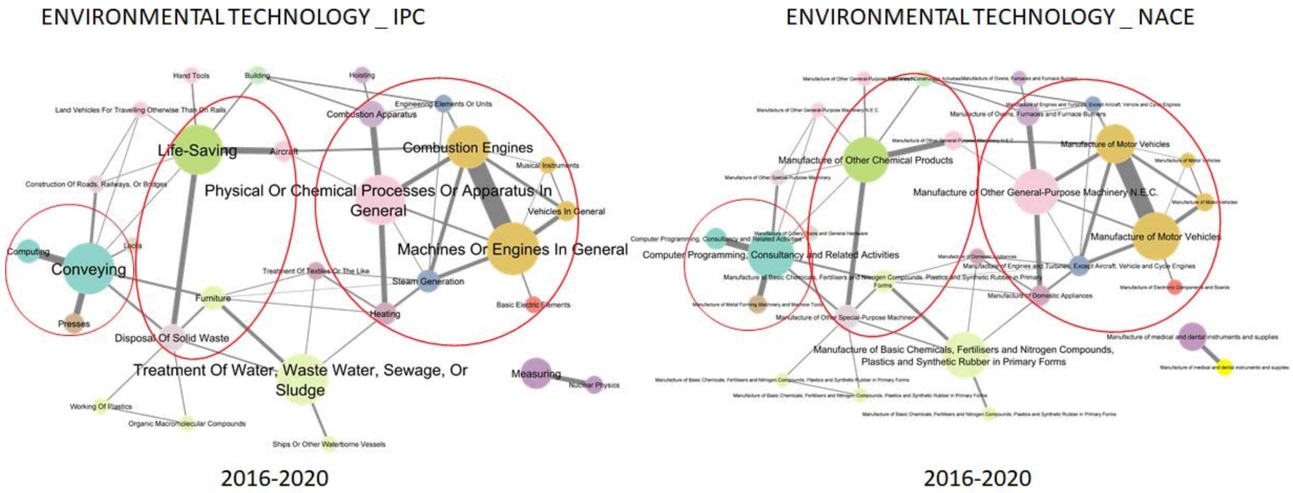
Figure 12 – Knowledge space and relatedness in Environmental technology in five-year periods 2016-2020 (IPC 3-digit classification and NACE v.2 classification)



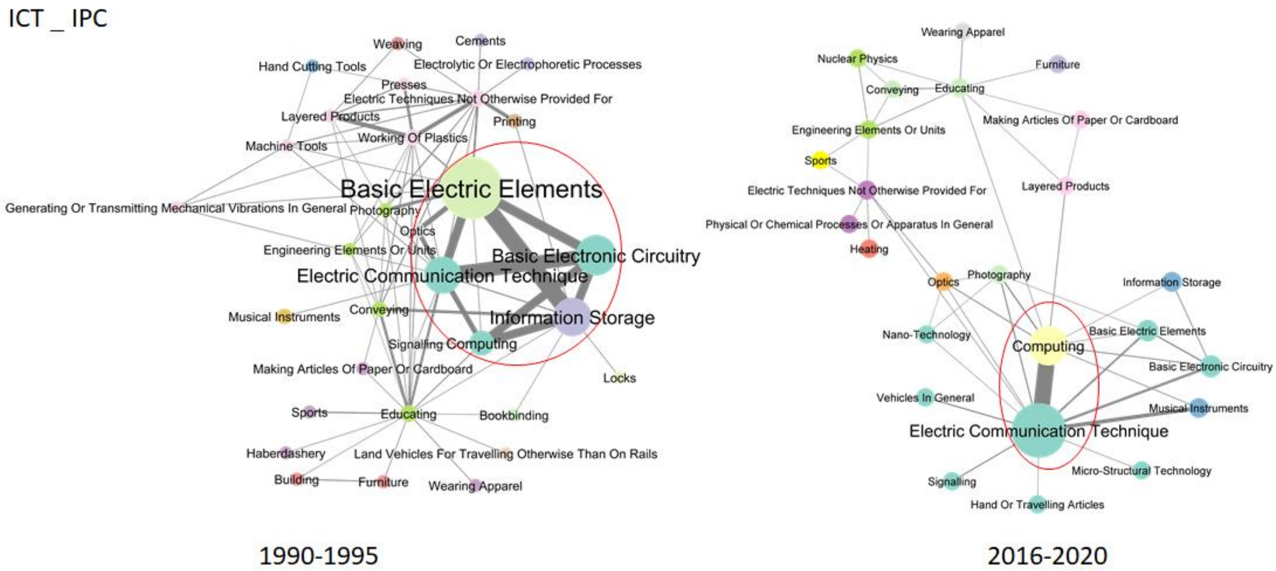
Source: Authors own calculation; EPO PATSTAT

4.3 Information and communication technology

Importance of Information and communication technologies again draws on European New green deal[6] but is as well, recognized as transformational tool in line with the strategic directions of new European Industrial strategy[7].

Figure 13 illustrates development of ICT knowledge space in ADRION region in last three decades, through snapshots of first five-year period from 1990 to 1995 and last five-year period from 2016 to 2020.

Figure 13 – Knowledge space and relatedness in ICT in five-year periods 1990-1995 and 2016-2020 (IPC 3-digit classification)

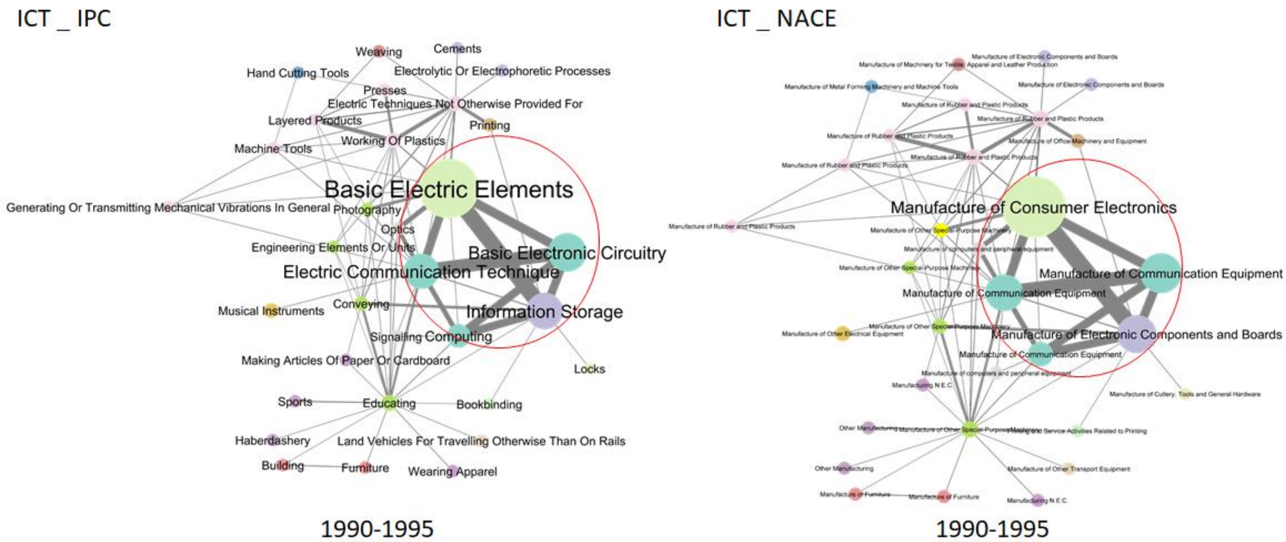


Source: Authors own calculation; EPO PATSTAT

As it is visible form Figure 12, ICT technologies, in five-year period form 1990 to 1995, where relatively highly interconnected in ICT core technological areas: Basic electric elements, Basic electronic circuitry, Electric communication technique, Computing and Information storage. Nevertheless, they related to various technological areas ranging from Educating, through Optics and Working of plastics. Development of knowledge space of ICT technologies throughout three decades are visible in Figure 12 as well. Up to period from 2016 to 2020, knowledge space of ICT technologies has changed quite a bit. Out of five highly interconnected core ICT technology areas in first five-year period, only two remained highly interconnected in last five-year period: Computing and Electric communication technique.

[6] https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/delivering-european-green-deal_en
[7] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0102&from=HR

Figure 14 – Knowledge space and relatedness in ICT in five-year periods 1990-1995 (IPC 3-digit classification and NACE v.2 classification)



Source: Authors own calculation; EPO PATSTAT

Figure 14 and figure 15 illustrate linkages between technology areas and manufacturing activities as classified by NACE v.2 classification, in bot five-year periods. As already mentioned, NACE v.2 classification is assigned to patent application by probability function, and does not exclusively designate patenting in certain technology area by certain manufacturing activity, but provide us with insight on stakeholders in ICT technology area. Figure 14 shows us linkages between core ICT technologies of the 1990s: Technology area of Basic electric elements is connected to Manufacture of Consumer Electronics (26.4); Manufacture of communication equipment (C26.3) is connected to three following technology areas: Electric communication technique, Basic electronic circuitry and Computing. Finally, technology area of Information storage is connected with Manufacture of Electronic components and boards (C26.1). Technology area of Optics was connected to Manufacture of computers and peripheral equipment (C26.2) and technology area Educating is linked to Manufacture of Other Special-Purpose Machinery (C28.9).

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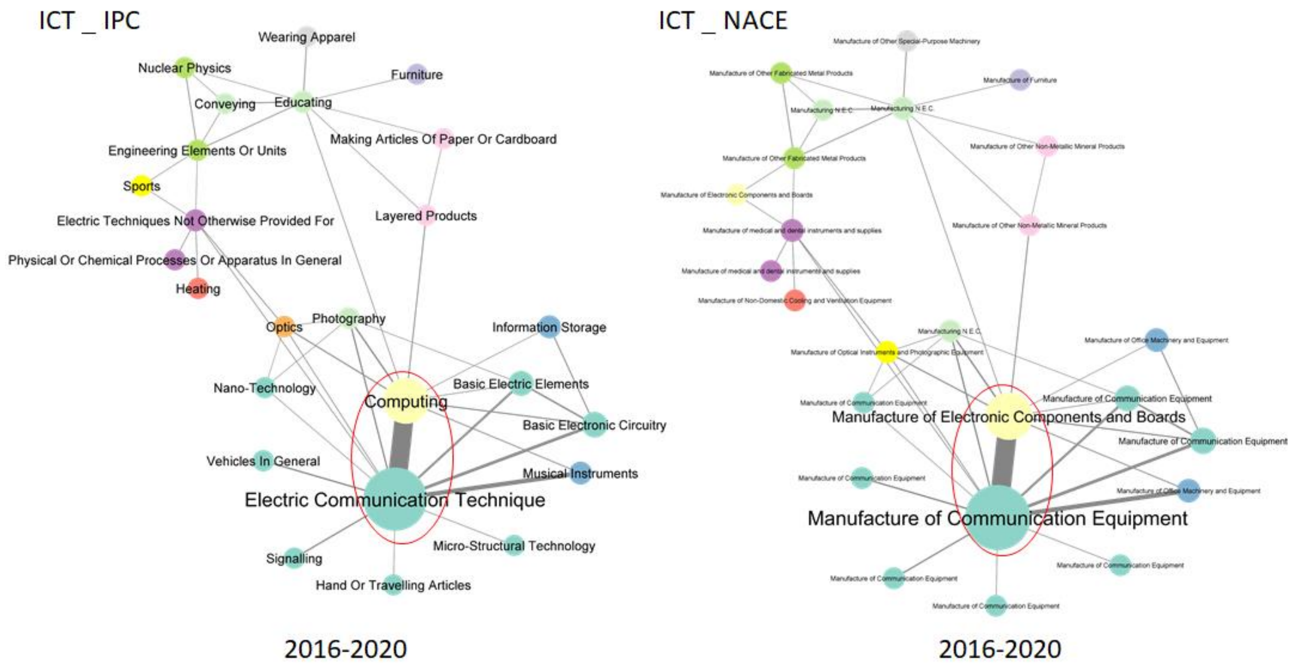
Figure 15 – Knowledge space and relatedness in ICT in five-year periods 2016-2020 (IPC 3-digit classification and NACE v.2 classification)



Source: Authors own calculation; EPO PATSTAT

In period from 2016 to 2020, as it is already mentioned, only two ICT technology areas remain strongly interrelated, and those are: Computing and Electric communication technique. AS it is visible from figure 15, Computing is linked to Manufacture of Electronic components and boards (C26.1) and Electric communication technique is linked with Manufacture of communication equipment (C26.3). Furthermore, Manufacture of communication equipment shares linkages to following technology areas: Vehicles in general, Signalling, Hand or travelling articles, Nano-technology and Micro-structural technology.

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5. KEY COMMON TECHNOLOGIES IN ADRION MACRO REGION – THE JUSTIFICATION AND RECOMMENDATIONS

One of the most important insights that has dominated the field of innovation research in recent decades is the fact that innovation is a collective activity. They are created within a broader system commonly referred to as an "innovation system" or an "innovation ecosystem" (Herkkert et al., 2011). The innovation capacity of a certain area and the level of innovation will depend on how the innovation system is organized and on the efficiency of its operation.

It is important to stress that the smart specialisation process, as one of the main features, includes entrepreneurial discovery process that identifies priority areas or what a country or region does best in terms of research, development and innovation (Foray et al., 2012). The main issues identified in the European Union countries were smaller share of high-tech R&D intensive sectors and spatial dispersion of the R&D activities. Camagni and Capello (2013) stressed that this spatial dispersion resulted in insufficient critical mass, investment duplications, inefficient resource allocation, weak learning processes, etc. Smart specialisation has a strong regional dimension because regions are increasingly important as sources of innovation activities, especially when the impacts of agglomerations are taken into account (Foray and Goenaga, 2013). Hence, regions need to focus on developing distinctive and original areas of specialisation. A regional approach to the innovation system was developed by experts in the field of geographical economics who tried to explain the role of institutions and organizations in the regional concentration of innovative activities (Asheim et al., 2003).

Smart specialisation is a process of identifying and selecting desirable areas for intervention where a cluster of activities should be developed. These areas should be discovered by entrepreneurs. Smart specialisation must not be associated with a strategy of the simple industrial specialisation of a particular region, but rather with R&D and innovation (Bilas, 2020). The main feature of smart specialisation is the definition of the limited set of priority areas for public investment which can best provide opportunities for growth and respond to social and economic challenges (Gianelle et al., 2019). Also, according to Haegeman et al. (2019), a key feature of smart specialisation is a clear thematic focus on research and innovation, through the selection of a limited number of priorities.

The separation of production and design as parts of globalisation processes has further reinforced the importance of knowledge production. At the same time, the spatial distribution of innovation activity is very uneven, largely due to the limited diffusion of knowledge over larger distances (Vlčkova et al., 2018).

As Kogler et al. (2017) stated, knowledge space methodology enables mapping and analyzing regional knowledge spaces and definition of science and technology domains that are present in a place/firms, and then to analyze their properties in terms of size and connectedness as a basis for the process of smart specilization. In the context of S3, domains for which high concetedness is found deserve a special attention/support.

Innovation is one of the most spatially concentrated activities and geographical proximity in the creation of knowledge continues to be important. Regional capabilities have been found to be more important for knowledge creation and regional specialisation than national ones. Patents are both a tool for promoting innovation and a useful metric by which to measure it.

Smart specialisation aims to boost regional and national innovation, contributing to growth and prosperity and enabling territories to focus on their competitive advantages (Gómez Prieto et al., 2019; Tolias, 2019).

Gianelle et al. (2019) analysed to what extent the principles of smart specialisation are actually translated into policy implementation. The main conclusion of this study is that regions and countries use the selective approach of smart specialisation and that only partial transition occurred from prior industrial policy to the smart specialisation approach. Main divergences are broadly defined priority areas, loose alignment of policy instruments with priorities, and scarce customisation of policy measures to the specific innovation needs. Ganielle et al. (2019) believe that one of the possible reasons is that incentive structure at the European Union level does not fully support the intervention logic of smart specialisation, and advise that this structure.

Due to data scarcity, it is still not possible to compare the results of policy actions taken thus far or still ongoing in the EU countries. However, so far, it can be concluded that most of the regions/countries of the European Union have identified similar S3 priority areas to focus on (agri-food, key enabling technologies, health, energy, digital agenda, etc.). One of the key factors which will contribute largely to the achievement of the desired results of the implementation of smart specialisation strategies is the ability of key stakeholders (quadruple helix) to collaborate in all phases of smart specialisation, from identifying the priority areas to implementing policy actions (Bilas, 2020).

Globally, innovation capacity is concentrated in several countries around the world, although that number is growing. However, innovation capacity changes over time and between countries. Countries that once dominated in the field of innovation will not necessarily dominate in the future. The question is what determines innovation capacity and how does innovation depend on location? On the one hand, businesses and the private sector are the main sources of innovation. On the other hand, the innovation capacity of companies within a country is determined by national policy and the structure and efficiency of public institutions. Innovation intensity depends on the interaction of the private and public sectors. Having all this in mind, it can be acknowledged that macro-regions represent specific challenge in terms of determining and implementing innovation strategies.

As stated in the EUSAIR, ADRION lacks on clustering and strong cooperation between research and public and private sectors. In order to successfully develop and implement common innovation strategy, these weaknesses should be addressed. Development of the innovation value chain as a platform for interconnecting stakeholders in the processes of innovation and commercialisation of innovation is of great importance. Innovation value chain is considered to be a fundamental instrument of growth strategies (Gunday et al., 2011).

For example, the Value Chain Innovation Initiative brings together academics and industry leaders and practitioners to advance the theory and practice of global value chain innovation through research and knowledge dissemination. Innovation value chain is the end-to-end approach to generate, transform and disseminate knowledge and ideas (Taghizadeh et al., 2014). Policies aimed at expanding the innovation capacity can have positive outcomes by encouraging research and development activities and establishing innovation networks.

It was expected that analysis will show high level of innovation activities on the north of the ADRION, and low level of innovation activities on the south of the ADRION. Lack of cooperation and connectivity between stakeholders, inconsistency of basic research in public sector and applied research in industry, improper functioning of institutions in charge of technology and information diffusion and lack of absorption capacity of companies can contribute to inefficient innovation system and consequently low innovation rate.

However, despite the differences within the ADRION, on the macro-region level, inclusive approach should be fostered. Blue Growth, as one of the pillars of EUSAIR strongly supports inclusive growth, as defined by EUSAIR.

As it is already mentioned, ADRION region knowledge space in last decade, has developed towards rather multi-clustered knowledge space with many interconnected technology domains that are producing majority of knew knowledge. Those technology domains or "clusters" are:

1. Medical and Veterinary "cluster"
2. Automotive "cluster"
3. ICT "cluster"
4. Environmental technology "cluster
5. Combustion engine "cluster"

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ANNEX

Annex 1. European patent applications filed with the EPO

Country of residence of the applicant*		2020	2019	Change
AT	Austria	2,303	2,346	-1.8%
BE	Belgium	2,400	2,422	-0.9%
BG	Bulgaria	52	35	48.6%
CY	Cyprus	64	48	33.3%
CZ	Czech Republic	205	203	1.0%
DE	Germany	25,954	26,762	-3.0%
DK	Denmark	2,404	2,415	-0.5%
EE	Estonia	57	48	18.8%
ES	Spain	1,791	1,885	-5.0%
FI	Finland	1,895	1,705	11.1%
FR	France	10,554	10,233	3.1%
GR	Greece	136	141	-3.5%
HR	Croatia	22	19	15.8%
HU	Hungary	107	97	10.3%
IE	Ireland	970	882	10.0%
IT	Italy	4,600	4,469	2.9%
LT	Lithuania	50	29	72.4%
LU	Luxembourg	394	415	-5.1%
LV	Latvia	27	22	22.7%
MT	Malta	65	58	12.1%
NL	Netherlands	6,375	6,942	-8.2%
PL	Poland	483	463	4.3%
PT	Portugal	249	272	-8.5%
RO	Romania	54	40	35.0%
SE	Sweden	4,423	4,395	0.6%
SI	Slovenia	165	122	35.2%
SK	Slovakia	55	42	31.0%
Total		**65,854**	**66,510**	-1.0%

* In cases where several applicants are mentioned on the application form, the country of residence of the first applicant listed applies.

Source: EPO.

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Annex 2. EPO Top 25 applicants

Rank*	Company	European patent applications in 2020	Change 2020 vs. 2019	Geographic origin**
1	SAMSUNG	3,276	14.6%	KR
2	HUAWEI	3,113	-11.7%	CN
3	LG	2,909	3.3%	KR
4	QUALCOMM	1,711	2.6%	US
5	ERICSSON	1,634	1.1%	SE
6	SIEMENS	1,625	-28.9%	DE
7	ROBERT BOSCH	1,597	6.6%	DE
8	SONY	1,477	-2.3%	JP
9	ROYAL PHILIPS	1,419	-8.0%	NL
10	BASF	1,305	-4.5%	DE
11	RAYTHEON TECHNOLOGIES	1,284	-46.3%	US
12	ALPHABET	1,117	-6.6%	US
13	MICROSOFT	1,087	-2.2%	US
14	JOHNSON & JOHNSON	1,049	7.8%	US
15	INTEL	1,011	23.6%	US
16	NOKIA	826	12.7%	FI
17	PANASONIC	792	1.3%	JP
18	GENERAL ELECTRIC	775	-37.9%	US
19	OPPO	715	-20.6%	CN
20	HP	699	23.5%	US
21	SIGNIFY	691	5.3%	NL
22	ABB	678	-1.6%	CH
23	HOFFMANN-LA ROCHE	656	-3.1%	CH
24	CONTINENTAL	653	5.8%	DE
25	MITSUBISHI ELECTRIC	647	-5.5%	JP

* This is the ranking of the main consolidated applicants at the EPO in 2020 (first-named applicant principle). It is based on European patent applications filed with the EPO, which include direct European applications and international (PCT) applications that entered the European phase during the reporting period. Applications by identifiable subsidiaries, not necessarily located in the same country, are allocated to the consolidated applicants.

** Country of residence of the headquarters.

Source: EPO.

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Annex 3. Established and emerging sectors and subsectors of the Blue Economy

ESTABLISHED SECTORS			
Relation to the sea	**Sector**	**Subsector**	**Activity (NACE rev.2)**
Marine-Based activities	Marine living resources	Primary sector	A03.11 Marine fishing (SSCF Capture fisheries)
			A03.12 Freshwater fishing (Capture fisheries LSF)
			A03.13* (Capture fisheries DWF)
			A03.21 Marine aquaculture
			A03.22 Freshwater aquaculture
			A03.23* (Shellfish aquaculture)
		Processing of fish products	C10.20 Processing and preserving of fish, crustaceans and molluscs
			C10.41 Manufacture of oils and fats
			C10.85 Manufacture of prepared meals and dishes
			C10.89 Manufacture of other food products n.e.c.
		Distribution of fish products	G46.38 - Wholesale of other food, including fish, crustaceans and molluscs
			G47.23 - Retail sale of fish, crustaceans and molluscs in specialised stores
	Marine non-living resources	Oil and Gas	B06.10 Extraction of crude petroleum
			B06.20 Extraction of natural gas
			B09.10 Support activities for petroleum and natural gas extraction
		Other minerals	B08.12 Operation of gravel and sand pits; mining of clays and kaolin
			B08.93 Extraction of salt
			B09.90 Support activities for other mining and quarrying
	Marine renewable energy	Offshore wind energy	D35.11 Production of electricity
			D35.12 Transmission of electricity
	Maritime transport	Passenger transport	H50.10 Sea and coastal passenger water transport
			H50.30 Inland passenger water transport
		Freight transport	H50.20 Sea and coastal freight water transport
			H50.40 Inland freight water transport
		Services and transport	H52.29 Other transportation support activities
			N77.34 Renting and leasing of water transport equipment
	Coastal tourism	Accommodation	I55.10 Hotels and similar accommodation
			I55.20 Holidays and other short-stay accommodation
			I55.30 Camping grounds, recreational vehicle parks and trailer parks
			i55.90 Other accommodation
		Transport	G47.30 Retail sale of automotive fuel in specialised stores
			H49.10 Passenger rail transport, interurban
			H49.31 Urban and suburban passenger land transport

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			H51.10 Passenger air transport
		Other Expenditure	G47.60 Retail sale of cultural and recreational goods in specialised stores
			G47.70 Retail sale of other goods in specialised stores
			I56.00 Food and beverage service activities
Marine-Related activities	Port activities	Cargo and warehousing	H52.10 Warehousing and storage
			H52.24 Cargo handling
		Port and water projects	F42.91 Construction of water projects
			H52.22 Service activities incidental to water transportation
	Shipbuilding and repair	Shipbuilding	C30.11 Building of ships and floating structures
			C30.12 Building of pleasure and sporting boats
			C33.15 Repair and maintenance of ships and boats
		Equipment and machinery	C13.92 Manufacture of made-up textile articles, except apparel
			C13.94 Manufacture of cordage, rope, twine and netting
			C25.99 Manufacture of other fabricated metal products n.e.c.
			C26.51 Manufacture of instruments and appliances for measuring, testing and navigation
			C28.11 Manufacture of engines and turbines, except aircraft, vehicle and cycle engines
			C32.30 Manufacture of sports goods

EMERGING SECTORS		
Relation to the sea	**Sector**	**Subsector**
Marine-Based activities	Marine renewable energy	Floating offshore wind
		Wave and tidal energy
		Floating solar photovoltaic energy
		Hydrogen generation offshore
	Marine minerals	n/a
	Desalination	n/a
Marine-Related activities	Maritime defence	n/a
	Submarine cables	n/a
	Blue bioeconomy and biotechnology	The algae sector

Source: The EU Blue Economy Report (2020).

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