ISSN 1831-9424

European Commission

SMART SPECIALISATION IN THE EU ENLARGEMENT REGION

Smart Specialisation in the Western Balkans: potential for knowledge-based economic cooperation

Radovanovic, N., Fabbri, E., Matusiak, M., Conte, A., Salotti, S., Dosso, M., Hollanders, H., Merkelbach, I., Tolias, Y., Duran Silva, N., Fuster Martí, E., Massucci, F., Plazas, A.

Joint Research Centre

EUR 31911 EN

Contact information

Emanuele Fabbri, European Commission - Joint Research Centre, Seville, Spain

e-mail: *emanuele.fabbri@ec.europa.eu*

EU Science Hub

https://joint-research-centre.ec.europa.eu

JRC136606

EUR 31911 EN

PDF ISBN 978-92-68-14411-4 ISSN 1831-9424 doi:10.2760/86912 KJ-NA-31-911-EN-N

Luxembourg: Publications Office of the European Union, 2024

How to cite this report: Radovanovic, N., Fabbri, E., Matusiak, M., Conte, A., Salotti, S., Dosso, M., Hollanders, H., Merkelbach, I., Tolias, Y., Duran Silva, N., Fuster Martí, E., Massucci, F.A. and Plazas, A., *Smart Specialisation in the Western Balkans: potential for knowledge-based economic cooperation*, Radovanovic, N., and Fabbri, E. editors, Publications Office of the European Union, Luxembourg, 2024, doi:10.2760/86912, JRC136606.

JRC TECHCNICAL REPORT

Smart Specialisation in the Western Balkans: potential for knowledge-based economic cooperation

EDITORS

Nikola Radovanović
Emanuele Fabbri

AUTHORS

Nikola Radovanović, Emanuele Fabbri, Monika Matusiak, Andrea Conte, Simone Salotti, Mafini Dosso, Hugo Hollanders, Iris Merkelbach, Yannis Tolias, Nicolau Duran, Enric Fuster, Francesco A. Massucci, Adrià Plazas

2024

CONTENTS

ABSTRACT

All Western Balkan economies launched their first respective Smart Specialisation strategy development processes by 2018, wishing to enhance their innovation policy frameworks with the evidence-based and participatory approach for revealing priority areas for policy intervention. Within these efforts, the economies had a complex task to thoroughly analyse their promising domains through economic, innovation and scientific mapping exercises. This report gives an overview of the regional competitiveness based on providing evidence on specialisation as well as emerging areas, highlighting their potential in detail. Although common patterns of economic specialisation are relatively rare, Western Balkan economies express a certain potential for science & technology collaborations. Smart Specialisation processes can enhance regional collaborations and contribute to bridging gaps between Science and Industry.

DISCLAIMER

EDITORS

Nikola Radovanovic,
European Commission, Joint Research Centre, Seville, Spain

Emanuele Fabbri,
European Commission, Joint Research Centre, Seville, Spain

AUTHORS

Nikola Radovanovic,
European Commission, Joint Research Centre, Seville, Spain

Emanuele Fabbri,
European Commission, Joint Research Centre, Seville, Spain

Monika Matusiak,
European Commission, Joint Research Centre, Seville, Spain

Andrea Conte,
European Commission, Joint Research Centre, Seville, Spain

Simone Salotti,
European Commission, Joint Research Centre, Seville, Spain

Mafini Dosso,
European Commission, Joint Research Centre, Seville, Spain

Hugo Hollanders,
UNU-MERIT, Maastricht, Netherlands

Iris Merkelbach,
Independent expert, Switzerland

Yannis Tolias,
Innovatia Systems, Thessaloniki, Greece

Nicolau Duran,
SIRIS Academic, Barcelona, Spain

Enric Fuster,
SIRIS Academic, Barcelona, Spain

Francesco A. Massucci,
SIRIS Academic, Barcelona, Spain

Adrià Plazas,
SIRIS Academic, Barcelona, Spain

EXECUTIVE SUMMARY

POLICY CONTEXT

Smart Specialisation is the capacity of an economic system to generate new specialties through the discovery of new domains of opportunity and the local concentration and agglomeration of related resources and competences (Foray, 2015). During the last decade, Smart Specialisation has become one of the core strategic approaches to Research and Innovation, as well as an effective policy instrument for higher competitiveness and increasing opportunities in the EU.

Following this success, also the Western Balkan economies chose to develop Smart Specialisation strategies (S3) to strengthen their innovation ecosystems and in 2017, and by 2018 all Western Balkan economies expressed their willingness to pursue the improvement of innovation policies by applying the Smart Specialisation approach with guidance and technical support of the European Joint Research Centre (JRC).

Smart Specialisation is part of the EU accession process for the six Western Balkans economies, and in order to facilitate the S3 design process the JRC has developed a framework[(1)] as a guidance made of phases and sub-articulated in stages accompanying policy makers in the path towards the drafting of the strategy and the formal approval. Mapping potential is one of the main pillars of this process, directly finalised to identify the main preliminary area of interest and properly inform the following phases of stakeholder dialogue and strategy drafting (Radovanovic and Bole, 2023; Perianez-Forte and Wilson, 2021; Radovanovic and Benner, 2019; Marinelli and Perianez-Forte, 2017; Kyriakou et al, 2016; Gianelle et al, 2016; Foray, 2015; Foray and Goenaga, 2013; Foray and Rainoldi, 2013; Foray et al., 2009).

The Western Balkans region is striving to enhance its economic development and foster innovation. Historically, the region has faced significant economic and social challenges - including high unemployment, low levels of innovation, and limited access to advanced technologies - however, in recent years, there has been a concerted effort to transition towards a knowledge-based economy and improve the region's overall economic performance.

In this transition the region is attempting a shift from traditional industries towards knowledge-intensive sectors. This shift is driven by the recognition that a knowledge-based economy can lead to higher levels of productivity, innovation, and competitiveness. Furthermore, the emphasis on knowledge-based economic activities has the potential to attract foreign direct investment and promote sustainable growth pathways.

Each economy in the region is currently working on advancing its innovation ecosystem through the adoption of smart specialisation processes.

Mapping potential is one of the activities that each economy in the region has addressed with different level of advancement and different challenges to tackle in terms of data availability and consistency of classifications. This publication comes at the end of an articulated activity conducted both at aggregated level in the region and at country specific level for each of the six Western Balkans economies.

KEY CONCLUSIONS

Mapping potential in a decision making context presents several methodological constraints, such as time boundednesses, heterogeneity and scarcity of data, and calls upon to adopt several and integrated methodologies.

In the report the main findings coming from the economic scientific and technological potential in the region are reported, as well as the main specificities for each economy. While there are significant opportunities for smart specialisation and knowledge-based economic cooperation in

(1) *For the Smart specialisation framework for Enlargement and Neighbourhood countries see Matusiak and Kleibrink (2018)*

the Western Balkans, several challenges need to be addressed.

The potential benefits of Smart Specialisation and knowledge-based economic cooperation in the Western Balkans include enhanced competitiveness, job creation, sustainable economic development, and integration into global value chains. By leveraging their specific strengths and fostering collaboration, the countries of the region can unlock their innovation potential and position themselves for long-term development path.

Smart specialisation offers a significant opportunity for the Western Balkans to transform their economies and promote sustainable growth. By aligning with their competitive advantages and fostering knowledge-based economic cooperation, the region can enhance innovation, productivity, and competitiveness. Addressing the challenges and seizing the opportunities of smart specialisation can contribute to the long-term economic development and integration of the Western Balkans into the global knowledge economy.

Smart specialisation is included in the key policy and programming documents for the entire EU enlargement and neighbourhood region, including the Western Balkan Agenda for Research, Innovation, Culture, Youth and Sport, Eastern Partnership deliverables for 2025, Joint Communication on renewed Southern Neighbourhood, Horizon Widera, IPA, NDICI and Economic and Investment Plans.

Findings from this analysis can represent a starting point for further elaborations, in line with the main goals of the Western Balkans Agenda for Research, Innovation, Culture, Youth and Sport and the Growth Plan for the Western Balkans.

MAIN FINDINGS

Economic specialisations in the six Western Balkans economies have been identified using aggregate industry data for employment and turnover for 2012-2019. These data have been extracted from the Orbis database, which comprises statistics on turnover and number of employees for enterprises operating at the NACE[(2)] 4-digit industry level.

For each WB economy, enterprise data have been aggregated to the NACE 3-digit industry level to identify two types of industries: industries with a current strength or already specialised industries with a sufficient critical mass, and industries with an emerging strength or industries with increasing degrees of specialisation and critical mass. For all the six Western Balkan economies combined, 58 industries have current strengths, 31 industries have emerging strengths, and 8 industries have both current and emerging strengths.

Industries that at country level present both current and emerging economic strengths are “Manufacture of parts and accessories for motor vehicles”, “Steam and air conditioning supply”, “Other specific construction works”, “Wholesale of food, beverages and tobacco”, “Support activities for transportation”, “Restaurants and mobile food service activities”, “Wired telecommunications activities”, “Other telecommunications activities”. Anyway at regional level common patterns of economic specialisation (both current and emerging) are relatively rare, and the Western Balkan economies appear to have their own unique pattern of specialisation.

With regards to scientific and technological potential, S&T data for the six WB economies have been aggregated and specialisations have been calculated on Scientific Publications, Patents, Trademarks, European competitive R&I and cultural projects and Clusters and Science Parks. Data sources on science and technology present several differences in terms of classifications and the topic modelling approach has been considered as adequate in order to overcome mismatching. 10 S&T domains of relevance for the WB R&D ecosystem were found that can be grouped into science-oriented (i.e. relatively publication-intense)

(2) The acronym NACE (Nomenclature Générale des Activités Économiques dans les Communautés Européennes) refers to the statistical classification of economic activities in the EU. For additional insights see: ***https://ec.europa.eu/eurostat/web/nace***

domains, balanced domains and technology-oriented (i.e. relatively patent-intense) domains, that is, ordered by number of total records: 1. Health and wellbeing is a science-oriented domain, with a large volume of associated records and a slowly growing trend. 2. ICT is a balanced domain, with a large volume of associated records and a rather stable trend. 3. Process industries and materials is a technology-oriented domain, with a large volume of associated records and a stable trend. 4. Better societies - governance, culture, education and the economy is a science-oriented domain, with a medium-sized volume of associated records and growing trend. 5. Food is a technology-oriented domain, with a medium-sized volume of associated records and a stable trend. 6. Environmental sciences and industries is a balanced domain, with a medium-sized volume of associated records and a stable trend. 7. Heavy machinery is a balanced domain, with a low volume of associated records and a slightly declining trend. 8. Energy is a balanced domain, with a low volume of associated records and a stable trend. 9. Electric and electronic technologies is a science-oriented domain, with a low volume of associated records and a stable trend. Finally, 10. Transport is a balanced domain, with a low volume of associated records and a stable trend.

The mismatch between economic and scientific and technological potential is not a surprise, particularly for non-tradable services, and although common patterns of economic specialisation are relatively rare, Western Balkan economies express a certain potential for science & technology collaborations. In this sense, the analysis of WB economies' S&T specialisation shows, overall, a notable thematic alignment or overlap. The 10 identified preliminary S&T domains are present in all the economies, and although the rank of each domain in each economy may change, the relative distribution of domains is largely similar. This means that whatever the selected S3 domains and niches in each economy are, there will be some peers with overlapping priorities and thus potential for collaboration. One of the goals of smart specialisation strategies in the region is to bridge the gap between Industry and Science, as well as enhance the development potential unlocking opportunities and exploiting technological strengths.

The analyses conducted at country level led to a deeper insight into each economy and informed policy makers and relevant stakeholders engaged in the process towards the drafting of the strategies.


CHAPTER
1

1. Introduction

Smart Specialisation is a key concept in regional development, focusing on identifying and developing areas of competitive advantage based on a region's specific strengths and potential. The Western Balkans region - comprising Albania, Bosnia and Herzegovina, Kosovo, Montenegro, North Macedonia, and Serbia - has seen significant economies in transition towards a knowledge based economy. With the goal of EU integration, the region has been focusing on economic reforms and development. This report examines the potential for smart specialisation and knowledge-based economic cooperation in the Western Balkans.

The six economies are characterized by a mix of agricultural, industrial, and service-based economies. While there has been progress in economic development, challenges such as high unemployment, low levels of foreign direct investment, and infrastructure gaps persist. Smart specialisation can provide a strategic framework for the Western Balkans to identify and build upon their competitive advantages, fostering innovation and economic growth. Each economy in the region possesses unique assets, including natural resources, human capital, and geographic location, which can be leveraged through smart specialisation.

In order to facilitate the S3 design process in the region, the JRC has developed a framework with phases and operational task. The S3 design framework represents a guidance that each economy has been following in its process towards the drafting of the Strategy.

One of the main challenging phase in the S3 design process regards the mapping potential. This phase is supposed to detect main potential areas of interest and inform the following phases of stakeholder dialogues and Strategy drafting.

Being Smart specialisation a paradigm strongly based on evidences, the mapping phase is called upon to provide relevant information adopting several and different methodologies, primarily both quantitative and qualitative.

The main objective of mapping potential in a context of decision making is to inform relevant stakeholders on main opportunities ahead. Smart specialisation is about prioritisation and structural transformation, any mapping potential activities is called upon to provide information on domains that have the potential to generate growth development and to a larger extent address main challenges ahead.

To this purpose several methodologies can be adopted and in this report main findings coming from the mapping of economic, scientific and technological potential in the region are proposed.

After the introduction, the report is articulated into 3 analytical parts, followed by conclusive remarks. The first part is dedicated to the presentation of the methodology adopted by the JRC in the EU enlargement and neighbourhood region and the state of play of the 6 Western Balkans economies in their path towards smart specialisation. The second part represents the main results coming from mapping economic potential. The third part represents the main results coming from mapping scientific and technological potential. The analytical parts are followed by conclusive remarks.

CHAPTER

2. Methodological approach and the progress of smart specialisation in the Western Balkan economies

Smart Specialisation is the capacity of an economic system to generate new specialties through the discovery of new domains of opportunity and the local concentration and agglomeration of resources and competences in these domains (Foray, 2015).

During the last decade, Smart Specialisation has become one of the core strategic approaches to Research and Innovation, as well as an effective policy instrument for higher competitiveness and increasing opportunities in the EU, mainly adopted within the EU cohesion policy.

Following the success of the implementation of the Smart Specialisation approach across the EU Member States, the Western Balkan economies chose to develop Smart Specialisation strategies to strengthen their innovation ecosystems. Starting from a small pilot project in 2017, JRC has developed the dedicated Smart Specialisation methodology, followed on a voluntary basis by the governments in the Western Balkan region. Following this success, DG REGIO, DG NEAR and DG RTD decided to further support this process, which is now included in the key policy and programming documents for the entire EU enlargement and neighbourhood region, including the Western Balkans Agenda for Research, Innovation, Culture, Youth and Sport, Eastern Partnership deliverables for 2025, Joint Communication on renewed Southern Neighbourhood, Horizon Widera, IPA, NDICI and Economic and Investment Plans.

In 2017, the JRC launched a project on "Smart specialisation and organisational development in enlargement and H2020 associated countries", with the overall objective of strengthening the capacity building in the EU Enlargement and Neighbourhood Region in the field of innovation policy and assisting public authorities in the design of Smart Specialisation Strategies. By 2018, all Western Balkan economies expressed their willingness to pursue the improvement of innovation policies by applying the Smart Specialisation approach with guidance and technical support of the Joint Research Centre

To address these growing needs in the Western Balkans region concerning the development of Smart Specialisation strategies, DG NEAR and JRC have collaborated and intensified the support in the development of Smart Specialisation strategies in the region, with practical guidance, methodological support and capacity building initiatives.

In the last 5 years the JRC has been providing guidance and assistance for the development of Smart Specialisation strategies in the Western Balkans, based on the extensive knowledge and analytical competences developed in Smart Specialisation Platform (S3P) within the support to EU countries. The overall objective has been to strengthen the capacity building of the Western Balkan economies in the field of innovation policy, and to assist public authorities in the design of Smart Specialisation strategies.

In order to have an effective design and implementation of place-based innovation policies a certain institutional maturity is seen as necessary for tailoring support instruments, acquiring, interpreting and using data, as well as renewing policy-cycle processes.

In order to facilitate the strengthening process of S3 institutional and administrative capacity in the region, the JRC supports the Western Balkans economies in terms of practical guidance and targeted analyses. With regards to practical guidance, two frameworks have been put in place, namely the "Smart specialisation framework for Enlargement and Neighbourhood coun-

tries"[3] (S3 Design Framework) and the "Smart Specialisation implementation framework for the EU Enlargement and Neighbourhood Region"[4] (S3 Implementation Framework). With regards to the analytical support, several studies have been conducted and currently available systemized in the "Knowledge hub"[5], a platform for facilitating knowledge sharing and collaboration among different stakeholders involved in design and implementation of Smart Specialisation strategies.

2.1 S3 Design Framework

The **"S3 Design Framework"** represents the main guidance supporting EU enlargement and neighbourhood economies in the path towards the drafting of the strategy and the formal approval. It is made of phases and sub-articulated in stages and is conceived as a hands-on instrument to tackle the numerous challenges linked the S3 design process, such as capacity-building, mapping potential, stakeholder dialogue, and institutional capacity for implementation towards the final strategy.

It is a practical contribution to the design and implementation of participatory, place-based and evidence-based innovation strategies, data availability and quality enhancement, as well as technology transfer in the WB region and strengthening the connections with the EU and within the region in terms of R&I capacity and performance. For each stage of the process and operational description is provided, and the role of national/regional administration is described with main research input needed.

The S3 design framework is reported in Annex 1, the framework is currently followed by all Western Balkans economies in their S3 design tasks as part of their EU accession processes. The aim of the framework is to provide an easy to follow guidance and this aim each phase of the framework contributes and informs the following one, towards the drafting of the Strategy.

One of the main part of the framework is represented by the "Mapping exercise" and more precisely the "Mapping of economic, innovation and scientific potential"[6]. Mapping is a statistical analysis of main strengths and specialisations in terms of economic, innovation and scientific potential, encompassing also other related drivers, such as e.g. human capital capacities. Its objective is to indicate preliminary areas of smart specialisation based on the expert assessment of matches between the three types of potential. The main output of this activity is the identification of preliminary domains to be further investigated in the phase of stakeholders' dialogue.

The mapping exercise in articulated into two phases. It starts with a quantitative analysis and it is followed by a qualitative insight. Additional analyses can provide better understanding of the priority domains. They can include international benchmarking, analysis of value chains, revealed comparative advantage, sector skills studies on future needs, relevant education indicators and other relevant issues.

The main objective of this phase is to inform relevant stakeholders taking part in the process of opportunities' exploration and decision making. The results of the mapping exercise must be consulted with internal and external stakeholders. Internal stakeholders include all the ministries and departments that have competences concerning the analysed potentials. External stakeholders are representatives of business, education and training institutions, academia and NGOs relevant from the point of view of the preliminary smart specialisation domains. The smart specialisation

(3) *See Matusiak and Kleibrink (2018)*

(4) *See Matusiak, et. al. (2022)*

(5) ***https://s3platform.jrc.ec.europa.eu/knowlegde-hub***

(6) *The mapping analysis foreseen in the S3 design framework is conducted at national or sub-national level, taking account of the specificities of each countries and handling main country specific constraints in terms of data availability, length of time-series and consistency of classifications. A national or sub/national perspective allows a deeper insight on country specific untapped potential. To the purpose of clarity, the mapping activity reported in this publication is fed with national data but aims at provide a Western Balkans perspective.*

process has to be transparent. The mapping report should be made available to the public minimum in electronic version and made available (in English) on the S3 Platform portal. If necessary, it should also be translated to the local language.

According to the S3 design framework and based on the actual availability, the main data considered in the quantitative part are expected to be provided by national statistical office, national patent/IPR office and other relevant institutions and are related to:

- industrial subsectors (NACE[7] rev. 2, 3 or 4 digit, 5-10 year period):
  - Employment;
  - Value added;
  - Number of companies by size;
  - Wages;
  - Share of innovative companies (CIS indicators);
- product groups or subsectors:
  - Exports;
- areas of science:
  - Scientific publications;
  - Patents;
- education and skills (if available):
  - Employment by occupation and industrial subsectors (ISCO-08, 3 or 4 digit; NACE rev. 2, 3 or 4 digit, 5-10 year period);
  - Employment by the highest education level achieved and industrial subsectors (ISCED; NACE rev. 2, 3 or 4 digit, 5-10 year period);
  - Number of students/graduates by education levels and field of study
  - STEM graduates

(7) *The acronym NACE (Nomenclature Générale des Activités Économiques dans les Communautés Européennes) refers to the statistical classification of economic activities in the EU. For additional insights see:* ***https://ec.europa.eu/eurostat/web/nace****.*

The qualitative interpretation of the results is necessary to overcome the constraints of existing industry and scientific classifications and uncover real sectors and value chains they represent[8]. The result of this analysis is the better definition of preliminary priority domains for the purposes of entrepreneurial discovery process.

Based on the actual availability of data, the above methodology has been adopted in the design process of the six Western Balkans economies, and integrated with other relevant analyses supporting the following phases of the S3 design framework.

In the following paragraphs the current state of play for each Western Balkans economy is reported.

2.2 The progress of smart specialisation in the Western Balkan economies

The economies of the Western Balkans are actively modernizing their economies, societies, and policies, and this process is closely linked to their aspirations to join the European Union.

Since 2014, smart specialisation (S3) is one of the thematic priorities for Pre-accession Assistance (IPA II) to enlargement countries, highlighting the relevant role of regional development, research and innovation in the EU Enlargement Policy. In the last several years, the progress in Smart Specialisation was evident in the entire Western Balkan region. Montenegro adopted its Smart Specialisation strategy and received positive assessment by the European Commission. Subsequently, the country launched the implementation phase, receiving further support by the

(8) *Specific value chains for priority domains have to be identified together with challenges and trends. It can be done on the basis of in-depth interviews, focus groups or case studies with experts representing the key and most innovative companies, sectorial experts and researchers cooperating with business. If interviews are considered, minimum 10-15 interviews with key organisations should be conducted per preliminary priority domain*

JRC in developing operational programmes for implementation of Smart Specialisation in priority areas. Montenegro established a sound structure for the implementation of Smart Specialisation and produced remarkable results for the first two years of strategy implementation. Serbia adopted its Smart Specialisation strategy in 2020 and related action plan to the strategy in 2021. The documents are currently being assessed by the European Commission services. All other Western Balkan economies have demonstrated advancements in their respective Smart Specialisation processes. Most notably, North Macedonia completed all the stages of the S3 framework and has prepared its first draft of the strategy, while Kosovo and Albania have finalised the stakeholder dialogue phase and are currently drafting the strategy. Bosnia and Herzegovina is also exhibiting important progress by successfully finalising the mapping exercise. If this pace is maintained, all Western Balkan economies might have finished their respective Smart Specialisation strategies by the end of 2024 and beginning of 2025.

The boxes below report the main achievements concerning the S3 processes in each Western Balkans economy.

Box 1. Smart Specialisation in Albania

Albania started the process of designing its S3 in 2016 and registered in the S3 platform in 2017. The country has finalized the mapping activities and the Entrepreneurial Discovery Process (EDP) phase.

Main domains explored during the EDP phase are: **1)** Agriculture Fisheries and Aquaculture; **2)** Manufacturing; **3)** Energy; **4)** Accommodation and support service activities; **5)** Information and Communication; **6)** Administrative and support service activities. Based on EDP findings three final vertical priorities are being identified and the country is currently focussing on **1)** Renewable Energy and Natural Resources; **2)** Healthy and Sustainable Food Chain; **3)** Sustainable and Diversified Tourism.

Considering the importance of this process for the Albanian Government and the fact that it covers a wide number of sectors, from February 2023 the process is coordinated by the Deputy Prime Minister leading the S3 Interministerial Committee and assisted by the National S3 Team. Smart Specialisation Strategy will be a priority of the Government of Albania and an important instrument for directing future investments in the priority areas and in developing a knowledge based society.

The main achievements so far include:

- governance setting for the design of S3 at national level with roles and responsibilities and institutional appointment on the S3 implementation;
- identification of preliminary sectors and potential cross-sectorial domains;
- awareness raising and collective learning on main challenges from the process;
- administrative capacity building on mapping, policy mix and monitoring.

Box 2. Smart Specialisation Bosnia and Herzegovina

Bosnia and Herzegovina launched the Smart Specialisation design process in 2018. The first achievement concerned the establishment of the S3 working group, approved by the National Council and coordinated by the Directorate for Economic Planning.

The implementation of the S3 design framework for the EU enlargement and neighbourhood is considering the country's governance structure. The specific features of the Federation of Bosnia y Herzegovina, Republika Srpska and Brcko District are taken into account during the implementation of the S3 design framework, with the aim to collect unitary contributions and define a single national strategy.

In coherence with this approach, Bosnia and Herzegovina has successfully completed the mapping activities, focusing on the following preliminary sectors: **1)** Metal and electrical industry; **2)** Production and processing of plastics; **3)** Production and processing of food and beverages; **4)** Wood industry; **5)** Tourism industry; **6)** ICT and digitization. Energy and environment are also investigated as an additional cross-cutting area.

The country is currently preparing the EDP phase to be implemented in 2024. The main achievements so far include:

- governance setting for the design of S3 at national level;
- identification of preliminary sectors from quantitative mapping;
- administrative capacity building on mapping, policy mix and monitoring.

Box 3. Smart Specialisation in Kosovo

Kosovo launched the Smart Specialisation design process in 2018. In 2020, the National S3 Team was created and is being coordinated by the Prime Minister's Office. Kosovo passed all initial stages of the S3 design framework, mapping most promising areas, conducting the Entrepreneurial Discovery Process and currently drafting the Strategy.

Potential priorities coming from the mapping phase that have been explored in the Entrepreneurial Discovery Process include: **1)** Information and Communication Technology; **2)** Creative Industry sector; **3)** Agro-processing sector; **4)** Wood processing sector; **5)** Green energy sector.

The main achievements so far include:

- governance setting for the design of S3 at national level with defined roles and responsibilities;
- identification of preliminary sectors from mapping activities;
- awareness raising and collective learning on main challenges from the process;
- administrative capacity building on mapping, policy mix and monitoring.

Box 4. Smart Specialisation in Montenegro

Montenegro launched the Smart Specialisation process in 2017 and finalised it in 2019. The Smart Specialisation strategy was adopted in June 2019 and the formal assessment of the strategy by the European Commission services (inter-DG panel) was carried out in October 2019. The letter from the European Commissioner for Neighbourhood and Enlargement, Olivér Várhelyi, confirming conditionally positive opinion of the Smart Specialisation Strategy of Montenegro was sent to the Prime Minister of Montenegro in December 2019.

The country is implementing the strategy and in December 2023 the Government of Montenegro submitted a self-assessment concerning the fulfilment of those criteria partially satisfied. The documentation received is currently being assessed by the European Commission services.

Montenegro has identified four main priority areas through Smart Specialisation: **1)** Sustainable agriculture and food value chain; **2)** Energy and sustainable environment; **3)** Sustainable and health tourism; and **4)** ICT.

The process helped Montenegro to set up an efficient governance system for innovation policy design and implementation. The country established a new body, the Council for Innovation and Smart Specialisation, to manage the implementation of the Smart Specialisation strategy and report to the Government of Montenegro.

The JRC has been providing continuous support for the country's efforts in establishing efficient implementation governance mechanism since the launch of the Smart Specialisation implementation phase.

Box 5. Smart Specialisation in North Macedonia

North Macedonia launched the Smart Specialisation process in 2018. Since then, it completed all stages focusing on defining the strategy framework, mapping potential, conducting the Entrepreneurial Discovery Process and formally adopting the strategy in 2023. In February 2024 the Government of North Macedonia formally submitted the strategy and the accompanying action plan to the European Commission, and the documentation is currently being assessed by the European Commission services.

The final priority areas of North Macedonia include: **1)** Smart agriculture and food with higher value-added; **2)** Electro-mechanical Industry - Industry 4.0; **3)** Sustainable Materials and Smart Buildings; and **4)** ICT.

North Macedonia was the first country from the EU enlargement and neighbourhood region to complete the qualitative analysis stage and the ensuing EDP in a "hybrid" mode, with both onsite and online participation of stakeholders, and with high efficiency. The political commitment was reiterated on many occasions and the country hosted an in-

ternational conference on Smart Specialisation in 2019.

By following the Smart Specialisation framework for the EU enlargement and neighbourhood, the country developed a robust structure for the implementation of innovation policy based on Smart Specialisation and finalised the draft of its Smart Specialisation strategy.

Box 6. Smart Specialisation in Serbia

Serbia launched the Smart Specialisation process in 2017 and thoroughly followed the methodology as given in the Smart Specialisation framework for the EU enlargement and neighbourhood. It adopted the Smart Specialisation Strategy in February 2020 while the Action Plan to the Strategy has been adopted in April 2021. Serbia submitted its Smart Specialisation framework documentation for official assessment in late 2022. In February 2024 the Government of Serbia has formally submitted the Action Plan 2023-2025 and the documentation is currently being assessed by the European Commission services.

Identified priority areas of Serbia include: **1)** Food for future; **2)** Machines and production process of the future; **3)** Creative industries; and **4)** ICT.

Serbia is also one of the countries participating in the UN global pilot programme "STI Roadmaps for the Achievement of the Sustainable Development Goals", with the JRC as a key partner. In this programme, Smart Specialisation is recognised as one of the global methodologies for localised Science, Technology and Innovation (STI) roadmaps for transformational development.

Among the main achievements in relation to Smart Specialisation in Serbia the following ones can be mentioned:

- identifying priority areas and sub-areas based on thorough implementation of the Smart Specialisation framework;
- having more than 250 different stakeholders taking part in defining priority areas and proposing policy measures number of stakeholders and setting up working groups for future dialogue on implementation;
- defining the structure for the governance of implementation with clear roles and responsibilities;
- allocating the funds, including IPA, to policy measures targeting Smart Specialisation priority areas.

CHAPTER

3. Economic potential in the Western Balkans

Mapping economic potential represents the first step of the mapping exercise. Below are presented the main findings from the analysis of each of the Western Balkan economies.

The economic fabric of an economy can be analysed by the identification of critical mass in terms of employment, turnover, and number of companies as well as the growth dynamics at the sub-sectorial level. This analytical insight provides a preliminary analysis for employment and turnover based on aggregate firm-level data from the Orbis database for 6 Western Balkan economies.

Economic specialisations in 6 Western Balkan economies (WB6) have been identified through aggregate industry data for employment and turnover for 2012-2019, which have been extracted from the Orbis database. Orbis contains data on turnover and number of employees for enterprises operating at the NACE 4-digit sector level, which is analysed within this report at the higher aggregate NACE 3-digit level.

For each WB economy, this section provides a mapping analysis of the economic potential at the NACE 3-digit industry level by identifying two types of industries: industries with a current strength or already specialised industries with a sufficient critical mass and industries with an emerging strength or industries with increasing degrees of specialisation and critical mass. For all 6 Western Balkan economies combined, 58 industries have current strengths, 31 industries have emerging strengths, and 8 industries have both current and emerging strengths.

3.1 Methodology adopted for mapping economic potential

The primary data used in this report are extracted from the Orbis database. Orbis comprises statistics on turnover and number of employees in companies operating at the NACE 4-digit sector level in each of the WB6 economies. Orbis data however contain a lot of missing values, and in several cases turnover and employment was negative or zero. Since turnover and employment can neither be negative nor zero, we considered these cases as missing. Table 1 contains the description of the data before imputation.

To impute missing values, we take three steps. First, we take the averages between observed data points for which information is missing in-between. Second, we carry forward the last observed values for each firm in each economy provided the firm is still active. Third, we carry backward the first observed values using the company's date of incorporation as the baseline. All data aggregations and missing data imputations have been done in STATA. Annex 2 provides more details.

Table 2 describes the dataset after imputation while Figure 1 and Figure 2 describe the impact of the imputations on total turnover and employment of all WB6 economies in the dataset. For all WB6 economies, before imputing missing values, data availability is about 56.5% for employment and 61% for turnover. But there are significant differences between economies, with above average data availability for both employment and turnover for Bosnia and Herzegovina, Montenegro, and North Macedonia, and for employment for Kosovo. After imputing missing values, data availability has improved to more than 75% for both employment and turnover, with the strongest improvement in data availability for Albania and Serbia for employment, and for Albania, Kosovo and Serbia for turnover.

Table 3, Table 4 and Table 5 show total turnover and total employment for each year for each WB6 economy before and after estimating the missing data.

Table 1. Data description before imputing missing data (2012 – 2019)

Economy	VARIABLE	# Observations	# Missing observations	# Available observations	# 'Zero' observations	# Negative observations
ALBANIA	Employment	3,650	2,774 (76.0%)	876 (24.0%)	214	-
	Turnover		2,456 (67.3%)	1,194 (32.7%)	2	7
BOSNIA & HERZEGOVINA	Employment	222,070	63,248 (28.5%)	158,822 (71.5%)	-	-
	Turnover		57,625 (25.9%)	164,445 (74.1%)	9,375	-
KOSOVO	Employment	383,770	167,868 (43.7%)	215,902 (56.3%)	-	-
	Turnover		344,212 (89.7%)	39,558 (10.3%)	11	-
MONTENEGRO	Employment	120,820	56,474 (46.7%)	64,346 (53.3%)	2,088	-
	Turnover		56,428 (46.7%)	64,392 (53.3%)	11,742	21
NORTH MACEDONIA	Employment	659,910	281,292 (42.6%)	378,618 (57.4%)	7	-
	Turnover		270,721 (41.0%)	389,189 (59.0%)	12,814	-
SERBIA	Employment	1,950,260	1,316,730 (67.5%)	633,530 (32.5%)	146,768	-
	Turnover		1,316,420 (67.5%)	633,840 (32.5%)	76,908	-
WB6	Employment	3,340,480	1,888,386 (56.5%)	1,452,094 (43.5%)	149,070	-
	Turnover		2,047,862 (61.3%)	1,292,618 (38.7%)	110,852	28

Table 2. Data description after imputing missing data (2012 – 2019)

Economy	VARIABLE	# Observations	# Missing observations	# Available observations	# 'Zero' observations	# Negative observations
ALBANIA	Employment	3,650	1,054 (28.9%)	2,596 (71.1%)	-	-
	Turnover		933 (25.6%)	2,717 (74.4%)	-	-
BOSNIA & HERZEGOVINA	Employment	222,070	24,033 (10.8%)	198,037 (89.2%)	-	-
	Turnover		21,941 (9.9%)	200,129 (90.1%)	-	-
KOSOVO	Employment	383,770	63,729 (16.6%)	320,041 (83.4%)	-	-
	Turnover		130,812 (34.1%)	252,958 (65.9%)	-	-
MONTENEGRO	Employment	120,820	21,441 (17.7%)	99,379 (82.3%)	-	-
	Turnover		21,441 (17.7%)	99,379 (82.3%)	-	-
NORTH MACEDONIA	Employment	659,910	106,826 (16.2%)	553,084 (83.8%)	-	-
	Turnover		102,814 (15.6%)	557,096 (84.4%)	-	-
SERBIA	Employment	1,950,260	500,242 (25.7%)	1,450,018 (74.3%)	-	-
	Turnover		500,242 (25.76%)	1,450,018 (74.3%)	-	-
WB6	Employment	3,340,480	1,888,386 (56.5%)	1,452,094 (43.5%)	-	-
	Turnover		2,047,862 (61.3%)	1,292,618 (38.7%)	-	-

Table 3. Distribution of firms, employment, and turnover before and after imputations of missing data (2012-2019): Albania and Bosnia and Herzegovina

	Year	# Firms	ALBANIA		# Firms	BOSNIA & HERZEGOVINA	
			Employment	Turnover		Employment	Turnover
Before	2012	365	12,761	1,894,263	22,207	271,275	19,118,130
After			53,172	5,792,853		379,353	25,835,311
Before	2013	365	11,399	1,964,435	22,207	282,566	19,127,755
After			47,496	6,007,448		395,142	25,848,318
Before	2014	365	11,315	2,033,923	22,207	296,048	19,796,494
After			47,145	6,219,947		413,995	26,752,019
Before	2015	365	8,272	1,915,537	22,207	307,941	20,560,003
After			34,467	5,857,910		430,627	27,783,788
Before	2016	365	11,471	1,873,982	22,207	319,688	21,104,412
After			47,797	5,730,832		447,053	28,519,476
Before	2017	365	11,807	2,013,097	22,207	348,708	22,317,181
After			49,194	6,156,259		487,635	30,158,353
Before	2018	365	12,242	2,342,023	22,207	330,506	23,290,562
After			51,007	7,162,149		462,182	31,473,732
Before	2019	365	12,569	2,362,287	22,207	319,865	23,134,029
After			52,372	7,224,118		447,301	31,262,202

Table 4. Distribution of firms, employment, and turnover before and after imputations of missing data (2012-2019): Kosovo and Montenegro

	Year	# Firms	KOSOVO		# Firms	MONTENEGRO	
			Employment	Turnover		Employment	Turnover
Before	2012	38,377	70,725	326,316	12,082	32,821	2,297,686
After			125,621	3,168,121		61,577	4,310,855
Before	2013	38,377	74,829	355,182	12,082	33,049	2,510,334
After			132,911	3,448,372		62,005	4,709,819
Before	2014	38,377	68,864	383,133	12,082	35,414	2,582,273
After			122,316	3,719,739		66,442	4,844,790
Before	2015	38,377	61,483	437,463	12,082	38,761	2,935,227
After			109,206	4,247,210		72,723	5,506,993
Before	2016	38,377	82,380	465,305	12,082	43,932	3,247,610
After			146,323	4,517,525		82,424	6,093,077
Before	2017	38,377	80,645	478,129	12,082	46,019	3,653,809
After			143,241	4,642,031		86,339	6,855,177
Before	2018	38,377	78,846	524,140	12,082	48,475	3,827,283
After			140,047	5,088,734		90,948	7,180,644
Before	2019	38,377	84,963	523,028	12,082	49,083	4,123,582
After			150,912	5,077,937		92,088	7,736,552

Table 5. Distribution of firms, employment, and turnover before and after imputations of missing data (2012-2019): North Macedonia and Serbia

	Year	# Firms	NORTH MACEDONIA		# Firms	SERBIA	
			Employment	Turnover		Employment	Turnover
Before	2012	65,991	157,384	7,490,865	195,026	473,326	19,160,589
After			274,188	12,696,381		762,200	58,955,658
Before	2013	65,991	169,808	8,921,106	195,026	537,522	21,176,435
After			295,832	15,120,518		865,575	65,158,261
Before	2014	65,991	186,324	9,778,032	195,026	530,643	20,539,707
After			324,606	16,572,935		854,498	63,199,098
Before	2015	65,991	203,193	10,587,226	195,026	560,752	22,249,539
After			353,994	17,944,450		902,983	68,460,119
Before	2016	65,991	222,169	11,443,861	195,026	558,812	24,584,193
After			387,054	19,396,374		899,859	75,643,672
Before	2017	65,991	234,877	12,498,325	195,026	701,684	28,292,489
After			409,193	21,183,601		1,129,926	87,053,811
Before	2018	65,991	239,770	13,609,806	195,026	743,228	30,696,331
After			417,718	23,067,468		1,196,824	94,450,250
Before	2019	65,991	241,970	14,353,299	195,026	765,114	31,188,881
After			421,550	24,327,626		1,232,067	95,965,788

As described in the methodology adopted with the S3 design framework, aggregate industry level data are used to identify two types of industries:

- Industries with a current strength. These include specialised industries with critical mass, i.e. those industries for which the degree of specialisation and relative size for both employment and turnover are above predefined thresholds;
- Industries with an emerging strength. These include emerging industries with increasing degrees of specialisation and relative size, i.e. those industries for which the change in the degree of specialisation and the change in relative size for both employment and turnover are above predefined thresholds.

For all industries the following indicators are calculated for both employment and turnover:

- Average degree of specialisation for 2012-2019;
- Average relative size in national economy for 2012-2019;
- Rate of change between degree of specialisation in 2012 and 2019;
- Rate of change between relative size in national economy between 2012 and 2019.

Degrees of specialisation are calculated using Location Quotients (LQs), which compare the relative size of an industry in an economy with the relative size of the same industry for all WB6 economies combined. Specialized industries with critical mass are identified as those industries for which the degree of specialisation and relative size for both employment and turnover are above the thresholds shown in the first two columns in Table 6. Emerging industries with increasing degrees of specialisation and relative size are identified as those industries for which the change in the degree of specialisation and the change in relative size for both employment and turnover are above the thresholds shown in the last two columns in

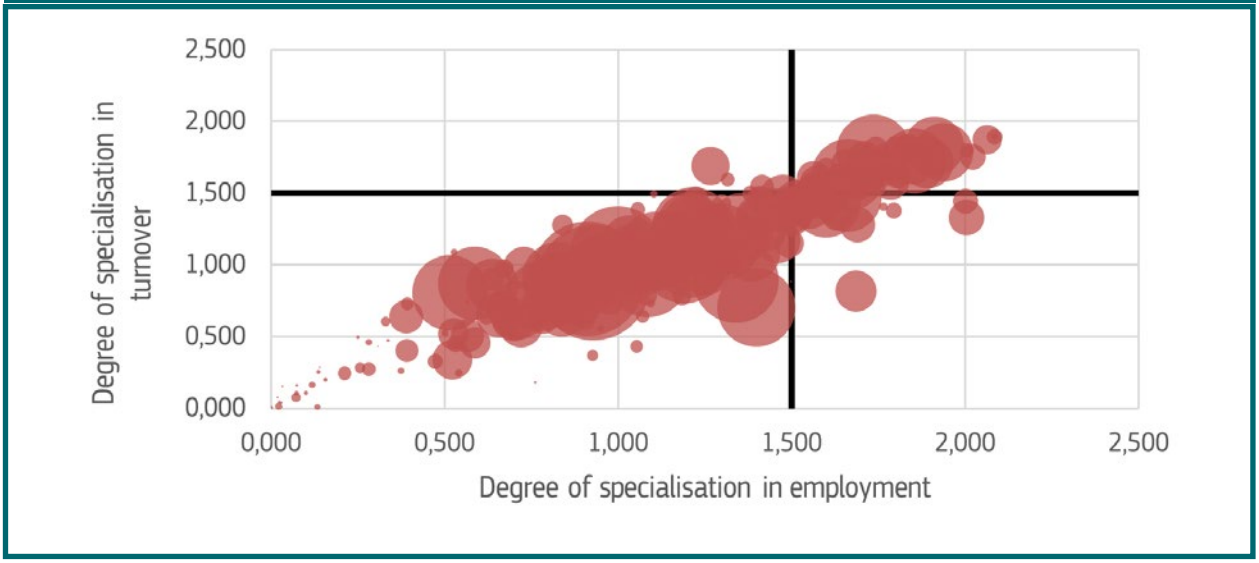
Table 6. For identifying current strengths, for both employment and turnover, for all WB6 economies the same minimum relative size of 0.5% has been used, for the degree of specialisation for 5 economies a minimum LQ of 1.5 has been used and for Serbia, as this WB6 economy is contributing an above average share to the WB6 total, a minimum LQ of 1.25 has been used. For changes over time, for both employment and turnover, for all economies for both changes in relative size and the degree of specialisation, these have to be at least zero or positive.

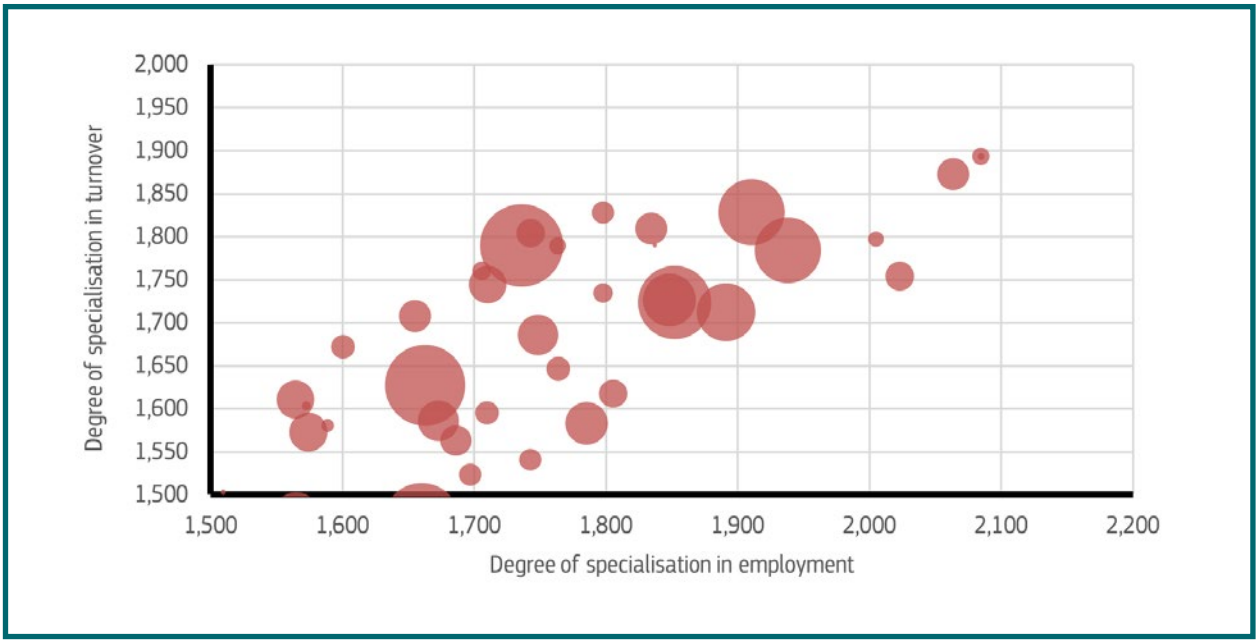
Figure 1 provides visual examples of the selection methodology for identifying specialised industries with critical mass. The figure on the top plots for all industries the degree of specialisation in employment on the horizontal axis and the degree of specialisation in turnover on the vertical axis. The sizes of the bubble measure the relative size of each industry in the national economy. The two bold black lines show the threshold values for the two degrees of specialisation. Only those industries will be selected for which the two degrees of specialisation are sufficiently high. The figure in the middle zooms in on the top-right quadrant where both degrees of specialisation are above the threshold values. Industries should also be sufficiently large, and only those industries where turnover and employment are at least 0.5% of the national economy will be selected. In the figure on the bottom these industries are highlighted in blue, these are the industries where the size of the bubble is sufficiently large.

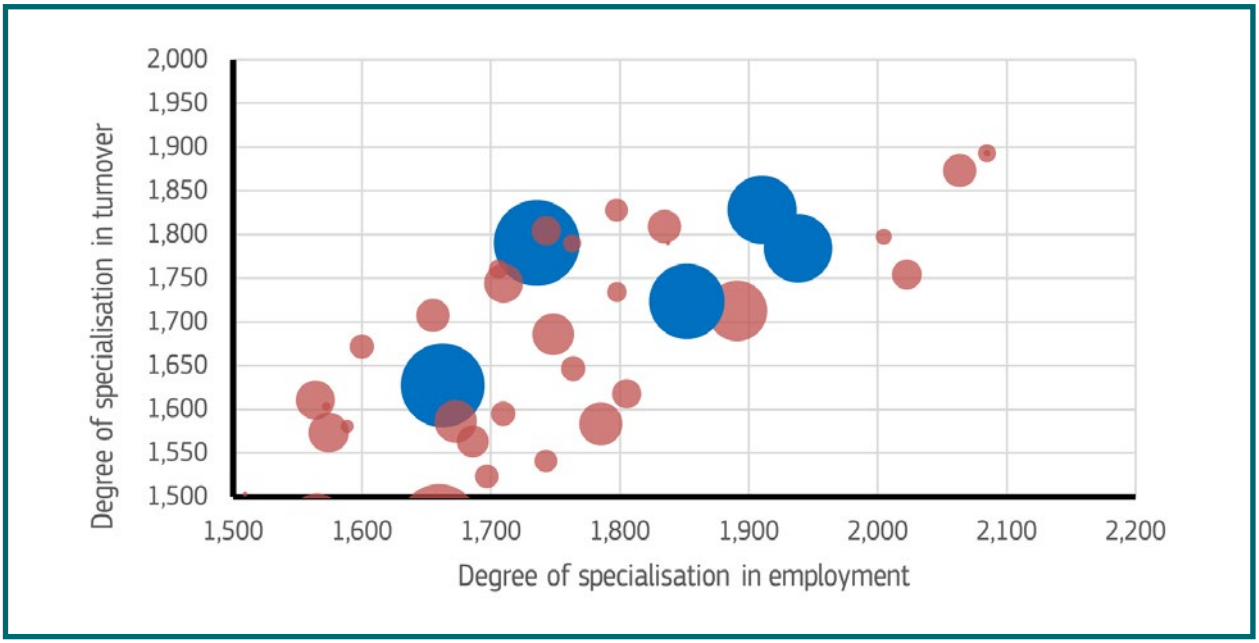
Table 6. Thresholds used for identifying economic specialisations

Economy	Current strengths		Emerging strengths	
	Degree of specialisation	Relative size	Change in degree of specialisation	Change in relative size
ALBANIA	1.5	0.5%	0.000	0.000
BOSNIA & HERZEGOVINA	1.5	0.5%	0.000	0.000
KOSOVO	1.5	0.5%	0.000	0.000
MONTENEGRO	1.5	0.5%	0.000	0.000
NORTH MACEDONIA	1.5	0.5%	0.000	0.000
SERBIA	1.25	0.5%	0.000	0.000

Figure 1. Selecting specialised industries with critical mass – graphical examples







3.2 Selecting industries - results

For all 6 Western Balkans economies combined, 58 industries have current strengths, 31 industries have emerging strengths, and 8 industries have both current and emerging strengths. For each economy results are discussed below including a comparison with the results of previous analyses conducted in 2018[9]. For industries with current strengths, we expect to find a significant number of industries which were both identified in the 2018 WB6 study and this study, as time periods in both reports (2010-2017 respectively 2012-2019) overlap using comparable data for 6 out of 8 years (for the period 2012-2017). For industries with emerging strengths, we do not expect to find many industries with emerging strengths in both studies as changes have been calculated for two different time periods: respectively between 2010 and 2017 and between 2012 and 2019. As economies recovered more from the economic crises in 2012 as compared to 2010, changes over time for the following 7 years will most likely be different for most industries and most economies.

In the following paragraphs current and emerging strengths for each WB economy are reported.

(9) *See Matusiak and Kleibrink (2018). In 2018, the JRC prepared the report "Supporting an Innovation Agenda for the Western Balkans", with the objective of facilitating the reflection on how to foster the economic development and competitiveness of the WB region.*

3.2.1 Albania: industries with current and emerging strengths

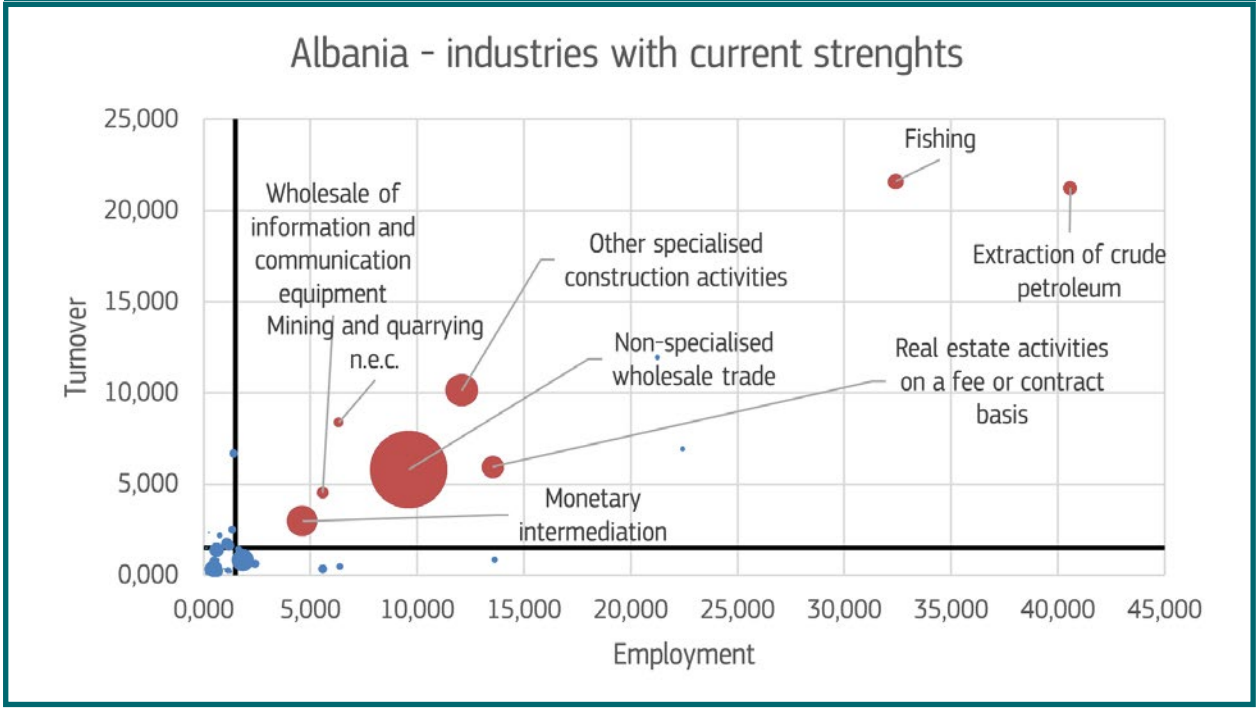
For Albania eight industries have been identified having current strengths and three industries with emerging strengths. One industry has both a current and emerging strength: Other specialised construction activities (NACE 439). Compared to the 2018 WB6 study which identified eight industries as having current strengths, the results in Table 7 confirm current strengths for six industries. Extraction of crude petroleum (NACE 061) and Mining and quarrying n.e.c. (NACE 089) are new compared to the 2018 study. For industries with emerging strengths only one industry was identified in both the 2018 and this study: Other specialised construction activities (NACE 439).

Table 7. Identified economic specialisations for Albania

ECONOMY	CURRENT STRENGTHS	EMERGING STRENGTHS
ALBANIA	* 031 Fishing 061 Extraction of crude petroleum 089 Mining and quarrying n.e.c. * 439 Other specialised construction activities * 465 Wholesale of information and communication equipment * 469 Non-specialised wholesale trade * 641 Monetary intermediation * 683 Real estate activities on a fee or contract basis	** 439 Other specialised construction activities 464 Wholesale of household goods 711 Architectural and engineering activities and related technical consultancy

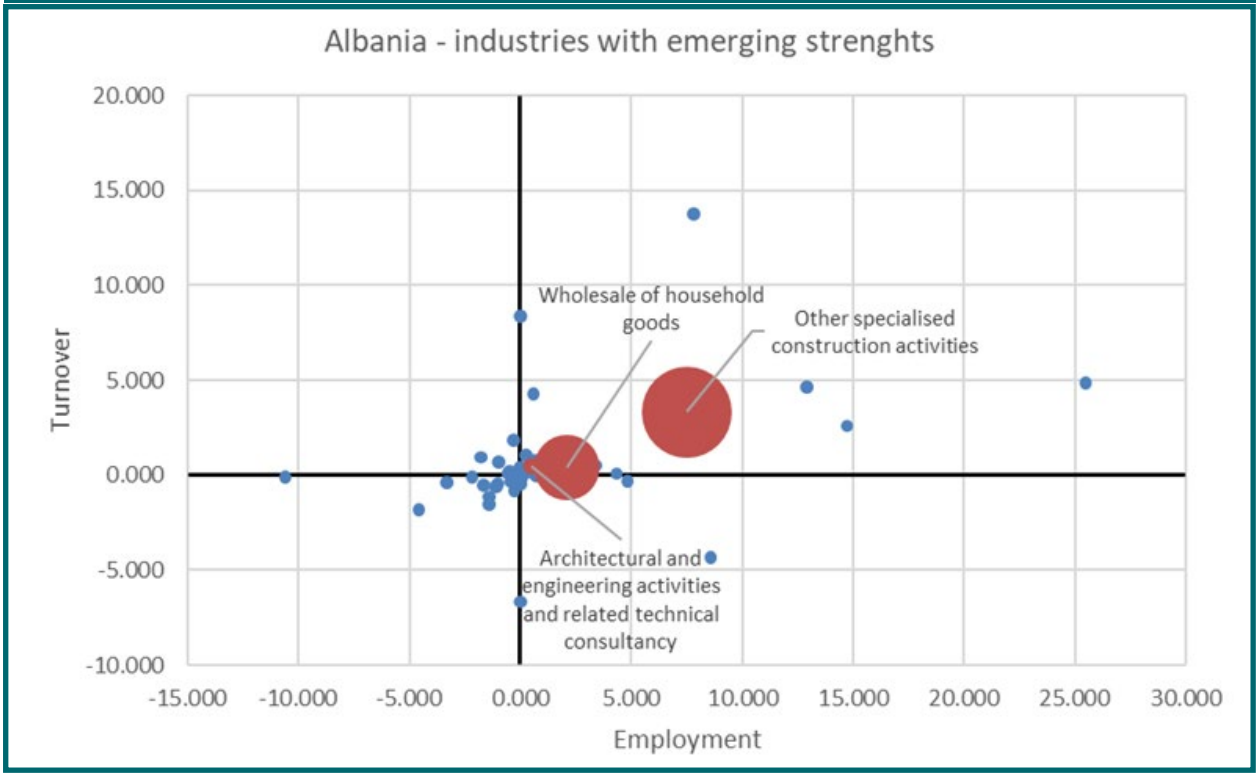
** Industry also identified as having a current strength in the 2018 study. ** Industry also identified as having an emerging strength in the 2018 study. Industry names are those used in the NACE classification. The 3-digit numbers show the corresponding NACE code.*

Figure 2. Albania - industries with current strengths



The horizontal axis shows the degree of specialisation in employment, the vertical axis shows the degree of specialisation in turnover. The size of the bubble measures the relative size of the industry in the national economy.

Figure 3. Albania - industries with emerging strengths



The horizontal axis shows the change over time in the degree of specialisation in employment, the vertical axis shows the change over time in the degree of specialisation in turnover.

3.2.2 Bosnia and Herzegovina: industries with current and emerging strengths

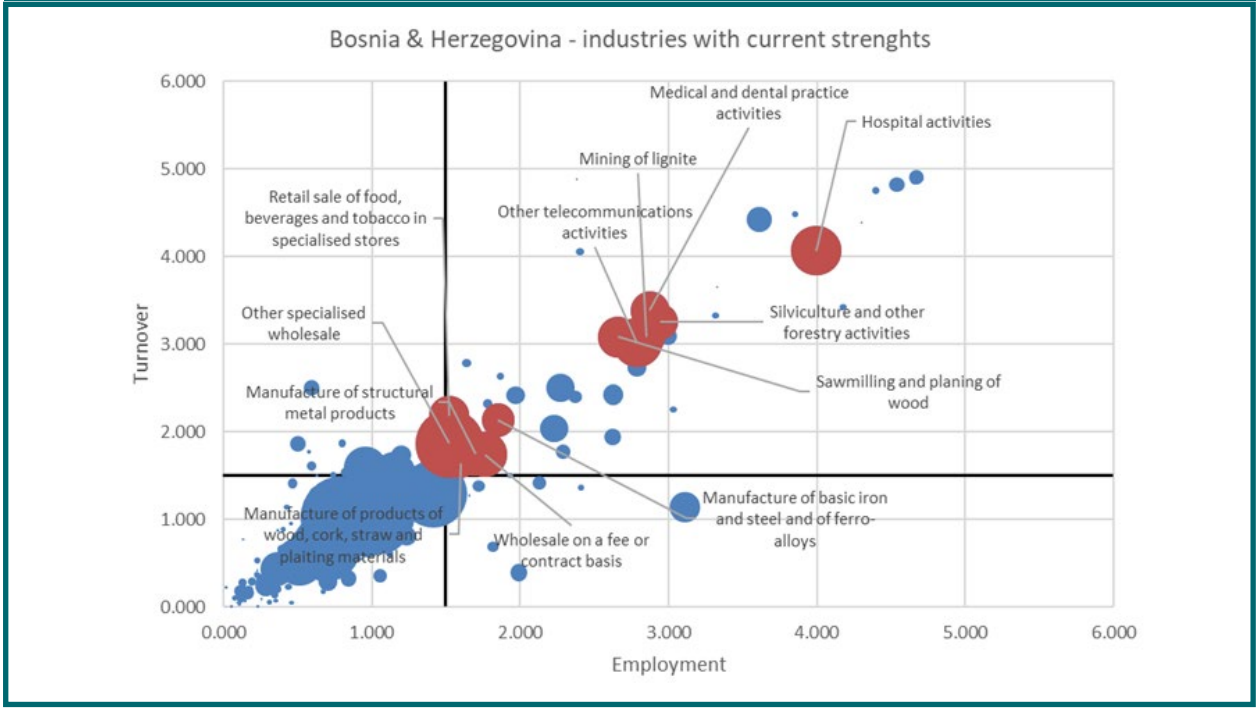
For Bosnia and Herzegovina 12 industries have been identified having current strengths and six industries with emerging strengths. One industry has both a current and emerging strength: Other telecommunications activities (NACE 619). Compared to the 2018 WB6 study which identified seven industries as having current strengths, the results in Table 8 confirm current strengths for all seven industries identified in the 2018 study. In addition, five more industries have a current strength: Manufacture of products of wood, cork, straw and plaiting materials (NACE 162), Manufacture of basic iron and steel and of ferro-alloys (NACE 241), Other specialised wholesale (NACE 467), Hospital activities (NACE 861), and Medical and dental practice activities (NACE 862). For industries with emerging strengths three industries were identified in both the 2018 and this study: Processing and preserving of meat and production of meat products (NACE 101), Manufacture of plastic products (NACE 222), and Manufacture of other fabricated metal products (NACE 259).

Table 8. Identified economic specialisations for Bosnia and Herzegovina

ECONOMY	CURRENT STRENGTHS	EMERGING STRENGTHS
BOSNIA AND HERZEGOVINA	* 021 Mining of lignite * 052 Silviculture and other forestry activities * 161 Sawmilling and planing of wood 162 Manufacture of products of wood, cork, straw and plaiting materials 241 Manufacture of basic iron and steel and of ferro-alloys * 251 Manufacture of structural metal products * 461 Wholesale on a fee or contract basis 467 Other specialised wholesale * 472 Retail sale of food, beverages and tobacco in specialised stores * 619 Other telecommunications activities 861 Hospital activities 862 Medical and dental practice activities	** 101 Processing and preserving of meat and production of meat products 108 Processing and preserving of meat and production of meat products ** 222 Manufacture of plastic products ** 259 Manufacture of other fabricated metal products 619 Other telecommunications activities 641 Monetary intermediation

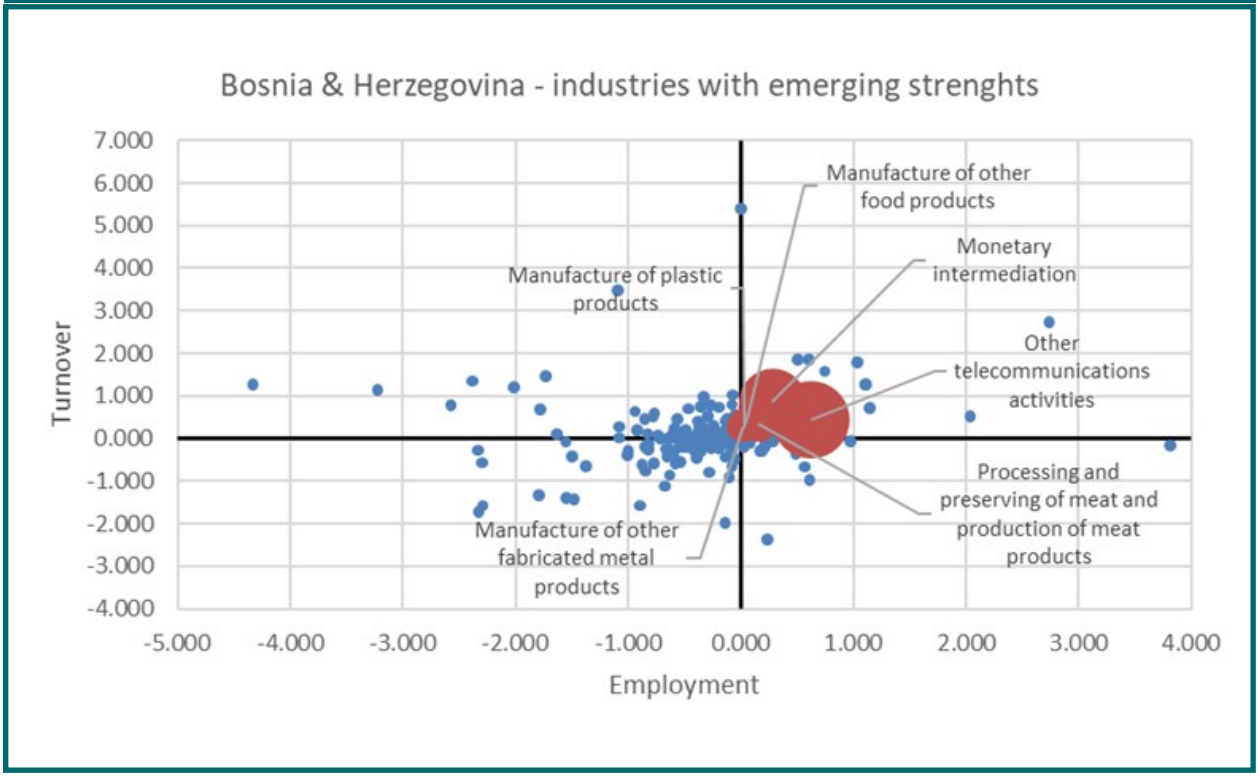
** Industry also identified as having a current strength in the 2018 study. ** Industry also identified as having an emerging strength in the 2018 study. Industry names are those used in the NACE classification. The 3-digit numbers show the corresponding NACE code.*

Figure 4. Bosnia and Herzegovina – industries with current strengths



The horizontal axis shows the degree of specialisation in employment, the vertical axis shows the degree of specialisation in turnover. The size of the bubble measures the relative size of the industry in the national economy.

Figure 5. Bosnia and Herzegovina – industries with emerging strengths



The horizontal axis shows the change over time in the degree of specialisation in employment, the vertical axis shows the change over time in the degree of specialisation in turnover.

3.2.3 Kosovo: industries with current and emerging strengths

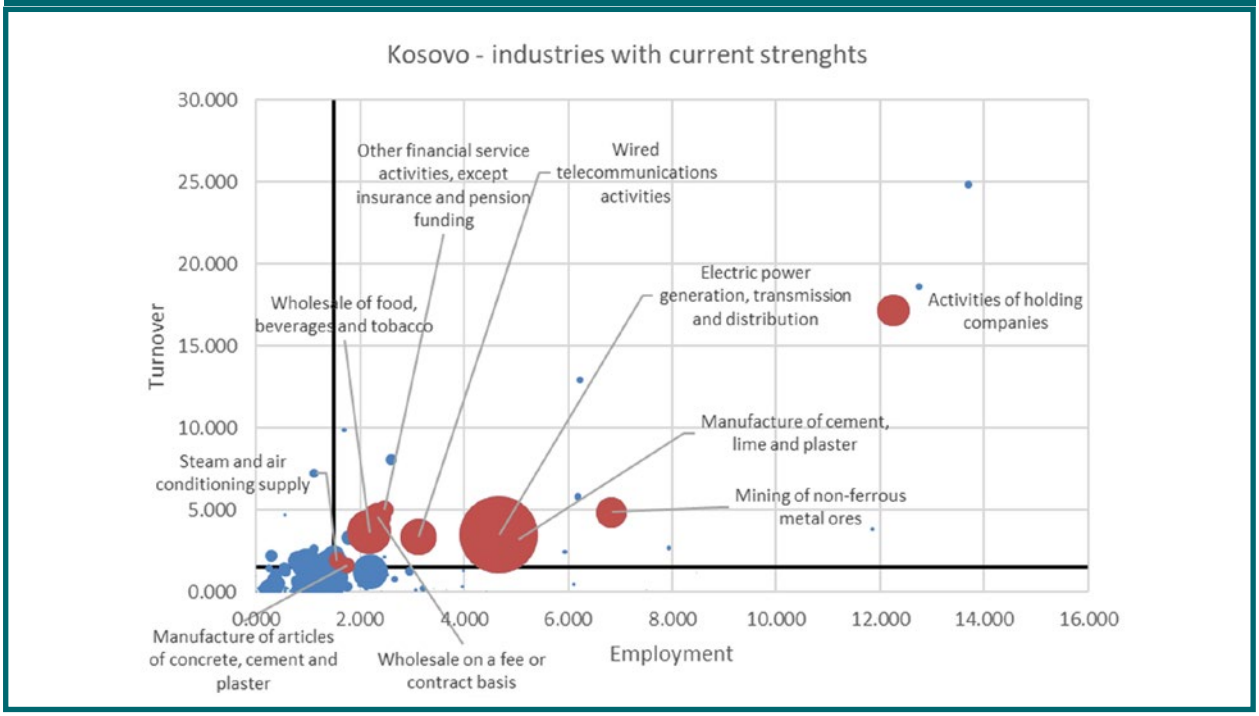
For Kosovo, 10 industries have been identified having current strengths and five industries with emerging strengths. Three industries have both a current and emerging strength: Steam and air conditioning supply (NACE 353), Wholesale of food, beverages and tobacco (NACE 463) and Wired telecommunications activities (NACE 611). Compared to the 2018 WB6 study which identified nine industries as having current strengths, the results in Table 9 confirm current strengths for seven industries. Manufacture of articles of concrete, cement and plaster (NACE 236). Steam and air conditioning supply (NACE 353), and Activities of holding companies (NACE 642), are new compared to the 2018 WB6 study. For industries with emerging strengths there is no industry identified in both the 2018 and this study.

Table 9. Identified economic specialisations for Kosovo

ECONOMY	CURRENT STRENGTHS	EMERGING STRENGTHS
KOSOVO	* 072 Mining of non-ferrous metal ores * 235 Manufacture of cement, lime and plaster 236 Manufacture of articles of concrete, cement and plaster * 351 Electric power generation, transmission and distribution 353 Steam and air conditioning supply * 461 Wholesale on a fee or contract basis * 463 Wholesale of food, beverages and tobacco * 611 Wired telecommunications activities 642 Activities of holding companies * 649 Other financial service activities, except insurance and pension funding	353 Steam and air conditioning supply 463 Wholesale of food, beverages and tobacco 472 Retail sale of food, beverages and tobacco in specialised stores 611 Wired telecommunications activities 641 Monetary intermediation

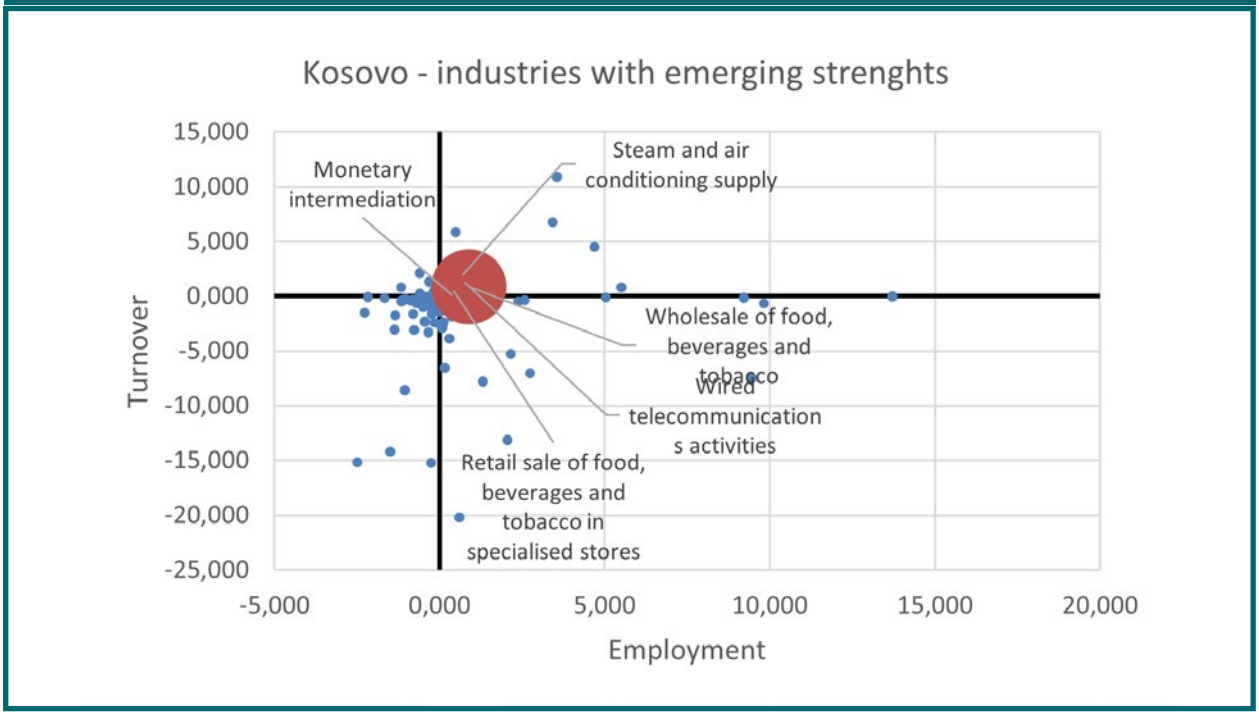
** Industry also identified as having a current strength in the 2018 study. Industry names are those used in the NACE classification. The 3-digit numbers show the corresponding NACE code.*

Figure 6. Kosovo – industries with current strengths



The horizontal axis shows the degree of specialisation in employment, the vertical axis shows the degree of specialisation in turnover. The size of the bubble measures the relative size of the industry in the national economy.

Figure 7. Kosovo – industries with emerging strengths



The horizontal axis shows the change over time in the degree of specialisation in employment, the vertical axis shows the change over time in the degree of specialisation in turnover.

3.2.4 Montenegro: industries with current and emerging strengths

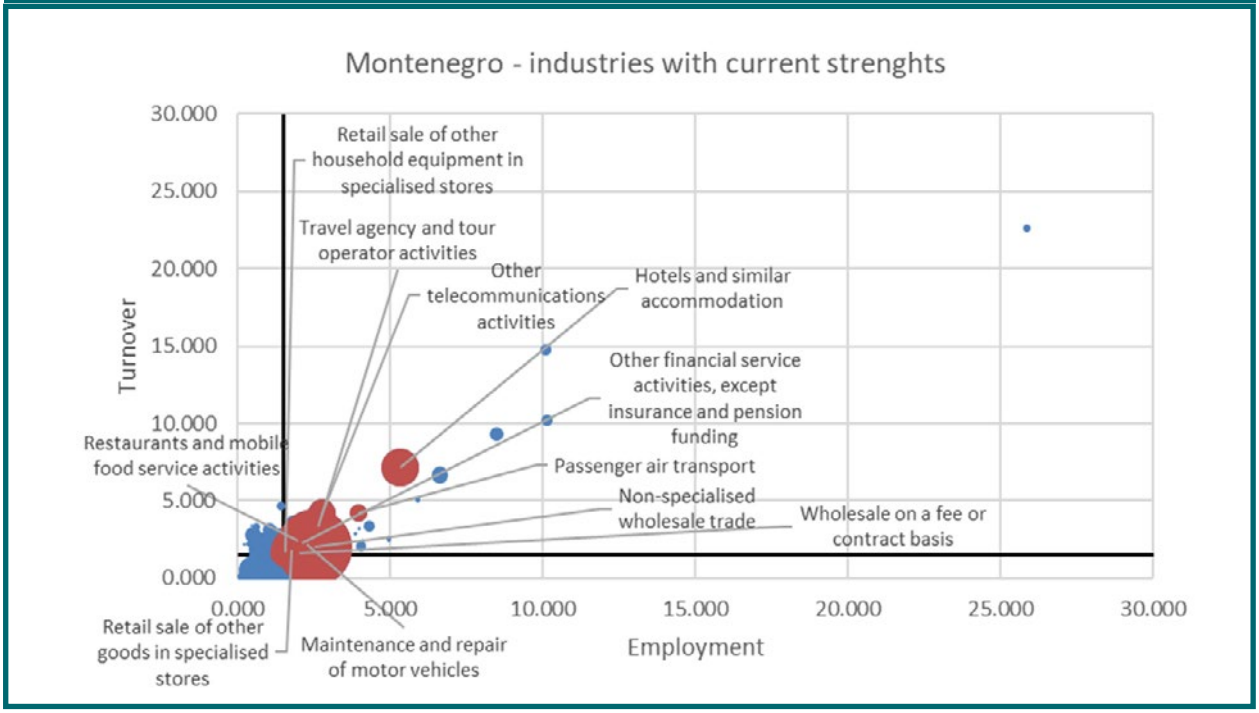
For Montenegro 11 industries have been identified having current strengths and five industries with emerging strengths. There are no industries with both a current and emerging strength. Compared to the 2018 WB6 study which identified 12 industries as having current strengths, the results in Table 10 confirm current strengths for nine industries. Wholesale on a fee or contract basis (NACE 461) and Travel agency and tour operator activities (NACE 791) are new compared to the 2018 WB6 study. For industries with emerging strengths two industries were identified in both the 2018 and this study.

Table 10. Identified economic specialisations for Montenegro

ECONOMY	CURRENT STRENGTHS	EMERGING STRENGTHS
MONTENEGRO	* 452 Maintenance and repair of motor vehicles 461 Wholesale on a fee or contract basis * 469 Non-specialised wholesale trade * 475 Retail sale of other household equipment in specialised stores * 477 Retail sale of other goods in specialised stores * 511 Passenger air transport * 551 Hotels and similar accommodation * 561 Restaurants and mobile food service activities * 619 Other telecommunications activities * 649 Other financial service activities, except insurance and pension funding 791 Travel agency and tour operator activities	351 Electric power generation, transmission and distribution ** 412 Construction of residential and non-residential buildings ** 421 Construction of roads and railways 432 Electrical, plumbing and other construction installation activities 467 Other specialised wholesale

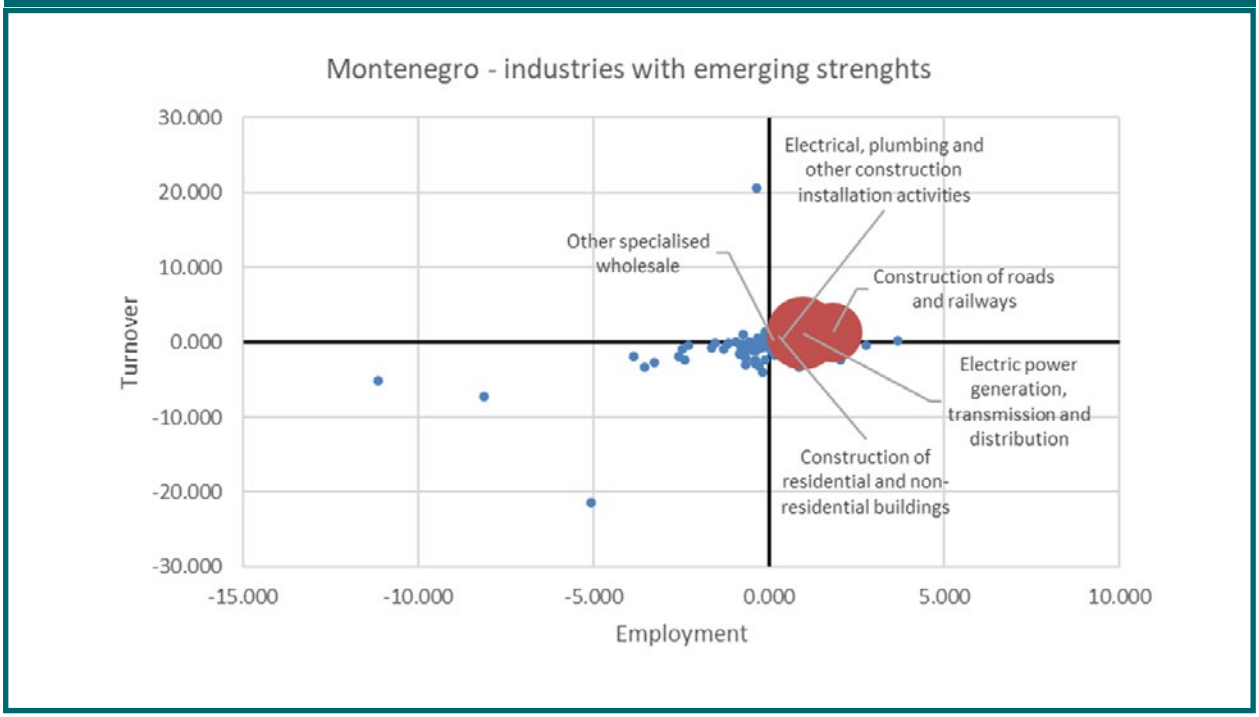
** Industry also identified as having a current strength in the 2018 study. ** Industry also identified as having an emerging strength in the 2018 study. Industry names are those used in the NACE classification. The 3-digit numbers show the corresponding NACE code.*

Figure 8. Montenegro – industries with current strengths



The horizontal axis shows the degree of specialisation in employment, the vertical axis shows the degree of specialisation in turnover. The size of the bubble measures the relative size of the industry in the national economy.

Figure 9. Montenegro – industries with emerging strengths



The horizontal axis shows the change over time in the degree of specialisation in employment, the vertical axis shows the change over time in the degree of specialisation in turnover.

3.2.5 North Macedonia: industries with current and emerging strengths

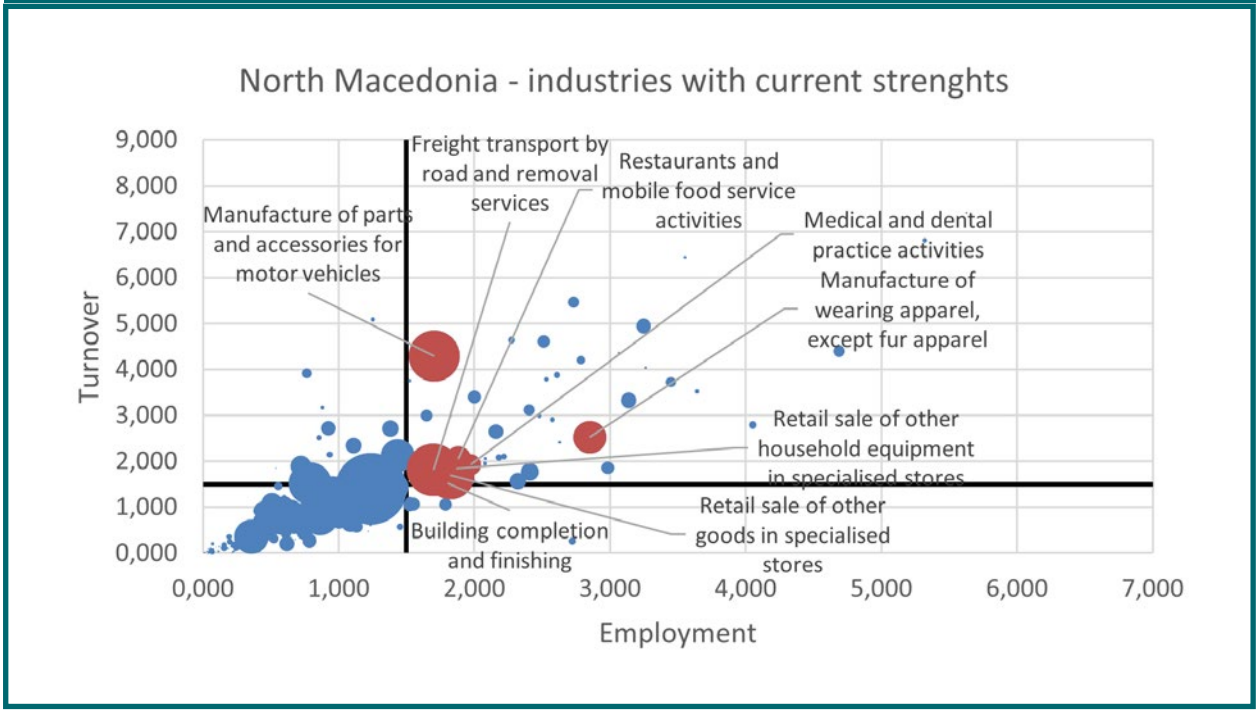
For North Macedonia eight industries have been identified having current strengths and six industries with emerging strengths. Two industries have both a current and emerging strength: Manufacture of parts and accessories for motor vehicles NACE 293) and Restaurants and mobile food service activities (NACE 561). Compared to the 2018 WB6 study which identified five industries as having current strengths, the results in Table 11 confirm current strengths for five industries identified in the 2018 study. In addition, Manufacture of parts and accessories for motor vehicles (NACE 293), Building completion and finishing (NACE 433) and Medical and dental practice activities (NACE 862) have been identified as having a current strength. For industries with emerging strengths only one industry was identified in both the 2018 and this study: Manufacture of parts and accessories for motor vehicles (NACE 293).

Table 11. Identified economic specialisations for North Macedonia

ECONOMY	CURRENT STRENGTHS	EMERGING STRENGTHS
NORTH MACEDONIA	* 141 Manufacture of wearing apparel, except fur apparel 293 Manufacture of parts and accessories for motor vehicles 433 Building completion and finishing * 475 Retail sale of other household equipment in specialised stores * 477 Retail sale of other goods in specialised stores * 494 Freight transport by road and removal services * 561 Restaurants and mobile food service activities 862 Medical and dental practice activities	108 Manufacture of other food products 259 Manufacture of other fabricated metal products ** 293 Manufacture of parts and accessories for motor vehicles 467 Other specialised wholesale 561 Restaurants and mobile food service activities 920 Gambling and betting activities

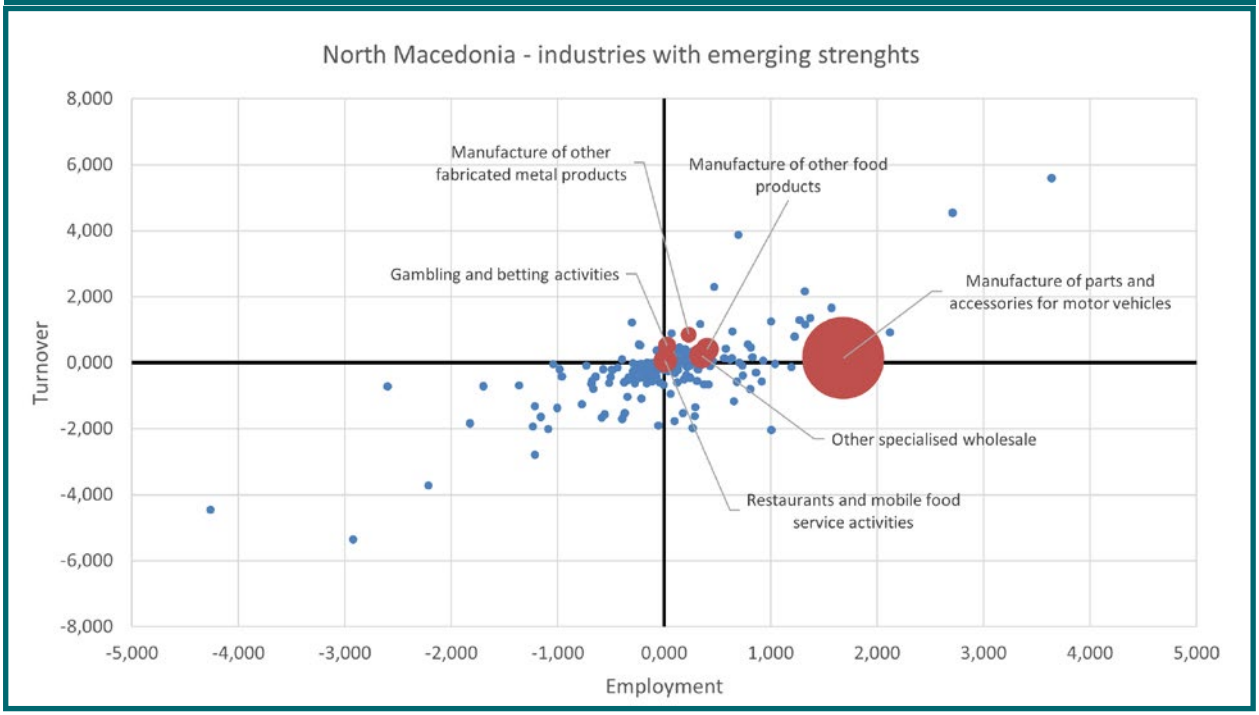
** Industry also identified as having a current strength in the 2018 study. ** Industry also identified as having an emerging strength in the 2018 study. Industry names are those used in the NACE classification. The 3-digit numbers show the corresponding NACE code.*

Figure 10. North Macedonia - industries with current strengths



The horizontal axis shows the degree of specialisation in employment, the vertical axis shows the degree of specialisation in turnover. The size of the bubble measures the relative size of the industry in the national economy.

Figure 11. North Macedonia - industries with emerging strengths



The horizontal axis shows the change over time in the degree of specialisation in employment, the vertical axis shows the change over time in the degree of specialisation in turnover.

3.2.6 Serbia: industries with current and emerging strengths

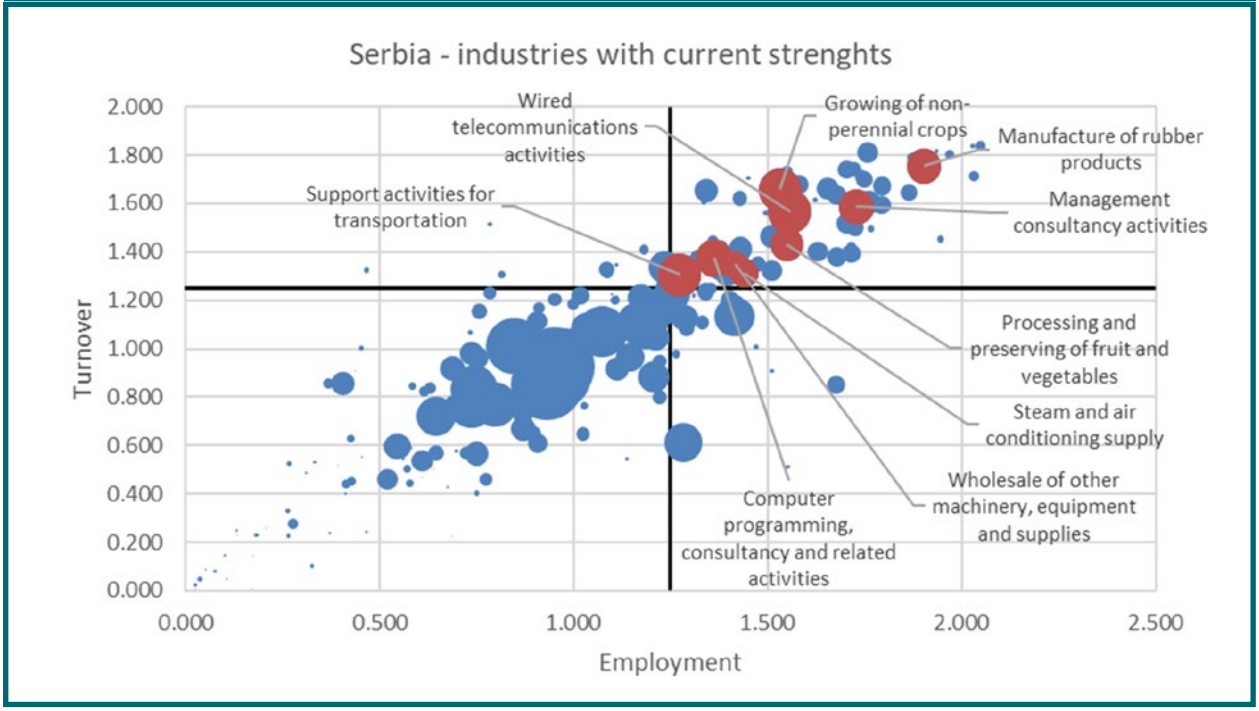
For Serbia nine industries have been identified having current strengths and six industries with emerging strengths. One industry has both a current and emerging strength: Support activities for transportation (NACE 522). Compared to the 2018 WB6 study which identified five industries as having current strengths, the results in Table 12 confirm current strengths for four industries identified in the 2018 study. Processing and preserving of fruit and vegetables (NACE 103), Manufacture of other food products (NACE 108), Steam and air conditioning supp (NACE 353), Wholesale of other machinery, equipment and supplies (NACE 466), Support activities for transportation (NACE 522), and Computer programming, consultancy and related activities (NACE 620) are new compared to the 2018 WB6 study. For industries with emerging strengths only one industry was identified in both the 2018 and this study: Support activities for transportation (NACE 522).

Table 12. Identified economic specialisations for Serbia

ECONOMY	CURRENT STRENGTHS	EMERGING STRENGTHS
SERBIA	* 011 Growing of non-perennial crops 103 Processing and preserving of fruit and vegetables * 221 Manufacture of rubber products 353 Steam and air conditioning supply 466 Wholesale of other machinery, equipment and supplies 522 Support activities for transportation * 611 Wired telecommunications activities 620 Computer programming, consultancy and related activities * 702 Management consultancy activities	251 Manufacture of structural metal products 412 Construction of residential and non-residential buildings 475 Retail sale of other household equipment in specialised stores 477 Retail sale of other goods in specialised stores 494 Freight transport by road and removal services ** 522 Support activities for transportation

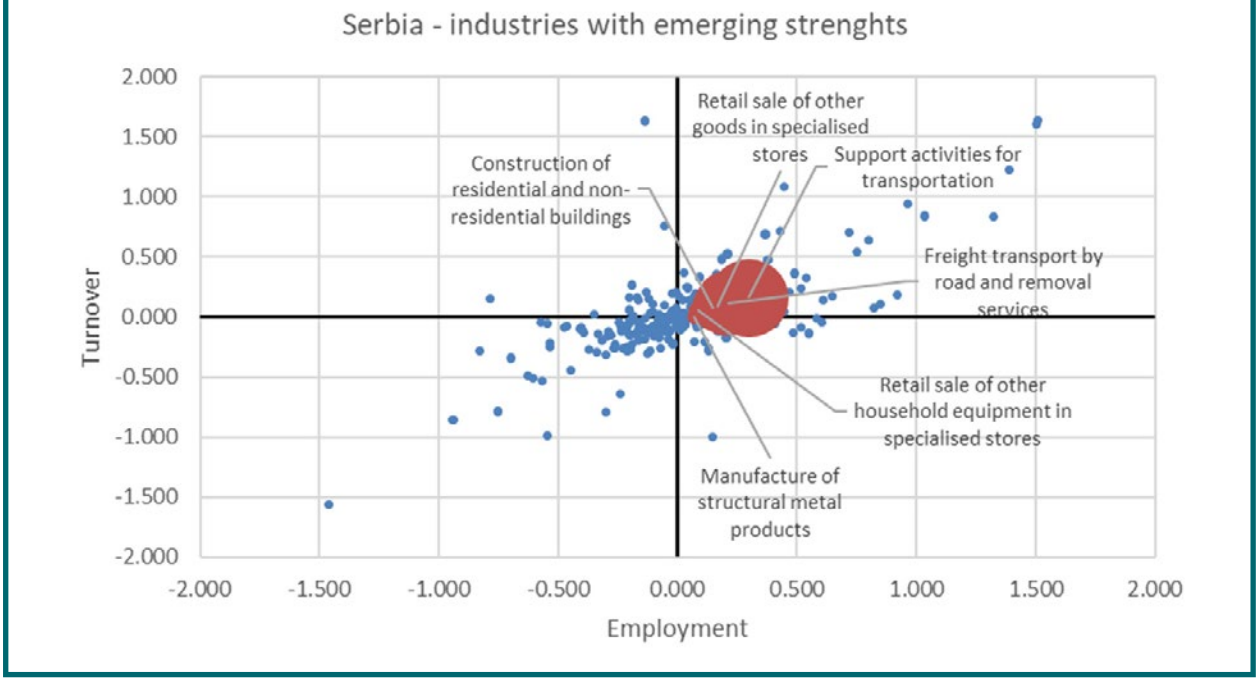
** Industry also identified as having a current strength in the 2018 study. ** Industry also identified as having an emerging strength in the 2018 study. Industry names are those used in the NACE classification. The 3-digit numbers show the corresponding NACE code.*

Figure 12. Serbia – industries with current strengths



The horizontal axis shows the degree of specialisation in employment, the vertical axis shows the degree of specialisation in turnover. The size of the bubble measures the relative size of the industry in the national economy.

Figure 13. Serbia – industries with emerging strengths



The horizontal axis shows the change over time in the degree of specialisation in employment, the vertical axis shows the change over time in the degree of specialisation in turnover.

3.3 Current and emerging similarities across WB6 economies

Among all current strengths of economic specialisation, WB6 economies have differing strengths (Table 13). Where there are shared similarities however, it is at maximum between three economies: for Wholesale on a fee or contract basis (NACE 461) for Bosnia and Herzegovina, Kosovo and Montenegro. More frequent are shared similarities between two economies:

- Steam and air conditioning supply (NACE 353) for Kosovo and Serbia
- Non-specialised wholesale trade (NACE 469) for Albania and Montenegro
- Retail sale of other household equipment in specialised stores (NACE 475) for Montenegro and North Macedonia
- Retail sale of other goods in specialised stores (NACE 477) for Montenegro and North Macedonia
- Restaurants and mobile food service activities (NACE 561) for Montenegro and North Macedonia
- Wired telecommunications activities (NACE 611) for Kosovo and Serbia
- Other telecommunications activities (NACE 619) for Bosnia and Herzegovina and Montenegro
- Other financial service activities, except insurance and pension funding (NACE 649) for Kosovo and Montenegro
- Medical and dental practice activities (NACE 862) for Bosnia and Herzegovina and North Macedonia

Table 13. Current strengths – Similarities and Dissimilarities across economies

Industry Name	NACE	AL	BA	KV	ME	MK	RS
Growing of non-perennial crops	011						✓
Silviculture and other forestry activities	021		✓				
Fishing	031	✓					
Mining of lignite	052		✓				
Extraction of crude petroleum	061	✓					
Mining of non-ferrous metal ores	072			✓			
Mining and quarrying n.e.c.	089	✓					
Processing and preserving of fruit and vegetables	103						✓
Manufacture of wearing apparel, except fur apparel	141					✓	
Sawmilling and planing of wood	161		✓				
Manufacture of products of wood, cork, straw and plaiting materials	162		✓				
Manufacture of rubber products	221						✓
Manufacture of cement, lime and plaster	235			✓			
Manufacture of articles of concrete, cement and plaster	236			✓			
Manufacture of basic iron and steel and of ferro-alloys	241		✓				
Manufacture of structural metal products	251		✓				

Industry Name	NACE	AL	BA	KV	ME	MK	RS
Manufacture of parts and accessories for motor vehicles	293					✓	
Electric power generation, transmission and distribution	351			✓			
Steam and air conditioning supply	353			✓			✓
Building completion and finishing	433					✓	
Other specialised construction activities	439	✓					
Maintenance and repair of motor vehicles	452				✓		
Wholesale on a fee or contract basis	461		✓	✓	✓		
Wholesale of food, beverages and tobacco	463			✓			
Wholesale of information and communication equipment	465	✓					
Wholesale of other machinery, equipment and supplies	466						✓
Other specialised wholesale	467		✓				
Non-specialised wholesale trade	469	✓			✓		
Retail sale of food, beverages and tobacco in specialised stores	472		✓				
Retail sale of other household equipment in specialised stores	475				✓	✓	
Retail sale of other goods in specialised stores	477				✓	✓	
Freight transport by road and removal services	494					✓	
Passenger air transport	511				✓		
Support activities for transportation	522						✓
Hotels and similar accommodation	551				✓		
Restaurants and mobile food service activities	561				✓	✓	
Wired telecommunications activities	611			✓			✓
Other telecommunications activities	619		✓		✓		
Computer programming, consultancy and related activities	620						✓
Monetary intermediation	641	✓					
Activities of holding companies	642			✓			
Other financial service activities, except insurance and pension funding	649			✓	✓		
Real estate activities on a fee or contract basis	683	✓					
Management consultancy activities	702						✓
Travel agency and tour operator activities	791				✓		
Hospital activities	861		✓				
Medical and dental practice activities	862		✓			✓	

From Table 14, we observe a similar pattern for emerging strengths of economic specialisation, with WB6 economies having different strengths. Where there are shared similarities, it is at maximum between two economies:

- Manufacture of other food products (NACE 108) for Bosnia and Herzegovina and North Macedonia
- Manufacture of other fabricated metal products (NACE 259) for Bosnia and Herzegovina and North Macedonia
- Construction of residential and non-residential buildings (NACE 412) for Montenegro and Serbia
- Other specialised wholesale (NACE 467) for Montenegro and North Macedonia
- Monetary intermediation (NACE 641) for Bosnia and Herzegovina and Kosovo

Table 15 summarizes industries in respective WB economies that share both current and emerging strength. Whilst this occurs in relatively few cases, the table shows that there are no such overlapping industries across WB6 economies.

The economic fabric of an economy can be analysed by the identification of critical mass in terms of employment and turnover as well as growth dynamics at sub-sectorial level. These insights can directly contribute to the S3 processes of each

Table 14. Emerging strengths – Similarities and dissimilarities across economies

Industry Name	NACE	AL	BA	KV	ME	MK	RS
Processing and preserving of meat and production of meat products	101		✓				
Manufacture of other food products	108		✓			✓	
Manufacture of plastic products	222		✓				
Manufacture of structural metal products	251						✓
Manufacture of other fabricated metal products	259		✓			✓	
Manufacture of parts and accessories for motor vehicles	293					✓	
Electric power generation, transmission and distribution	351				✓		
Steam and air conditioning supply	353			✓			
Construction of residential and non-residential buildings	412				✓		✓
Construction of roads and railways	421				✓		
Electrical, plumbing and other construction installation activities	432				✓		
Other specialised construction activities	439	✓					
Wholesale of food, beverages and tobacco	463			✓			
Wholesale of household goods	464	✓					
Other specialised wholesale	467				✓	✓	
Retail sale of food, beverages and tobacco in specialised stores	472			✓			
Retail sale of other household equipment in specialised stores	475						✓
Retail sale of other goods in specialised stores	477						✓

Industry Name	NACE	AL	BA	KV	ME	MK	RS
Freight transport by road and removal services	494						✓
Support activities for transportation	522						✓
Restaurants and mobile food service activities	561					✓	
Wired telecommunications activities	611			✓			
Other telecommunications activities	619		✓				
Monetary intermediation	641		✓	✓			
Architectural and engineering activities and related technical consultancy	711	✓					
Gambling and betting activities	920					✓	

Table 15. Industries with current and emerging strengths

Industry	NACE	AL	BA	KV	ME	MK	RS
Manufacture of parts and accessories for motor vehicles	293					✓	
Steam and air conditioning supply	353			✓			
Other specific construction works	439	✓					
Wholesale of food, beverages and tobacco	463			✓			
Support activities for transportation	522						✓
Restaurants and mobile food service activities	561					✓	
Wired telecommunications activities	611			✓			
Other telecommunications activities	619		✓				

WBs economy as well to other economic collaboration opportunities in the region. Economic specialisations in 6 Western Balkan economies have been identified using aggregate industry data for employment and turnover for 2012-2019. These data have been extracted from the Orbis database, which comprises statistics on turnover and number of employees for enterprises operating at the NACE 4-digit industry level.

For each WB6 economy, enterprise data have been aggregated to the NACE 3-digit industry level. These aggregate data have then been used to identify two types of industries: industries with a current strength or already specialised industries with a sufficient critical mass and industries with an emerging strength or industries with increasing degrees of specialisation and critical mass. Industries with a current strength are identified as those industries for which the degree of specialisation and relative size for both employment and turnover are above predefined thresholds. Industries with an emerging strength are identified as those industries for which the change in the degree of specialisation and the change in relative size for both employment and turnover are above these thresholds.

For all 6 Western Balkan economies combined, 58 industries have current strengths, 31 industries have emerging strengths, and 8 industries have both current and emerging strengths. Common patterns of specialisation, both current and emerging, are relatively rare, WB economies appear to have their own unique pattern of specialisation.


CHAPTER
4

4. Science and technology potential of the Western Balkans

The current section aims to map the science and technology potential in Western Balkans aggregate as well as in each individual territorial ecosystems, in particular:

- characterise and describe possible preliminary specialisation domains for the WB region and its composing economies at a fine grain;
- produce relevant distribution and specialisation indicators by domain;
- identify and characterise relevant actors, from each WB economy, for each domain;
- map collaboration patterns among these actors;
- identify key foreign partners;
- provide insight to support strategic and operational decision-making in:
  - economic specialisation and public support to private R&D investment
  - science and innovation policies and capacity-building.

To achieve these aims, international data sources representing research and innovation inputs and outputs is utilised: scientific publications, patents, European publicly-funded R&D and creative projects, and registered trademarks.

The analysis carried out used the most granular data available, that is, each single record for each WB publication, patent, project and trademark in the covered period was used to extract quantitative and semantic information. In particular, science and innovation activities and ecosystems in the whole WB region and for each WB economy are explored, for the period 2011-2020, through the following sources:

- internationally indexed scientific publications (from Scopus®, Elsevier B.V.);
- competitive research and innovation European projects (from European Union research and innovation framework programmes FP7 and Horizon 2020);
- competitive creative, cultural and media European projects (from Creative Europe);
- international patents from the European Patent Office's DOCDB database via the Open Patent Services (OPS);
- the European Union trademarks and registered Community designs registry (EUIPO);
- cluster organisations, present in the Cluster Organisations Mapping Tool of the European Cluster Collaboration Network;
- science parks and areas of innovation belonging to the International Association of Science Parks and Areas of Innovation (IASP).

For international patent applications, the 2010-2019 time window was analysed, due to the 18-months filing-publication delay and in order to mitigate as much as possible missing data due to delays in communications from national patent offices to the European Patent Office, from where patent data were collected.

4.1 Methodology adopted for mapping science and technology

The methodology adopted in the present analysis aims at quantifying research and innovation activities from heterogeneous data sources and at qualifying them according to emergent classification systems. The work strategy is conceived in a bid to provide local stakeholders with an overview of the strengths of their national research and innovation efforts, and to capture their evolution over time. The analysis includes data, for the 2011-2020 ten-year period, from the following data sources:

Table 16. Summary of data sources

Scope	Source	Data extraction criteria	Num. of records (2011-2020)
Scientific publications in internationally indexed journals	*Scopus®* (Elsevier B.V.)	Publications with at least one author with a Western Balkan country affiliation.	95,373
International patents	*DOCDB database* via the *Open Patent Services (OPS)* of the European Patent Office	At least one Western Balkan country inventor or applicant	2,933*
European Commission funded **research and innovation projects**	*CORDIS* - European Commissions' Community Research and Development Information Service	FP7 and H2020 projects with at least one Western Balkan partner	675
European Commission funded **cultural and creative projects**	*Creative Europe* - European Commission's framework programme for support the culture and audio-visual sectors.	Creative Europe (and its predecessor programme) projects with at least one Western Balkan partner	355
Trademark registrations	World Intellectual Property Organisation	Total trademark registrations by residents per WB country (direct and via the Madrid system)	25,387

** 2010-2019*

The countries covered in the analysis are quite varied regarding size and academic / innovative resources; this translates into differences in data availability and volume. Data richness is fundamental for analytical reliability and, consequently, for the strength and level of detail of the qualitative conclusions extracted from it. The following table presents the distribution of records across the Western Balkans economies:

Table 17.Geographical distribution of records**

	Publications	EU R&I projects (FP7, H2020)	Patents	Creative Europe and available predecessor programmes	Registered trademarks
Serbia	73.0%	68.0%	88.2%	53.0%	51.2%
Montenegro	4.2%	4.4%	3.2%	2.8%	0.8%
Albania	4.6%	4.7%	2.0%	11.0%	16.9%
Bosnia and Herzegovina	11.5%	7.6%	4.8%	12.4%	2.3%
North Macedonia	9.0%	12.7%	1.9%	20.6%	28.7%
Kosovo	4.6%	2.5%	0%	0.3%	0%
Total number of records	109,106	675	2,943	355	25,396

*** NB: percentages do not necessarily sum up to one, since the same records may be linked to more than one economy.*

The approach followed 5 sequential steps to analyse the data, exploring, characterising and classifying R&D&I activities of the WB economies; both according to taxonomies chosen qualitatively ad-hoc and to topics emerging from the data itself, independently from the NACE sector codes. Finally, all results were qualitatively mapped towards NACE sectors, so that all the S&T potentials identified could be readily translated into economic potentials as expressed by traditional economic statistics.

A thorough explanation of each of the above methodological steps is provided in Annex 3.

4.2 Specialisation analysis of the Western Balkans region

As first introduction to the S&T specialisation of the WB, in this section we present and discuss aggregate S&T data for the six WB economies and calculate, where appropriate, the specialisations using the native taxonomies of the original datasets, by using EU-27 as the baseline.

4.2.1 Descriptive statistics of the covered data sources

SCIENTIFIC PUBLICATIONS

We retrieved 95,373 records from Scopus, each one of them having at least one co-author from the Western Balkans in the time window between 2011 and 2020. Figure 14 presents the trends in terms of output.

From Figure 14 it is evident that the indexed scientific output of Western Balkans has grown fast between 2008 and 2012 to reach a ceiling of approximately 9,300 publications per year until 2015 and started growing since 2016 to reach 10,400 publications in 2020, matching the growth pattern of EU-27.

Figure 14. Output per year in scientific publications

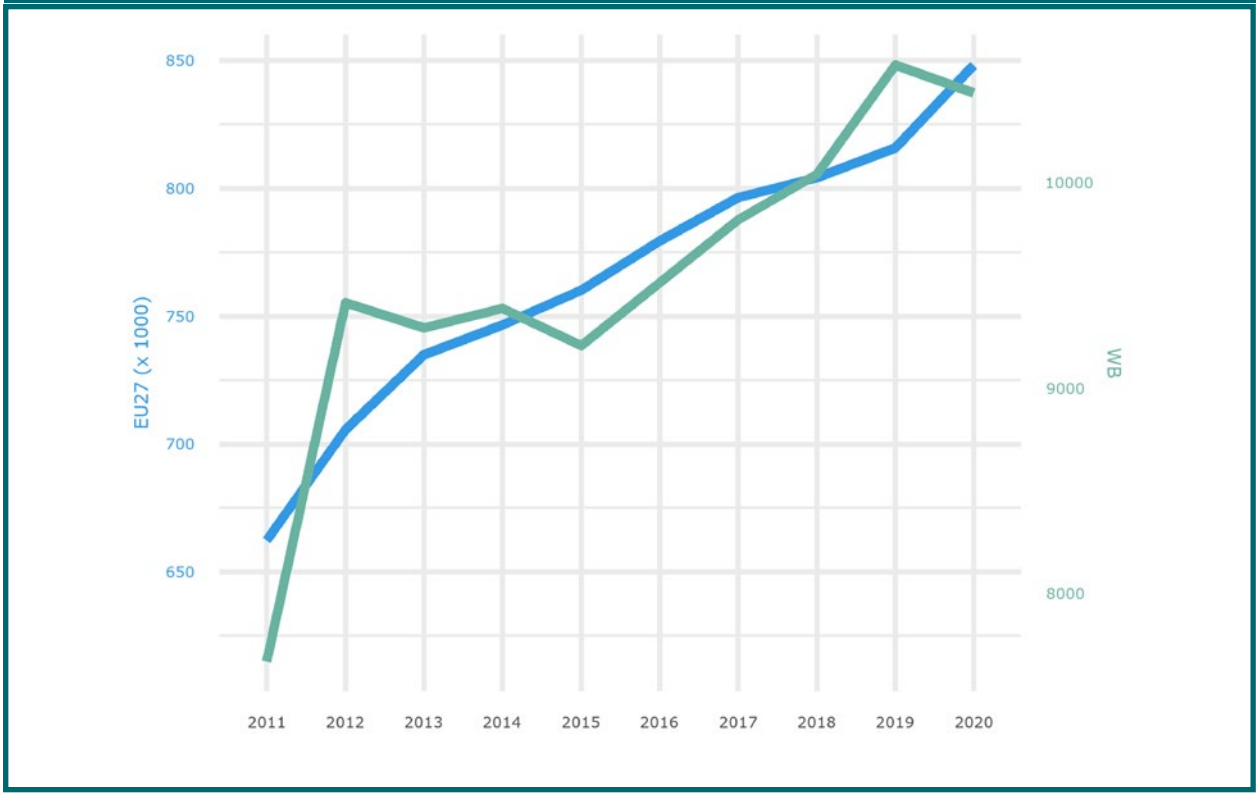
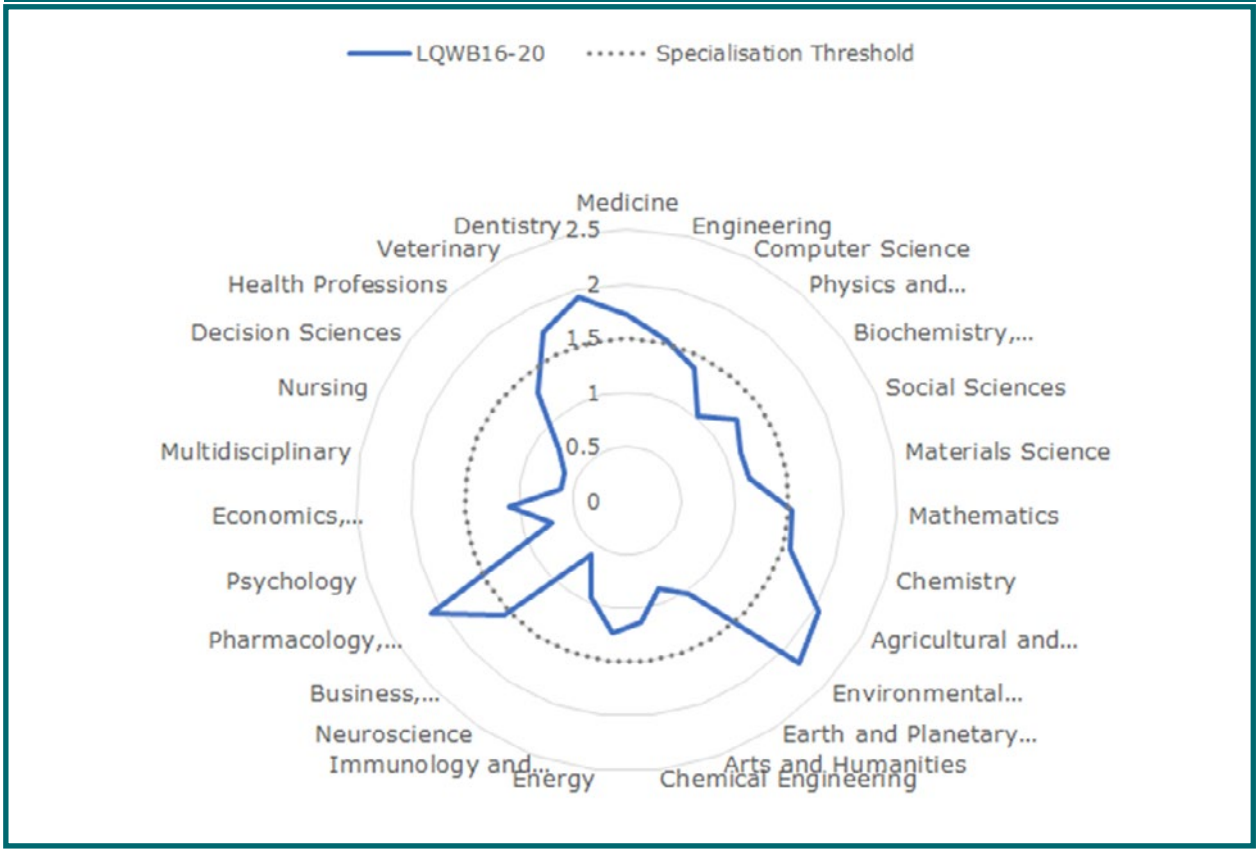


Figure 15 presents the location quotients (LQ) for the period 2016-2020 calculated using the Scopus-provided Subject Areas taxonomy, in decreasing order of EU27 publications. As in all our calculations, a value of one corresponds to the distribution of the baseline (in this case EU-27 publications per subject area) while values higher than 1.5 indicate 50% or stronger concentration of outputs versus the baseline.

Our calculations indicate that there are ten subject areas where Western Balkans seem to be strongly specialised (i.e. having LQ>=1.5) versus the EU-27 baseline. These are, in decreasing order of LQ, Environmental Science (2.18), Pharmacology, Toxicology and Pharmaceutics (2.08), Agricultural and Biological Sciences (2.04), Dentistry (1.93), Veterinary (1.73), Medicine (1.70), Chemistry (1.57), Business, Management and Accounting (1.56), Engineering (1.52) and Mathematics (1,52). There are also other subject areas (Computer Science, Health Professions, Biochemistry, Genetics and Molecular Biology, Energy, Materials Science, Social Sciences and Chemical Engineering) where Western Balkans seem to be well above the EU-27 baseline, all having LQ values larger than 1.12.

Figure 16 shows the location quotients calculated over two five-year time windows with the EU-27 as the baseline. In this figure, the top-right quadrant (green discs; LQ >= 1 for both axes) is linked to persistent specialisation Subject Areas, the top-left quadrant (blue discs; LQ>=1 on the y-axis) encloses emerging areas of specialisation, the bottom-left quadrant (red discs; LQ < 1 for both axes) is related with those areas of persistent low specialisation and finally, the bottom-right (purple discs; LQ < 1 on the x axis) features the declining specialisation areas. Two dotted lines are included, demarcating the specialisation thresholds of LQ = 1.5 for both periods. Everything above these lines can be considered as an area of strong specialisation in both 5-year intervals. Finally, the size of discs corresponds to the number of publications for each label. This type of figure is used consistently throughout this report.

Figure 15. Specialisation in scientific publications by decreasing order of publications in Scopus-provided subject areas



By virtue of the above, we find that:

- There are 18 subject areas where LQ >= 1 for both periods (plotted in green). Of these, seven, already discussed above, are above the specialisation threshold for both periods;
- 2 subject areas where LQ turned positive in the second time period (emerging specialisations, plotted in blue): Business, Management and Accounting is above the specialisation threshold in the second period, while Earth and Planetary Sciences deviates around the baseline of LQ = 1;
- There are no subject areas where LQ turned negative in the second time period (declining specialisations);
- 7 subject areas where LQ < 1 for both periods (plotted in red). These are Arts and Humanities, Decision Sciences, Immunology and Microbiology, Multidisciplinary, Neurosciences, Nursing and Psychology.

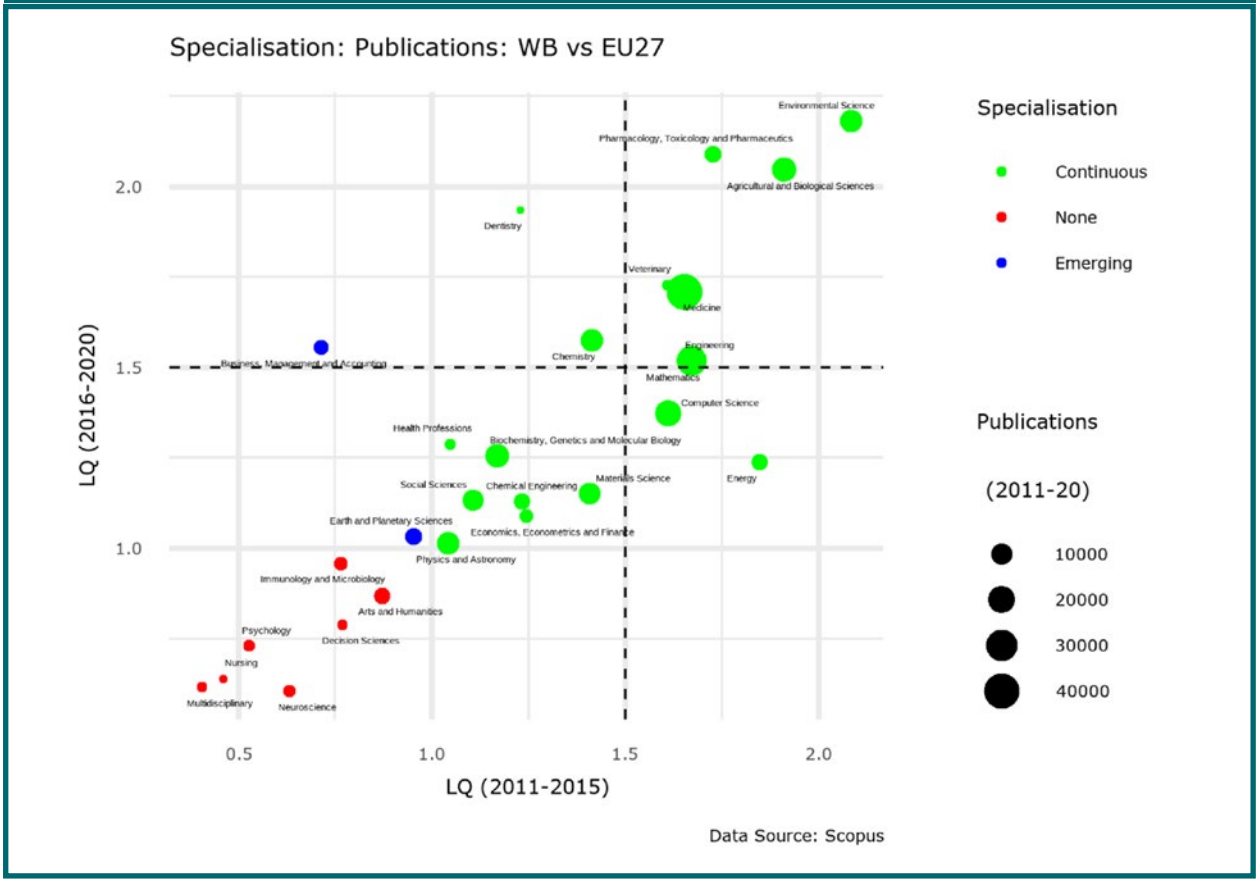
INTERNATIONAL PATENTS

We retrieved 2,933 records from the European Patent Office, each one of them having at least one co-inventor from the Western Balkans in the time window between 2010 and 2019. The corresponding number of records for EU-27 was 4,025,332. Figure 17 presents the trends in terms of patents per year.

From Figure 17 it is evident that the patent output of Western Balkans has been declining in the period from 2012 to 2015, remained -42.5% lower that its peak value in 2011 until 2017 and since then, it is growing. Serbia is the trend-setter, contributing 88% of the output.

Figure 18 presents the location quotients for the period 2010-2019 calculated using the EPO-provided International Patent Classification taxonomy in decreasing order of the top-20 IPC level-2 codes by granted EU-27 patents.

Figure 16. Specialisation trends for all subject areas calculated over two 5-year periods



Our calculations indicate that there are nine IPCs where Western Balkans are large enough (>20 patent families over the period) and seem to be specialised (i.e. having LQ>=1) versus the EU-27 baseline in the period 2010-2019. These are, in decreasing LQ, F03: Machines or Engines (mentioned in 162 patents), F26: Drying (13), E03: Water supply; Sewerage (22), A63: Sports; Games; Amusements (33), and A01: Agriculture, Forestry, Animal Husbandry, Hunting, Trapping, Fishing (112).

There were 114 IPC level 2 codes in our dataset that covers WB. The top-10 IPC codes by number of Western Balkan patents in our observation period are A61 (230), Y02 (220), F03 (162), G06 (137), A01 (112), H01 (91), H02 (89), G01 (79), B65 (72) and H04 (64) - see Annex 3 for more detail on the labels.

Figure 19 shows the location quotients calculated over two five-year time windows with the EU-27 as the baseline. We find that:

- There are 11 IPCs where LQ > 1 for both periods (plotted in green). Of them, 4 have LQ > 1.5 in both periods. These are, in decreasing number of records, F03: Machines or Engines (162), A63: Sports; Games; Amusements (33), F26: Drying (13) and F22: Steam generation (6).
- There are 15 IPCs where LQ turned greater than 1 in the second time period (emerging specialisations, plotted in blue). B65: Conveying; Packing; Storing (82) is the most significant in terms of output. E02 (20) B42 (16) B67 (10) and F17 (10) are strongly specialised in the second 5-yr period, also having more than 9 patents.
- There are 14 IPCs where LQ turned lower than 1 in the second time period (declining specialisations, plotted in purple). Of them, G06 (137), H02 (89), A47 (59), F24 (40) were the most significant in terms of patents;
- There are 73 IPCs where LQ is below the specialisation threshold for both periods (plotted in red). Of these, the top 5 in terms of patents are H01 (91), G01 (85), H04 (63), B60 (62) and F16 (48).

Figure 17. Output per year in European patents, WB vs EU-27

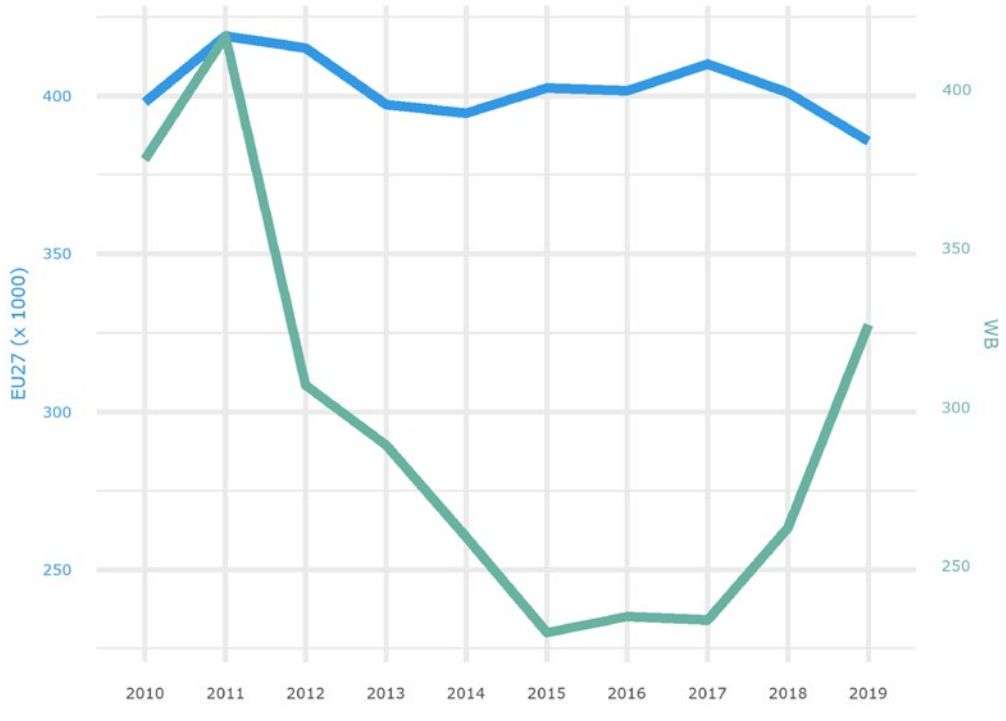


Figure 18. Specialisation in patents by decreasing order of class count in EPO-provided International Patent Classification Codes (only the top 30 entries are shown)

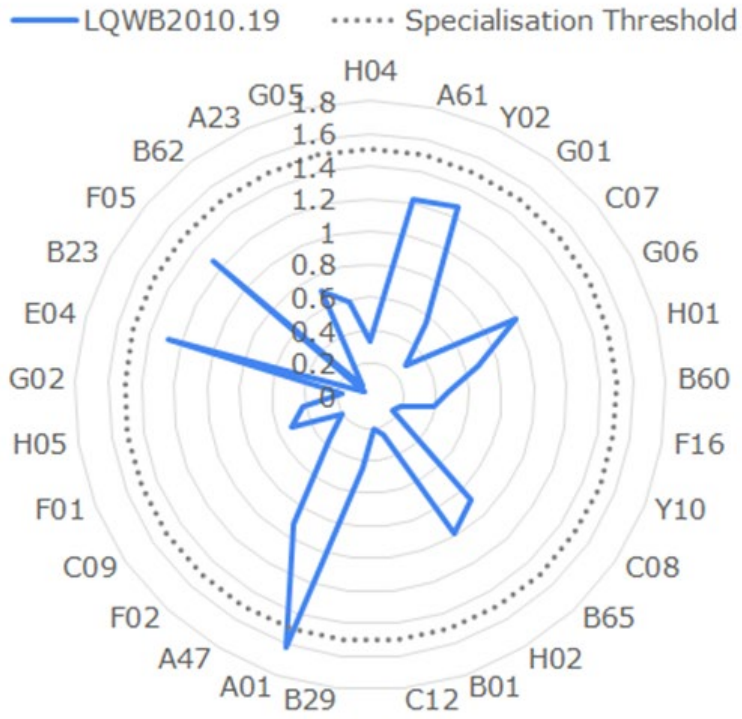
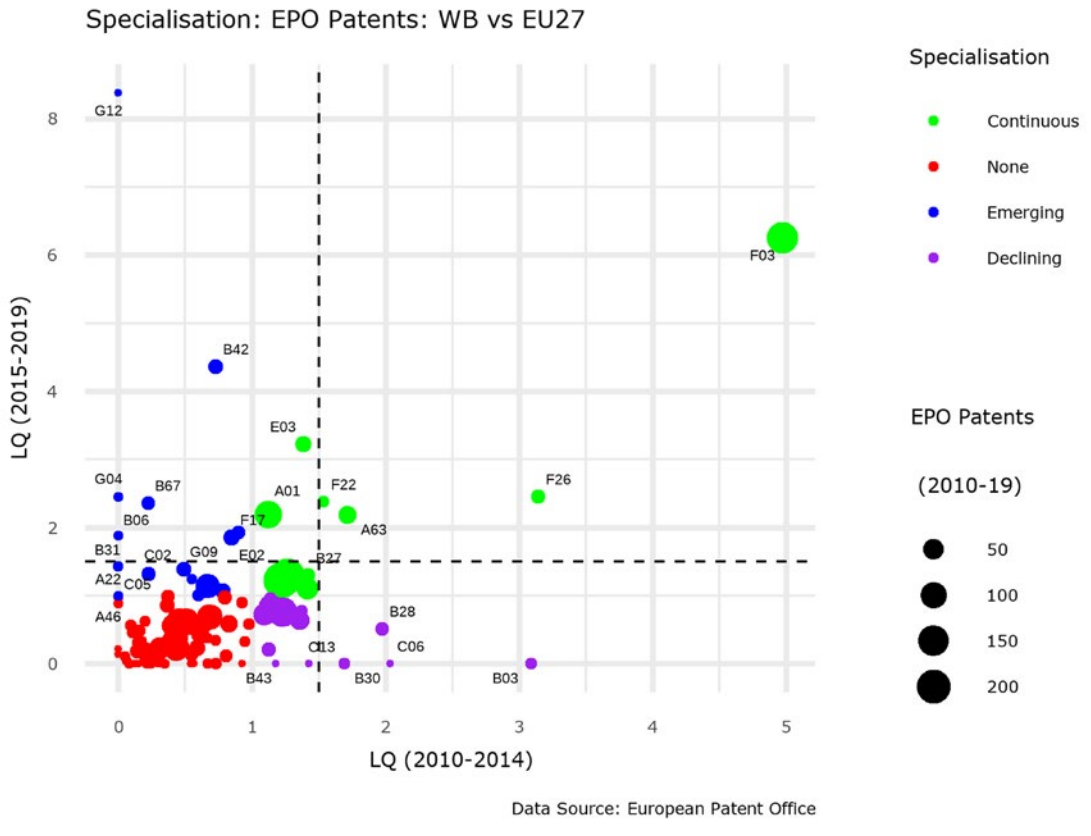


Figure 19. Specialisation trends for all IPC codes calculated over two 5-year periods



TRADEMARKS

We retrieved from the World Intellectual Property Organisation 25388 records of trademarks registered worldwide in the period from 2011 to 2020, each one of them being owned by a legal entity or a physical person based in one of the Western Balkan economies. The corresponding number of records for EU-27 was 1,852,901 in the same period. Figure 20 presents the trends in terms of trademark registrations per year.

From Figure 20 it is evident that yearly WB trademark registration activity matches the same for EU-27, with the WB yearly output being 1.37% of the EU-27 output.

For Western Balkans, the top Nice Classes by the count of registered trademarks associated with them were 35[10] (6588), 30[11] (4437), 5[12] (4391), 41[13] (3590), 29[14] (2728) and 32[15] (2491). The full titles for the Nice Classes are included in Annex 3.

Figure 21 presents the location quotients for the periods 2011-2015 and 2016-2020 calculated using the WIPO-provided Nice Classification codes in decreasing order of registered EU-27 trademarks. The full titles for the labels used in this plot are included in Annex 3. From Figure 21 it is evident that, with the exception of Nice Class 13, the WB specialisation profile did not change in the two 5-year intervals.

Our calculations indicate that there are five Nice Classes where Western Balkans seem to be strongly specialised versus the EU-27 baseline in both 5-year intervals (Nice 5: pharmaceutical preparations; Nice 30: Bread, flat bread, pastries; vinegar, relishes; chutneys (condiments); spices; dips; ketchup, mustard; pastes (condiments); Nice 29: Delicatessen articles, namely olives with herbs and pickled in brine, sheep's cheese in brine and in herbal oil, cream cheese being filling for fruit, fruit filled with cream cheese, goats' milk cheese; pickled vegetables with various fillings and fruits; pulp concentrates; piccalilli; pickles; soups; vegetable pies; mince meat in pastry and in flat bread, included in class 29; edible oils and fats: Nice 32: Non alcoholic drinks; essences for making beverages; non-alcoholic fruit extracts; non-alcoholic fruit drinks; non-alcoholic fruit nectars; non-alcoholic fruit juices; beverage preparations; liqueur preparations; lemonades; syrups for lemonade; fruit nectars; syrups for beverages; sorbets, and Nice 34: Tobacco, whether manufactured or unmanufactured; cigarettes; cigars; tobacco products; tobacco substitutes, none being for medicinal or curative purposes; matches and smokers' articles).

Moreover, Nice 8 (Hand tools and implements (hand operated); cutlery; side arms; razors; hair clippers for animals, electric and non-electric; interchangeable blades for brushes, combs, razors and hair clippers for animals; nail clippers, electric or non-electric; Electric and non-electric depilatory appliances; hair removing tweezers; pedicure sets; nail buffers, electric or non-electric; nail and hoof files, rasps (hand tools), farriers' knives, pliers and pincers; apparatus for tattooing; tool belts) is an emerging strong specialisation in the second 5-year interval. Figure 22 verifies the same conclusions.

Figure 22 shows the location quotients calculated over two five-year time windows with the EU-27 as the baseline. We find that:

- There are 16 Nice Classes where LQ>=1 for both periods (plotted in green). Of these, five (Nice Classes #5, #29, #30, #32 and #34 are strongly specialized and have a considerable number of trademarks associated with them.
- There are 4 Nice Classes where LQ turned greater than 1 in the second time period (emerging specialisations, plotted in blue). Of these, #8 is the single strong specialisation in

(10) Advertising; business management, organization and administration; office functions

(11) Mainly food and beverages

(12) Pharmaceuticals, medical and veterinary preparations and similar

(13) Education; providing of training; entertainment; sporting and cultural activities

(14) Meat and dairy products

(15) Beers and non-alcoholic beverages

the second period, with a relatively low number of trademarks (471).

- There are 2 Nice Classes (#13 and #23) where LQ turned lower than 1 in the second time period (declining specialisations, plotted in purple). Both of them are insignificant in terms of trademarks (91 and 81, respectively).
- Finally, there are 23 Nice Classes where LQ was lower than 1 for both periods (plotted in red). Of these, only Nice code #25 (1844), #42 (1792), #9 (1710) are the most significant in terms of registered trademarks.

Concluding, we can assert that the trademark activity in the last 10 years has been stable in terms of specialisation, with the strong specialisations being agri-food products, pharmaceuticals and tobacco products.

Figure 20. EU trademark registrations per year, WB vs EU-27

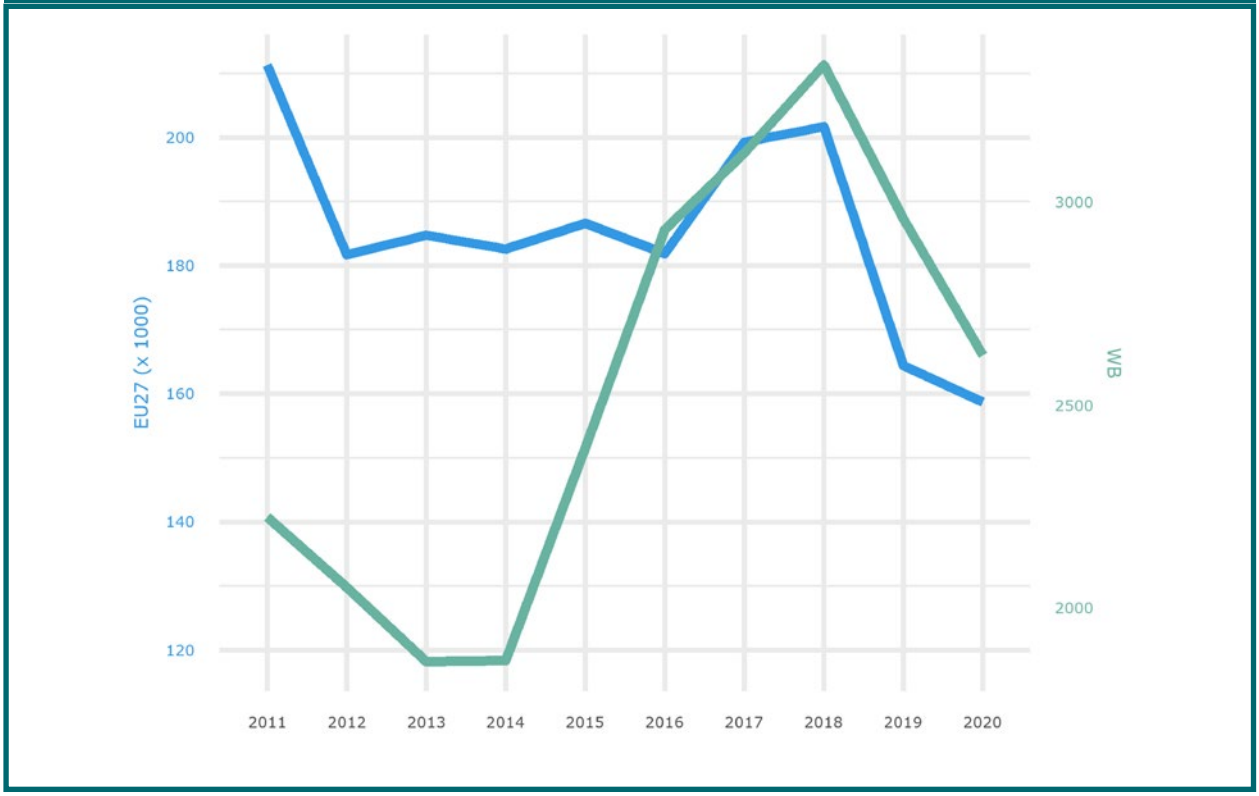


Figure 21. Specialisation in trademarks by decreasing order of EU-27 registered trademarks in WIPO-provided Nice Classification Codes

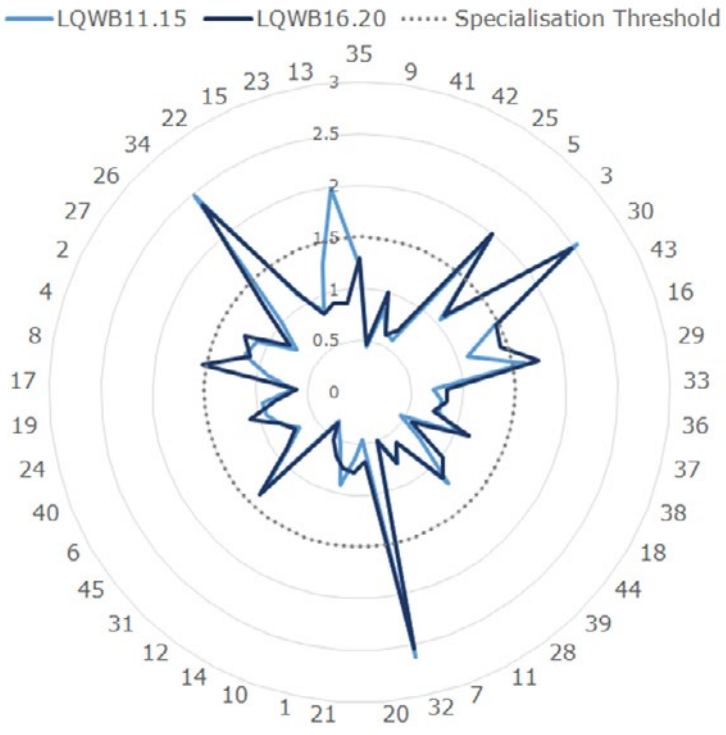
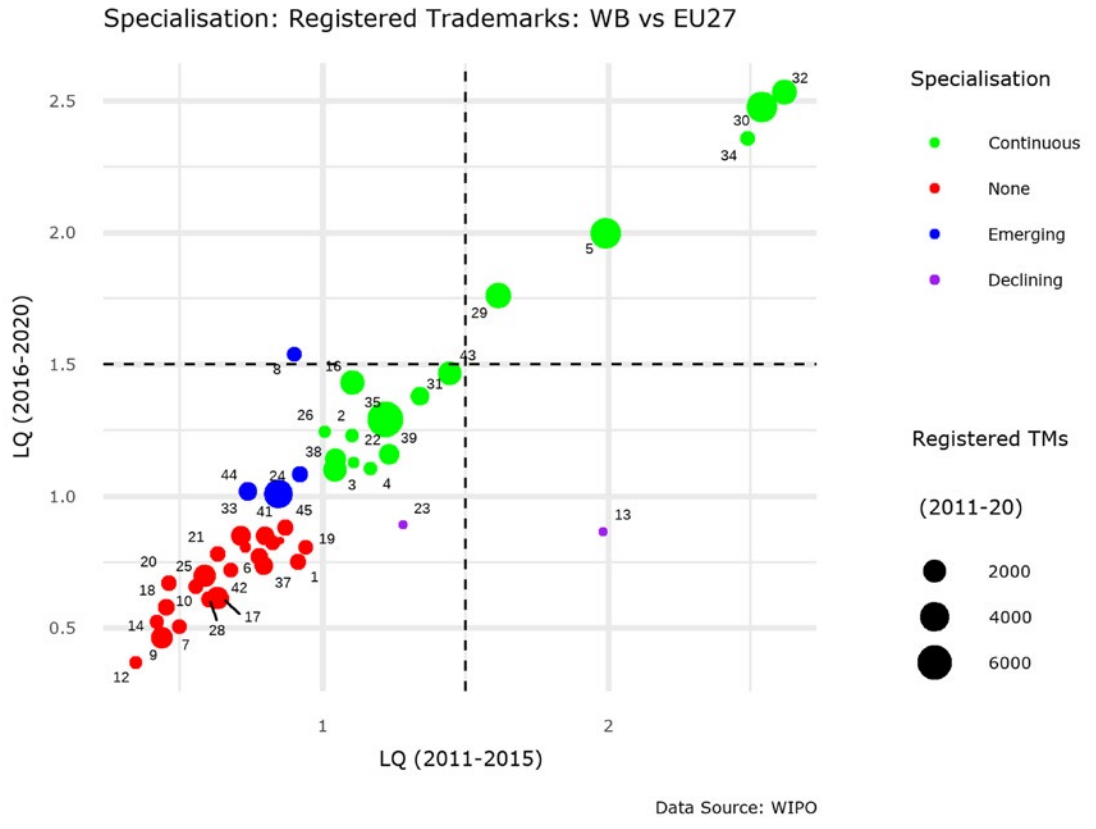


Figure 22. Specialisation trends for all Nice codes calculated over two 5-year periods



EUROPEAN COMPETITIVE R&I AND CULTURAL PROJECTS

We downloaded the records corresponding to 675 R&D projects funded by the European Commission in the WB via the FP7 and H2020 framework programmes and 355 cultural and creative projects funded by the European Commission in the WB via the Creative Europe programme and its predecessor. These data are available via the CORDIS[16] portal of the European Commission and the Creative Europe website[17]. Figure 23 shows the temporal trends of records for each of these data sources, where the evolution of the number of projects funded in the WB is compared with the EU-27 baseline.

As it can be observed in Figure 23, the number of projects obtained by WB follows roughly the same relative trends of the European Union for the FP7 and H2020 funded projects, where for both geographical perimeters the number of projects has a fairly increasing trend. The Table 18 presents the distribution of projects in the main H2020 programmes, revealing the high share of ICT and societal challenge-related projects in the WB economies.

(16) *https://cordis.europa.eu*

(17) *https://ec.europa.eu/programmes/creative-europe/*

Figure 23. R&I projects and Cultural projects funded by European competitive schemes

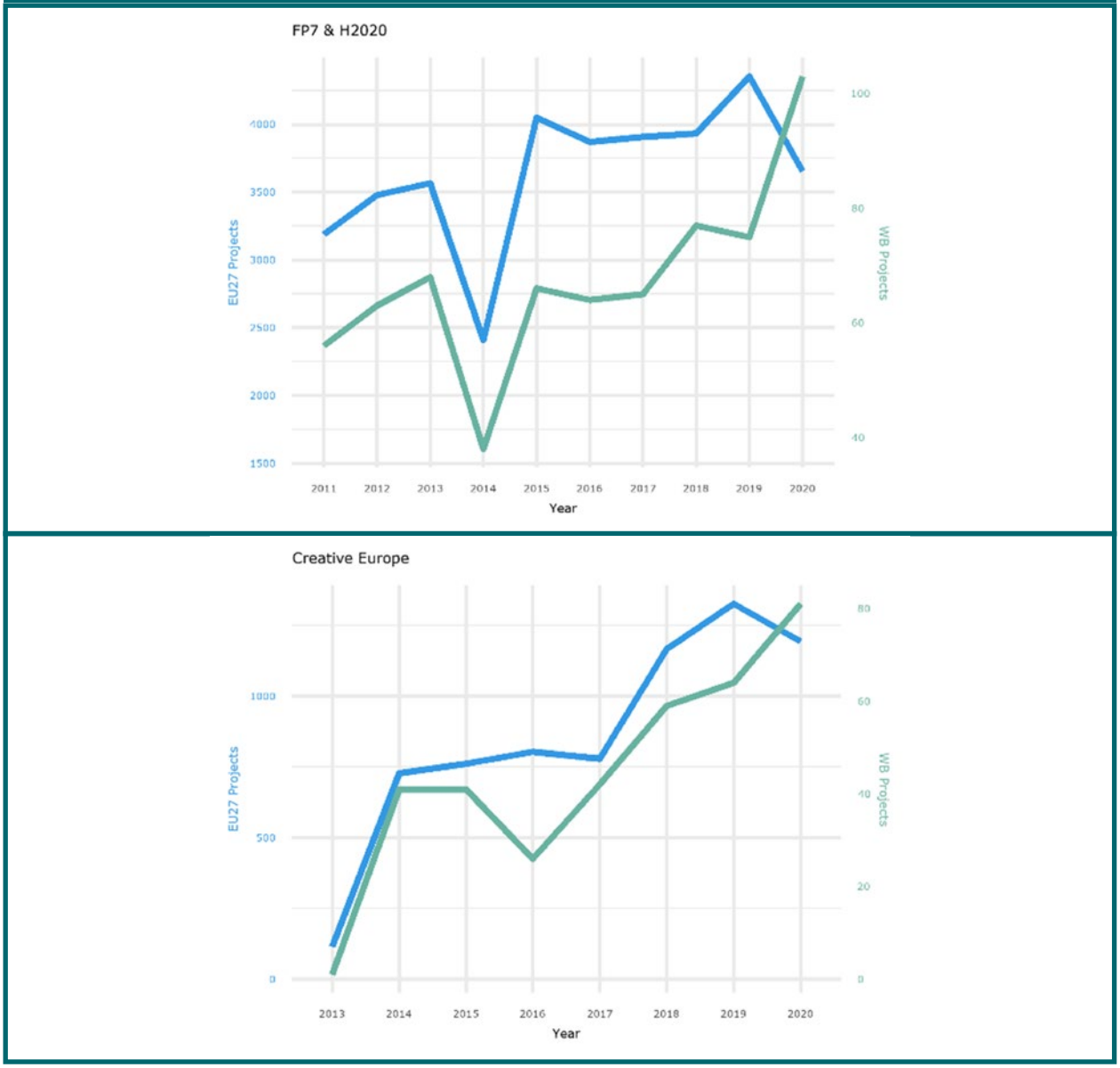


Table 18. Distribution of projects in the main H2020 programmes

	Albania	Bosnia and Herzegovina	Kosovo	Montenegro	Serbia	EU27
European Research Council (ERC)	0,00%	0,00%	0,00%	0,00%	2,53%	13,94%
Future and Emerging Technologies (FET)	0,00%	0,00%	0,00%	0,00%	0,47%	3,22%
Marie Skłodowska-Curie Actions (MSCA)	4,37%	13,85%	0,00%	3,72%	6,79%	8,38%
Research Infrastructures (RIs)	7,85%	3,65%	0,00%	7,25%	4,02%	3,32%
Industrial leadership (no subprogramme specified)	0,00%	0,00%	0,00%	0,00%	0,00%	0,38%
LEIT - ICT	5,61%	5,58%	16,21%	26,75%	16,58%	16,04%
LEIT - Nanotechnologies	0,00%	0,00%	0,00%	0,00%	0,00%	0,94%
LEIT - Advanced materials	16,05%	0,00%	0,00%	0,00%	0,25%	1,83%
LEIT - Biotechnology	0,00%	0,00%	0,00%	0,00%	1,37%	1,19%
LEIT - Advanced manufacturing and processing	0,00%	0,00%	0,00%	0,00%	1,98%	2,71%
LEIT - Space	0,00%	0,00%	2,10%	0,33%	1,23%	1,46%
Access to risk finance	0,00%	0,00%	0,00%	0,00%	0,00%	0,02%
Innovation In SMEs	0,00%	1,35%	0,00%	1,26%	7,71%	1,38%
Societal Challenges (no subprogramme specified)	0,00%	0,00%	0,00%	0,00%	0,56%	3,12%
Societal Challenges - Health	23,63%	5,65%	27,48%	15,99%	6,50%	9,34%
Societal Challenges - Food	4,86%	2,01%	0,00%	4,56%	6,82%	4,84%
Societal Challenges - Energy	11,06%	30,94%	0,00%	26,75%	13,69%	7,71%
Societal Challenges - Transport	0,61%	0,44%	0,00%	1,66%	3,33%	8,99%
Societal Challenges - Climate	6,31%	19,28%	24,41%	0,62%	3,95%	3,74%
Societal Challenges - Europe in a changing world	11,87%	11,69%	26,35%	0,00%	1,92%	1,32%
Societal Challenges - Secure societies	3,07%	1,87%	3,44%	11,12%	3,07%	2,18%
Widening actions	0,00%	0,00%	0,00%	0,00%	16,31%	1,47%
Science with and for Society	4,71%	3,69%	0,00%	0,00%	0,93%	0,56%
Euratom	0,00%	0,00%	0,00%	0,00%	0,00%	1,94%

CLUSTERS AND SCIENCE PARKS

In this subsection we analyse the data available in 2022 on the European Cluster Collaboration Network, collected through the Cluster Organisations Mapping Tool, and the information that appears on the directory of the IASP - International Association of Science Parks and Areas of Innovation, the main international association of science and technology parks and areas of innovation.

Although for the WB only four parks (UBT - Science and Innovation Campus in Kosovo and the Business incubator Novi Sad, Science Technology Park Belgrade, and the Science Technology Park Nis in Serbia) could be identified in IASP, the existence of clusters and science parks is a signal of economic specialisation and of innovation activity in the private sector.

For clusters in the Cluster Organisations Mapping Tool, the data source provides an indication of areas of specialisation, in the form of NACE codes, scientific disciplines and policy objectives, in a fashion similar to the Eye@RIS3 platform.

In the Cluster Organisations Mapping Tool of the European Cluster Collaboration Platform, Albania presents two Clusters: AgriNet Albania and Albanian ICT Association. The former is related to the Agricultural sector and the latter to the ICT sector.

Montenegro includes only one cluster, the Wine Cluster Montenegro (agriculture), featuring 350 members, of which 2 are research organisations.

Bosnia and Herzegovina, too, is home to just one cluster that seems rather comprehensive (113 cluster members of which 55 SMEs, 8 large companies and 50 research organisations). The cluster, named BIT Alliance, is connected to the priority "Digital transformation: Industry 4.0, smart and additive manufacturing, ICT trust, cyber security & network security: Internet of Things, and Smart system integration".

Looking at the clusters present in the Cluster Organisations Mapping Tool in North Macedonia, the MASIT - ICT chamber of commerce is related to the ICT sector; and the second cluster, the TTA-Textile Cluster Macedonia, is connected to the manufacturing and textile, but from the perspective of the creative industries and digital transformation. In fact, at the level of the priority areas this cluster is assigned to "Support to link cultural & creative industries with traditional industries" and "E-Commerce & SMEs online".

Even if Kosovo has on the list of the European Cluster Collaboration Platform just one cluster, this WB economy appears on the directory of the IASP with one Science Park. Both organisations listed therein are related to the ICT sectors and they seem to have a strong research activity. The cluster STIKK - Kosovo ICT Association is a large cluster, with diversified members and an important number of research organisations/universities/technology centres. The UBT - Science and Innovation Campus is the campus of the University for Business and Technology, a private institute of higher education and research in Pristina. The campus features an important Science Park, mainly specialised in the following industrial sectors: ICT & Communications, Robotics and Plant Automation, Mechanics, Subassemblies, Components.

Serbia has the most articulated cluster ecosystem across WB economies, with 25 clusters[18] present in the database of the Cluster Organisations Mapping Tool, and 3 Science Parks on the directory of the IASP. Among the different clusters, 8 of them are related to agriculture. As expected, the ICT domain also has an important presence. Furthermore, in Serbia there is a strong presence

(18) Association "Cluster for Energy Efficiency"; ASSOCIATION CLUSTER AGROINDUSTRY; Automobilski klaster Srbije; Center for organic production Selenča; Cluster AGRO START UP; Cluster for ecological culture and ecological energy Ecopanonia; Cluster for Entrepreneurial employment of young people Activator; Cluster of Cultural Routes; Cluster of medical and health tourism; CONSTRUCTION CLUSTER DUNDJER; Eucaap; Fonund tourism microregional cluster Subotica-Palić; ICT Cluster of Central Serbia; ICT Net; Klaster FACTS; NiCAT Cluster; Railway Cluster for South-East Europe; Serbia Film Commission; Serbian Games Association; Urban Planning Cluster; Vojvodina ICT Cluster; Vojvodina Metal Cluster; Vojvodina organic cluster; Wellness Serbia; and Кластер креативних инудстрија Војводине - Creative Industries Cluster of Vojvodina.

of a whole spectrum of sectors that were not observed for the rest of the WB economies: the cluster of automotive, the cluster of railway for logistics and a noticeable importance of the creative and cultural sector.

Regarding the three Science Parks listed in the IASP directory, the Science Technology Park Belgrade is a partnership between the Republic of Serbia Government, the City of Belgrade and the University of Belgrade that hosts and supports start-ups and high-tech companies (SMEs and development centres of international companies), helping them develop and commercialise innovative products and services and grow exports. It doesn't seem to have thematic or sectoral specialisation domains. Conversely, the Business incubator Novi Sad focuses on scaling up young companies in the IT and creative industries while the Science Technology Park Nis is centred especially in the field of high technology and on developing start-ups technologies arising from scientific research.

4.2.2 Definition and characterisation of the preliminary specialisation domains

GENERAL CONSIDERATIONS

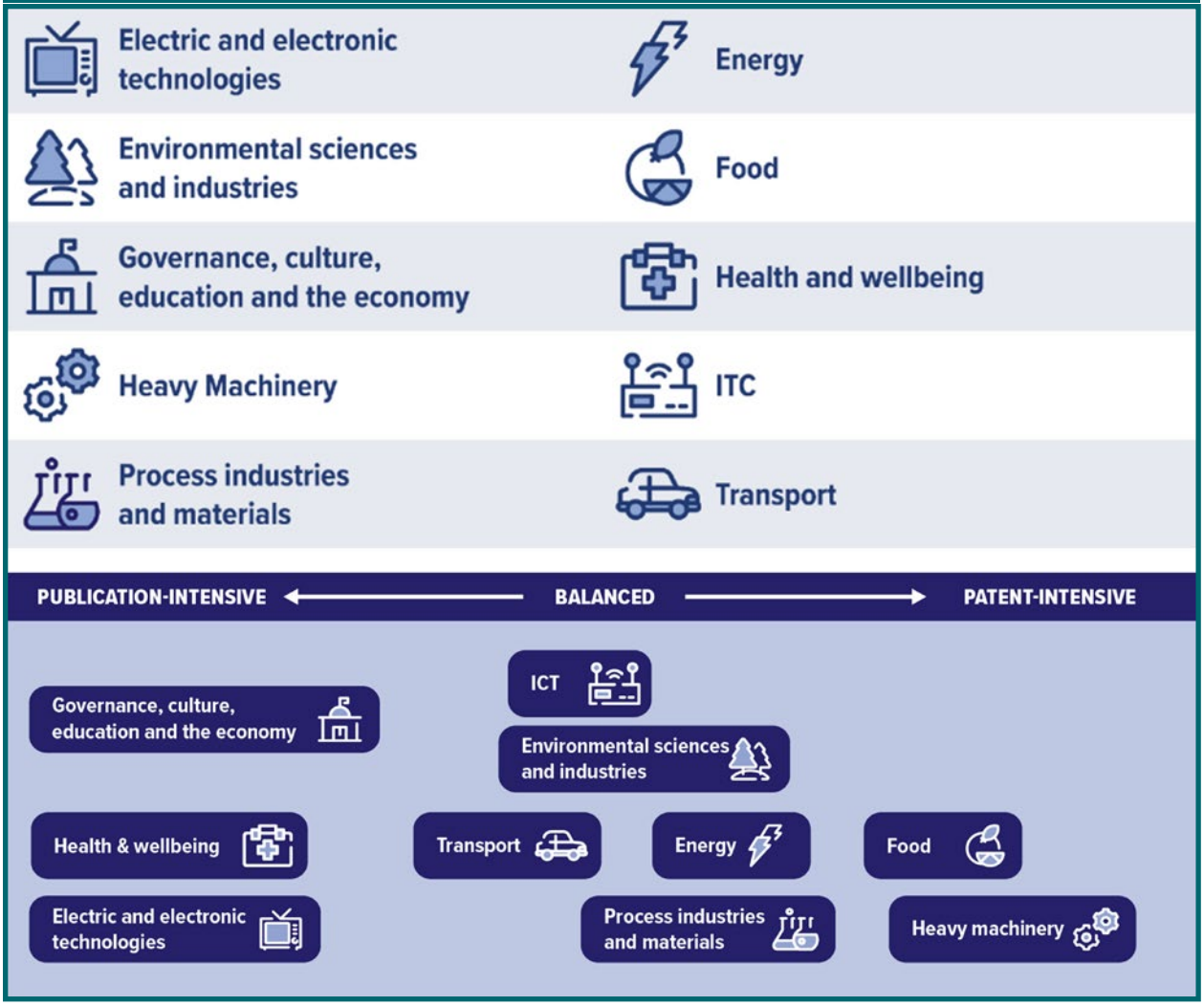
Through the methodology explained in the Annex 3, we used a topic modelling algorithm based on Latent Dirichlet Allocation to extract a series of emerging topics from the texts of the abstracts of WB publications, international patents and projects. In essence, these topics give an overall picture of the research and innovation themes covered by WB actors active in S&T endeavours.

This method ultimately yields a series of topics, each consisting of a list of related words. Given their very fine scale and their rather wide scope, we found in some cases that more than one of the extracted topics was covering the same broader domain once topics were grouped at a thematic scale relevant for the design of a smart specialisation strategy. In some other instances, instead, we found topics that were covering areas of research that were not immediately relevant for the scopes of the S3 design and implementation. Additionally, albeit topics allow one to get a very precise grasp of the technical content of the analysed texts, they are sometimes hard to interpret by the non-specialised public. For all these reasons, we decided to map the topics we extracted to a series of larger research and innovation domains of interest for the WB region. The names of the domains are not derived from any pre-existing classification scheme and were specifically designed in this study, although they are inspired by previous exercises of scientific and economic mapping of the WB, as well as domain names used in 2014-2020 EU smart specialisation strategies.

PRESENTATION AND QUANTIFICATION OF THE SPECIALISATION PRELIMINARY PRIORITY DOMAINS

Considering all the above, the following 10 domains were finally selected in this study, in alphabetical order in the Figure A.

Figure A. WB S&T preliminary priority domains of specialisation



The above choice allowed us to best capture the breadth and focus of research and innovation efforts of the WB economies. Furthermore, the proposed domains nicely capture the most important priority areas for R&D and innovation identified by WB policymakers and stakeholders in Radosevic et al. (2017)[19]: this study found those actors deemed ICT, energy, digital services, healthcare, food, environment and biosciences and biotechnology as priority areas for local R&D&I ecosystems. In the second schema above, the domains with large volumes of data associated have been identified and grouped them into science-oriented domains (i.e. relatively publication-intense), balanced domains and technology-oriented domains (i.e. relatively patent-intense and possibly more mature for a commercial exploitation).

Here, we present the main semantic content of each preliminary domain, by exploiting the emerging topics extracted from the abstracts and descriptions of WB publications, patents and projects that underpin the domains of the WB economies.

(19) Radosevic, S., Aralica, Z., Raos, J., Assessing Research and Policy Support Needs for Innovation in South East Europe, Smart EIZ Report, 2017.

Table 19. Overview of the semantic content of each preliminary domain identified in the present work

Domain	Keywords
Better societies - governance, culture, education and the economy	management, education, development, system, business, economic, urban, process, European, social, learning, new, model, analysis, data, systems, waste, countries, tourism, market
Electric and electronic technologies	power, voltage, system, electrochemical, distribution, current, electrode, carbon, systems, network, grid, circuit, voltammetry, electric, energy, fault, control, method, electrical, quality
Energy	energy, power, system, solar, gas, renewable, thermal, consumption, systems, heat, combustion, production, plants, efficiency, plant, electricity, oil, heating, fuel, sources
Environmental sciences and industries	water, species, river, soil, quality, air, pollution, samples, plant, new, forest, climate, heavy, filter, natural, different, environmental, system, metals, metal
Food	acid, food, plant, activity, oil, production, antioxidant, different, content, fruit, phenolic, species, quality, essential, wheat, total, products, cultivars, meat, extracts
Health & wellbeing	disease, cancer, patients, health, clinical, cell, treatment, human, study, syndrome, heart, risk, chronic, coronary, care, therapy, blood, stress, diseases, system
Heavy machinery	motor, power, system, magnetic, wheel, gear, rotor, induction, machine, control, speed, drive, je, energy, vibration, turbine, analysis, systems, electrical, electric
ICT	system, network, systems, data, networks, power, sensor, control, wireless, image, algorithm, model, neural, time, mobile, software, analysis, different, signal, language
Process industries and materials	properties, process, steel, surface, materials, different, ray, sup, laser, structure, thermal, analysis, metal, alloy, mechanical, acid, material, composite, nanoparticles
Transport	traffic, network, road, system, networks, vehicle, transport, railway, safety, routing, simulation, control, vehicles, mesh, wireless, air, model, urban, accidents, rail

Table 20 presents the total number and share of records per domain, segmented by data sources, to provide basic information on the nature of each domain.

As can be observed, the number of publications greatly outnumbers the number of records in the other data sources. The conclusions below, regarding the comparison and content of preliminary priority domains, are thus affected by the larger representation of publications and academic actors, and alternative ranking and interpretations could result from filtering or normalising data sources.

For the whole WB region, Health & wellbeing is the domain with the largest amount of associated records. This finding does not come as a surprise, given that scientific publications are the main source of data and that typically biomedical disciplines have fairly larger publication outputs than other research fields (see for instance Crespo et al (2013)[20]). In this case, however, we also found the WB region to be strongly specialised in related scientific publication areas: Pharmacology, Toxicology and Pharmaceutics (LQ = 2.08), Dentistry (1.93), Veterinary (1.73), Medicine (1.70) in terms of publications and (mildly) in Medical or Veterinary Science-Hygiene for patents (see section 3.1.1) with respect to the EU-27 baseline, thus the observed output in this specific domain is in fact due to a specific specialisation pattern. These findings also corroborate the listing of healthcare as an important priority area for R&D and innovation spending by WB policy makers and stakeholders[21].

(20) J.A. Crespo, Y. Li, J. Ruiz-Castillo, The measurement of the effect on citation inequality of differences in citation practices across scientific fields, PLoS ONE 8 (2013).

(21) Radosevic, S., Aralica, Z., Raos, J., Assessing Research and Policy Support Needs for Innovation in South East Europe, SmartEIZ Report, 2017.

Table 20. Number of records per data source and preliminary priority domain

	Publications	Patents	EC R&I Projects	Creative Europe & Culture
Health & wellbeing	40.134	338	120	10
Better societies - governance, culture, education and the economy	16.662	86	451	346
ICT	15.618	417	177	2
Process industries and materials	13.530	290	29	1
No domain	11.773	55	8	20
Food	11.444	274	90	1
Environmental sciences and industries	10.250	260	84	2
Electric and electronic technologies	3.285	142	8	0
Energy	2.958	249	90	0
Heavy machinery	1.565	1.720	8	1
Transport	1.451	53	28	0

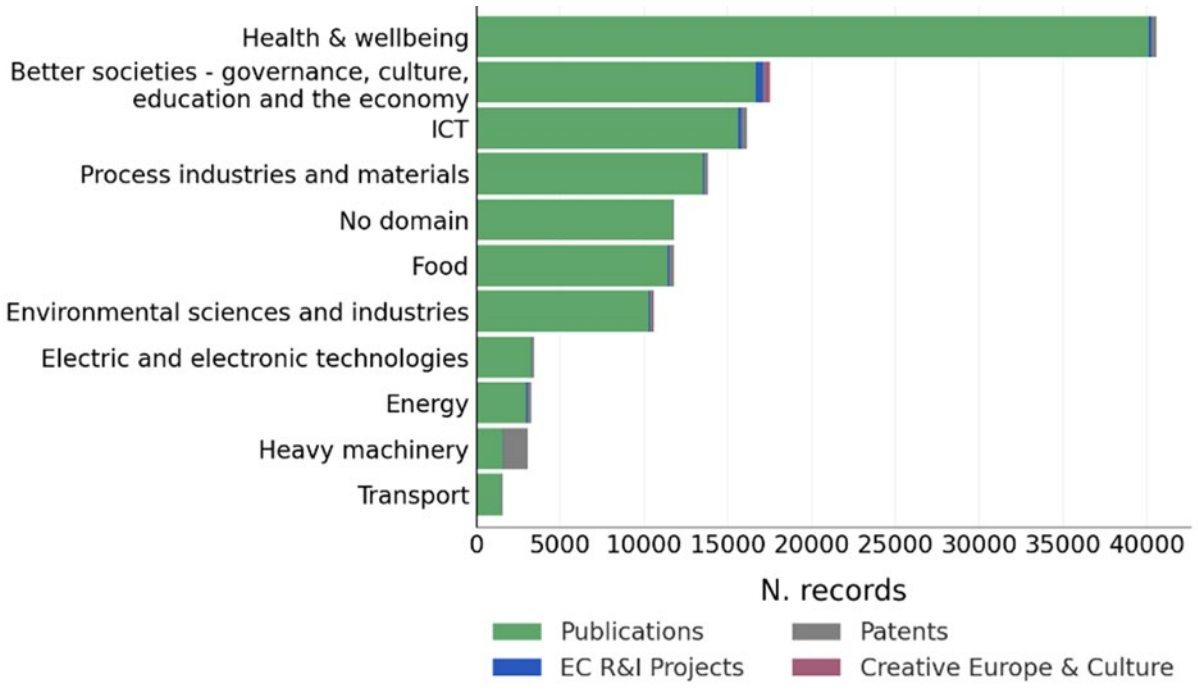
Better societies - governance, culture, education and the economy, this domain related with public policy, the social sciences and humanities and the creative industries is ranked 2nd. As one could have expected, European projects funded via the FP7, H2020 and the Creative Europe programmes are a fairly large percentage of the records. Because of the lower coverage of local sources for publications and due to its non-technological nature, this domain is harder to frame in the specialisation analyses carried out in the preceding section from publications, patents and trademarks. However, a continuous degree of specialisation with respect to EU-27 was detected in the patent class Sports; Games; Amusements.

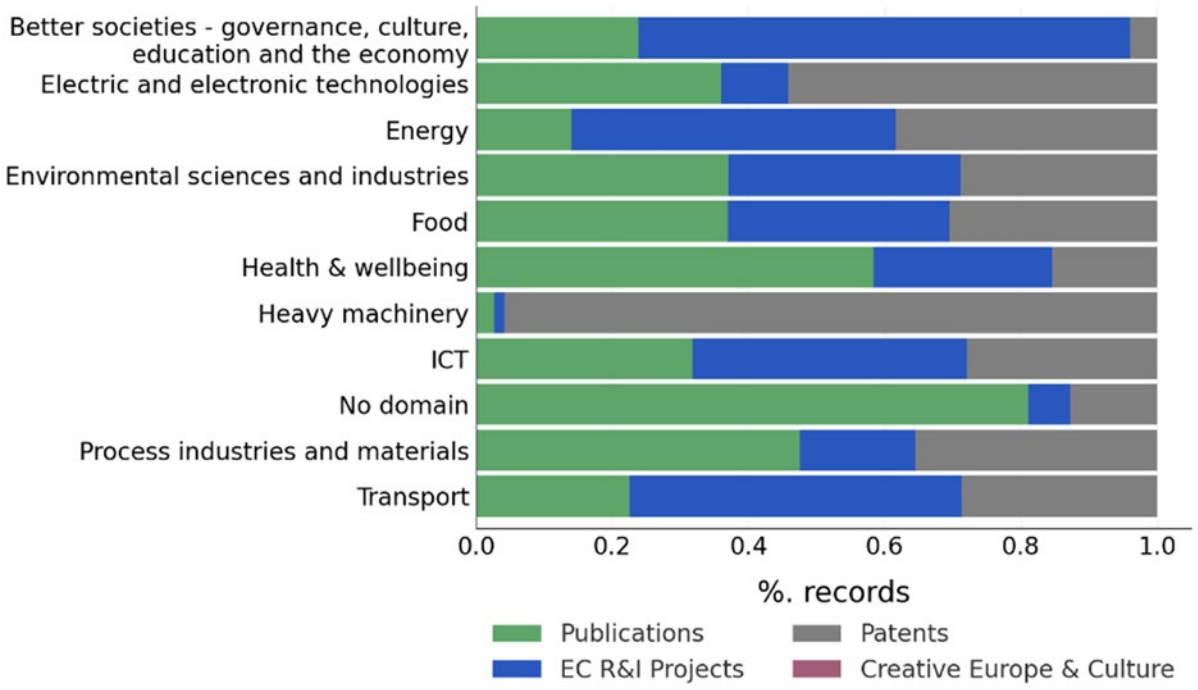
The third largest domain is found to be ICT, again an area deemed of strategic importance by WB policy makers and stakeholders[22]. The number of patents among the records pertaining to the ICT domain, i.e., G06, is the second highest (after Heavy Machinery), making this domain rather technology oriented. Computer science is a relevant scientific specialisation of the WB. However ICT seems to be a mildly declining specialisation in relation to the EU baseline.

The fourth domain by output for the WB region is that of process industries and materials. As observed, these research efforts are mainly related with advanced chemistry and materials, in line with the specialisation patterns observed in Chemistry and Chemical Engineering for publications and the emerging specialisation in Cement, Concrete, Artificial Stone, Ceramics observed in patents. Due to its relative patent intensity, this domain is rather technology oriented in relation to the rest.

(22) ibidem.

Figure 24. Number of records per data source and preliminary priority domain, and normalised results by total size of each data source





The 5th domain per number of records is Food, yet another area considered key for R&D and innovation by policymakers and stakeholders. Again, this finding is in line with the specialisation detected in patents (strong specialisation in the IPC class A01: Agriculture, Forestry, Animal Husbandry, Hunting, Trapping, Fishing with respect to EU-27) and in trademarks (specialisation with respect to EU-27 in the Nice classes food and beverages; Meat and dairy products; Beers and non-alcoholic beverages). This domain is also found to be relatively technology-oriented.

Environmental sciences and industries, the next domain per number of records, was also considered a strategic area for WB research and innovation development. A compatible pattern was uncovered in the preceding taxonomical analysis, where a specialisation with respect to EU27 was observed in the Water supply; Sewerage IPC patent class. Additionally, Environmental Science is found to be an area of strong and continuous specialisation in publications for the WB region against the EU-27 baseline.

Electric and electronic technologies follows in the ranking. This domain is primarily concerned with research and innovation in the fields of electric equipment, electronics and batteries, although no clear related specialisation could be detected for the case of patents and trademarks.

Energy is another domain deemed of particular importance for the WB R&D ecosystem, the 8th in terms of associated records. Again, the definition of this domain is in line with the specialisation analyses carried out previously. WB were indeed found to be specialised in the class Machines or Engines for patents, while a continuous specialisation in Energy for publications was detected. Notably, this is the third domain per patent contribution, a feature that makes the domain especially relevant for innovation and technology policy-setting in the region.

The following domain per number of associated records is Heavy machinery. This is the domain where the contribution of patents is the largest, making this the most technology-oriented domain. The backbone of this domain seems to be captured by the observed specialisation in patents for the classes Machines or Engines; Steam generation and Separation of solid materials using liquids or using pneumatic tables and, for the case of publications, Engineering, in which WB has a constant specialisation with respect to EU-27.

The last domain per number of records is Transport; this domain was not identified as a priority by WB policymakers and stakeholders and its relative volume of research and innovation activities is indeed found to be relatively more modest.

FINER AUTOMATIC THEMATIC CHARACTERISATION OF THE PRELIMINARY SPECIALISATION DOMAINS

To achieve a greater understanding of research and innovation domains in the WB, we have applied a second level automatic thematic classification derived from a deep learning topic modelling framework to the same data set of S&T documents. This time, in complementarity to the 10 domains identified above, 60 topics have been automatically extracted. In Figure 25 we present an evocative 2-D[23] visualisation[24] of the results achieved from this second Topic Modelling pipeline, where each point represents a document, and its colour represents the topic. For each topic, a series of manually assigned topic labels, based on the top KWs, are presented.

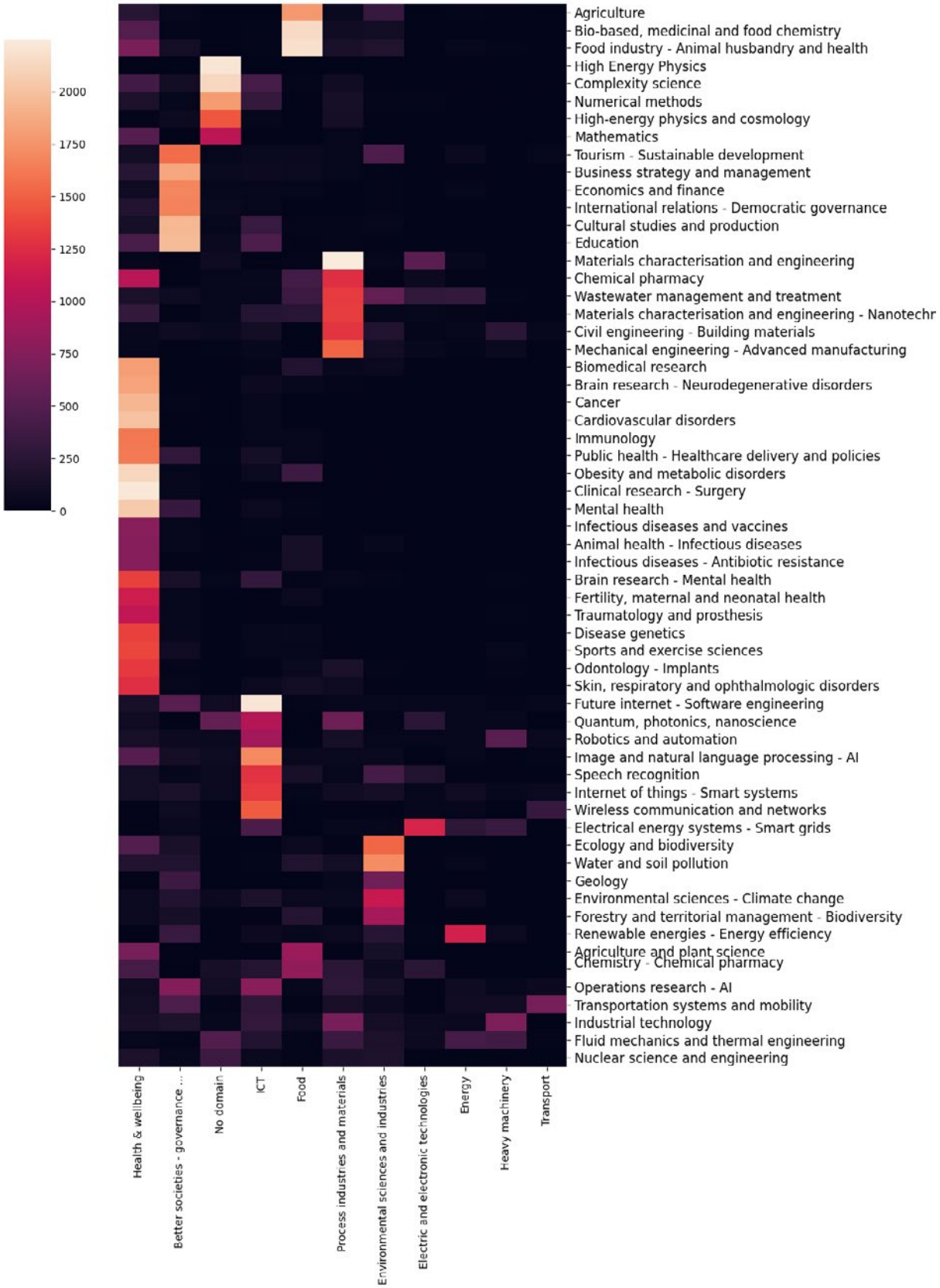
In Figure 26 we present a heat map of the alignment between the 10 S3 preliminary priority domains from the first topic modelling, and the more granular topics extracted from the second topic modelling. Several topics cluster for most of the preliminary domains, showing the consistency of both methodologies, and the thematic coherence of the 10 domains.

(23) See Maaten L, Hinton G. (2008).

(24) This dimensionality reduction has been done using the T-SNE algorithm. This figure is an abstract representation, and shouldn't be interpreted as a perfectly accurate description of the research portfolio due to the extreme dimensionality reduction that goes from 764 dimensions in the embedded space to a 2-D visualisation.

Figure 25. 2-D visualisation of the embedded space and the S&T topic labels. Each point represents a document and colours represent topics.

Figure 26. Heat map of the domains and BERT Topics alignment



Selecting the topics which better align with the domains, the next tables propose a second level thematic classification of the contents of each domain. Individual documents which belong to a domain, but not to one of the top aligned topics for that domain, are classified and bundled as "Others".

Table A. Health & wellbeing

Topic	Documents (n)	Top 20 Words
Clinical research - Surgery (31)	2226	artery surgical surgery aortic abdominal aneurysm acute vascular renal clinical treatment injury pulmonary disease postoperative coronary carotid cardiac patients liver
Obesity and metabolic disorders (50)	2116	disease patients cardiovascular diabetes risk blood syndrome metabolic insulin mellitus kidney liver renal diseases fatty chronic pressure lipid study dietary
Mental health (2)	2051	health disorder mental stress social study disorders patients life personality cross scale depression sectional students questionnaire anxiety symptoms use clinical
Cardiovascular disorders (45)	2001	coronary heart disease failure artery myocardial patients cardiac ventricular infarction acute atrial cardiovascular risk clinical stroke fibrillation intervention percutaneous therapy
Cancer (38)	1931	cancer carcinoma breast cell tumor lung thyroid tumors patients colorectal malignant clinical treatment lymph primary therapy ovarian metastatic cervical prognostic
Brain research - Neurodegenerative disorders (39)	1833	brain disorder alzheimer cognitive disease sclerosis disorders clinical multiple functional imaging patients protein treatment matter impairment neurodegenerative connectivity white schizophrenia
Biomedical research (1)	1805	stress cells oxidative rats cell effects wistar rat human tissue cancer male antioxidant liver kidney injury acid activity muscle protein
Public health - Healthcare delivery and policies (42)	1621	health care medical clinical study european healthcare medicine sectional disease services patients cancer public mental cross global national system drug
Immunology (18)	1609	disease cell patients cells clinical autoimmune arthritis syndrome immune blood leukemia inflammatory acute chronic systemic rheumatoid treatment stem renal sclerosis
Sports and exercise sciences (8)	1383	players physical athletes body exercise training soccer muscle activity sports basketball sport motor fitness female male strength elite young height
Disease genetics (24)	1359	genetic gene cancer disease risk dna syndrome patients variants human cell mutations polymorphisms disorder association analysis mutation clinical breast diseases
Brain research - Mental health (55)	1352	brain visual functional human stimulation auditory cognitive activity cortex speech motor language memory cortical children connectivity processing system sleep different
Odontology - Implants (58)	1319	dental oral bone implant treatment periodontal health implants teeth tooth tissue caries canal root denture dentistry dentures materials different gingival

Topic	Documents (n)	Top 20 Words
Skin, respiratory and ophthalmologic disorders (37)	1267	skin disease patients glaucoma clinical allergic nasal diseases treatment inflammatory eye surgery chronic asthma ocular cell corneal retinal intraocular laser
Fertility, maternal and neonatal health (12)	1148	pregnancy fetal women ovarian pregnant uterine section maternal cesarean gestational neonatal reproductive vaginal syndrome ultrasound birth preterm congenital delivery growth
Traumatology and prosthesis (48)	1068	fractures bone fracture hip surgical injuries knee pain joint surgery nerve injury ligament femoral treatment patients clinical functional tibial fixation
Chemical pharmacy (32)	1019	ii_complex crystal_structure cisplatin dft_calculation elemental_analysis title_compound cytotoxic_activity molecular_docking_study antiproliferative_activity cytotoxicity substituent hela synthesize_compound
Infectious diseases and vaccines (46)	773	patient covid hiv infection influenza serbia hcv 95_ child hcv_infection ribavirin measle hpv svr vaccination pertussis genotype vaccine ci
Infectious diseases - Antibiotic resistance (19)	762	patient antibiotic infection _coli antimicrobial_ resistance ciprofloxacin antibiotic_resistance child sepsis vancomycin nosocomial_infection serbia biofilm penicillin pseudomonas_aeruginosa erythromycin cdi escherichia_coli imipenem
Animal health - Infectious diseases (47)	756	serbia dog infection brucellosis tick pig red_fox parasite seroprevalence cattle sheep disease human virus goat fox herzegovina wild_boar bosnia _canis
Others	6915	

Table B. Better societies - governance, culture, education and the economy

Topic	Documents (n)	Top 20 Words
Education (54)	1957	education learning educational school students teaching system teachers process language student higher engineering course development university schools computer management software
Cultural studies and production (21)	1946	cultural european language heritage literary art contemporary film serbian music new historical social festival creative albanian philosophy literature tourism culture
Business strategy and management (10)	1843	management business innovation quality organizational companies performance research process marketing satisfaction industry system information service market model customer analysis enterprises
Economics and finance (41)	1684	economic financial countries european market growth development sector policy economy economies crisis rate transition trade capital foreign banking exchange analysis
International relations - Democratic governance (14)	1661	political social european legal law international serbian war countries human rights national albanian public herzegovina union state democratic policy ethnic
Tourism - Sustainable development (28)	1555	development urban tourism sustainable management environmental city rural spatial land areas planning forest european economic cities heritage data local infrastructure
Others	5813	

Table C. ICT

Topic	Documents (n)	Top 20 Words
Future internet - Software engineering (44)	2209	data system software systems cloud web computing security management information application service business model development services mobile applications network process
Image and natural language processing - AI (20)	1702	image data neural recognition detection classification analysis images network learning system different networks processing text segmentation algorithm feature mining machine
Wireless communication and networks (11)	1477	network networks wireless system channel mobile communication access radio traffic relay power protocol simulation systems fading transmission performance routing video
Internet of things - Smart systems (52)	1325	sensor wireless networks system network monitoring data mobile energy smart systems devices localization power detection nodes sensors robot measurement field
Speech recognition (7)	1282	signal filter frequency image signals digital noise estimation speech processing sensing time filters video function power compression algorithm system reconstruction
Quantum, photonics, nanoscience (27)	1003	optical quantum laser antenna field magnetic power wave waveguide voltage dielectric surface beam solitons energy high photonic light electron
Robotics and automation (43)	911	control robot system systems controller robots robotic motion motor model gear vibration dynamic vehicle design mechanical fuzzy speed force drive
Operations research - AI (3)	775	fuzzy decision process optimization system criteria algorithm problem multi model management systems selection analysis data production method problems quality parameters
Others	5088	

Table D. Food

Topic	Documents (n)	Top 20 Words
Food industry - Animal husbandry and health (30)	2176	food meat milk production products quality acid dairy flour cows wheat content fatty protein cheese feed different samples composition fat
Bio-based, medicinal and food chemistry (36)	2145	antioxidant activity phenolic oil extracts essential compounds total oils content plant extract antimicrobial species composition medicinal properties extraction bioactive acid
Agriculture (51)	1773	plant soil fruit cultivars wheat seed plants yield production maize different quality crop species growth grain cultivar content crops root
Agriculture and plant science (22)	873	species plant cultivars genetic plants fruit breeding wheat maize yield sunflower pollen traits genotypes seed populations production diversity grapevine different
Others	4451	

Table E. Heavy machinery		
Topic	**Documents (n)**	**Top 20 Words**
Industrial technology (0)	718	process manufacturing sensor system design printing production surface thermal je materials technology industry pressure systems temperature plastic device 3d cutting
Robotics and automation (43)	526	control robot system systems controller robots robotic motion motor model gear vibration dynamic vehicle design mechanical fuzzy speed force drive
Fluid mechanics and thermal engineering (57)	386	flow heat gas wind fluid power transfer water turbine energy model air pressure system combustion thermal engine temperature numerical plant
Electrical energy systems - Smart grids (26)	342	power system voltage distribution energy systems network current grid control motor wind electrical fault electric induction transmission quality load converter
Others	997	

Table F. Transports		
Topic	**Documents (n)**	**Top 20 Words**
Transportation systems and mobility (4)	674	traffic road vehicle transport system vehicles safety railway urban transportation noise network management problem air model accidents systems parking public
Wireless communication and networks (11)	333	network networks wireless system channel mobile communication access radio traffic relay power protocol simulation systems fading transmission performance routing video
Others	480	

Table G. Electric and electronic technologies		
Topic	**Documents (n)**	**Top 20 Words**
Electrical energy systems - Smart grids (26)	1195	power system voltage distribution energy systems network current grid control motor wind electrical fault electric induction transmission quality load converter
Materials characterisation and engineering (34)	533	inf ray sup properties films oxide diffraction nanoparticles powder structure phase carbon thin crystal magnetic powders electrochemical thermal hydrogen materials
Others	1649	

Table H. Energy		
Topic	**Documents (n)**	**Top 20 Words**
Renewable energies - Energy efficiency (23)	1174	energy power renewable solar heat thermal system building heating efficiency buildings systems water production plants waste consumption sources electricity plant
Fluid mechanics and thermal engineering (57)	407	flow heat gas wind fluid power transfer water turbine energy model air pressure system combustion thermal engine temperature numerical plant
Others	1604	

Table I. Environmental sciences and industries

Topic	Documents (n)	Top 20 Words
Water and soil pollution (16)	1713	water river soil pollution heavy quality samples metals metal waste environmental fish sediment sediments soils plant species lake urban waters
Ecology and biodiversity (9)	1518	species new genus sp fauna river fish water genetic balkan populations european sea lake diversity mediterranean taxonomic population taxa freshwater
Environmental sciences - Climate change (29)	1107	water climate air data river quality precipitation change temperature pollution model wind urban solar soil meteorological weather atmospheric flood analysis
Forestry and territorial management - Biodiversity (40)	922	forest species forests vegetation plant tree soil conservation pine climate natural flora habitat communities european ecological mountain management balkan area
Geology (25)	642	basin rocks river deposits geological tectonic water geochemical loess sediments sedimentary archaeological rock late mineral karst volcanic lake deposit seismic
Wastewater management and treatment (6)	576	development urban tourism sustainable management environmental city rural spatial land areas planning forest european economic cities heritage data local infrastructure
Others	3748	

Table J. Process industries and materials

Topic	Documents (n)	Top 20 Words
Mechanical engineering - Advanced manufacturing (56)	1515	steel alloy properties mechanical alloys machining process surface welding corrosion laser composite materials material metal high coatings composites fracture thermal
Materials characterisation and engineering - Nanotechnology (49)	1341	poly drug nanoparticles properties polymer acid nanocomposites materials delivery hydrogels composite composites different methacrylate tissue films hydrogel systems nanocomposite release
Wastewater management and treatment (6)	1327	waste water process carbon adsorption oil acid production metal treatment removal wastewater zeolite different materials electrochemical clay natural copper
Civil engineering - Building materials (59)	1291	concrete element analysis finite structures steel method model composite structural seismic shear dynamic crack numerical strength mechanical load material structure
Chemical pharmacy (32)	1266	complexes ii derivatives activity acid inf crystal new compounds molecular structure sup ligand metal novel chemical ligands methyl cancer drug
Industrial technology (0)	686	invention sensor machine lid material bottle groove screw pipe container plate knitted_fabric fabric temperature chamber textile_material cmm box inductor friction
Others	6096	

4.2.3 Mapping the preliminary priority domains unto economic sectors

Once the relevant domains for the scientific and innovative potential of the WB region have been established, we proceeded to map them onto a set of qualitatively matching economic and industrial sectors, as framed by NACE, rev 2, 2-digit codes. We accomplished the latter by exploiting the eye@RIS3 tool, retrieved in 2022. As stated, the tool provides S3 priorities for European and extra-European territories, each with a series of related NACE codes. In brief, for each herein defined domain, we identified in the tool all qualitatively matching priorities, irrespective of their geographical provenance. We then retained the corresponding NACE codes and finally selected all the ones we deemed pertinent for the WB case. It is relevant to stress, once again, that the whole procedure (and therefore the final mapping obtained) is purely qualitative and thus that the domain to NACE mappings are approximate and do not aspire to be rigorous in any way.

The results of the mapping effort are summarised in Table 21. As it can be observed, several NACE codes are associated with each of the priorities. Of these categories, 14 were identified as either a current or an emerging strength in the previous section dedicated to mapping of the economic potential, while 19 were not. Among the sectors not listed in the report, the greatest part falls in the "Better societies - governance, culture, education and the economy" domain: these missing sectors are mainly linked with educational and cultural activities.

Table 21. Mapping of the domains defined in this report to economic activities classification NACE, Rev. 2 (2008) at two-digit level*

		NACE	Strength	
Domain	**code**	**Description**	**C**	**E**
Better societies - governance, culture, education and the economy	I.55	Accommodation		
	J.63	Information service activities		
	K.64	Financial service activities, except insurance and pension funding		
	P.85	Education		
	R.90	Creative, arts and entertainment activities		
	R.91	Libraries, archives, museums and other cultural activities		
	R.93	Sports activities and amusement and recreation activities		
Electric and electronic technologies	C.26	Computer, electronic and optical products		
	C.27	Electrical equipment		
	C.28	Machinery and equipment n.e.c.		
	J.61	Telecommunications		
Energy	D.35	Electricity, gas, steam and air conditioning supply		
Environmental sciences and industries	A.02	Forestry and logging		
	E.36	Water collection, treatment and supply		
	E.37	Sewerage		
	E.38	Waste collection, treatment and disposal activities; materials recovery		
	M.72	Scientific research and development		

		NACE	Strength	
Domain	code	Description	C	E
Food	A.01	Crop and animal production, hunting and related service activities		
	A.03	Fishing and aquaculture		
	C.10	Food products		
	C.11	Beverages		
Health & wellbeing	C.21	Basic pharmaceutical products and pharmaceutical preparations		
	J.63	Information service activities		
	Q.86	Human health activities		
	Q.87	Residential care activities		
Heavy machinery	C.28	Machinery and equipment n.e.c.		
	M.72	Scientific research and development		
ICT	J.61	Telecommunications		
	J.62	Computer programming, consultancy and related activities		
	J.63	Information service activities		
Process industries and materials	C.20	Chemicals and chemical products		
	C.28	Machinery and equipment n.e.c.		
	C.32	Other manufacturing		
	M.72	Scientific research and development		
Transport	C.29	Motor vehicles, trailers and semi-trailers		
	C.30	Other transport equipment		
	H.49	Land transport and transport via pipelines		
	H.51	Air transport		
	M.71	Architectural and engineering activities; technical testing and analysis		

**The last two columns denote if the respective activity was identified as a current (C, green) or emerging (E, blue) strength, respectively, in the Mapping of the economic potential*

Because the corresponding year of issue is known for all records belonging to each data source, and since records have been linked to domains, it is possible to study temporal trends associated with each domain.

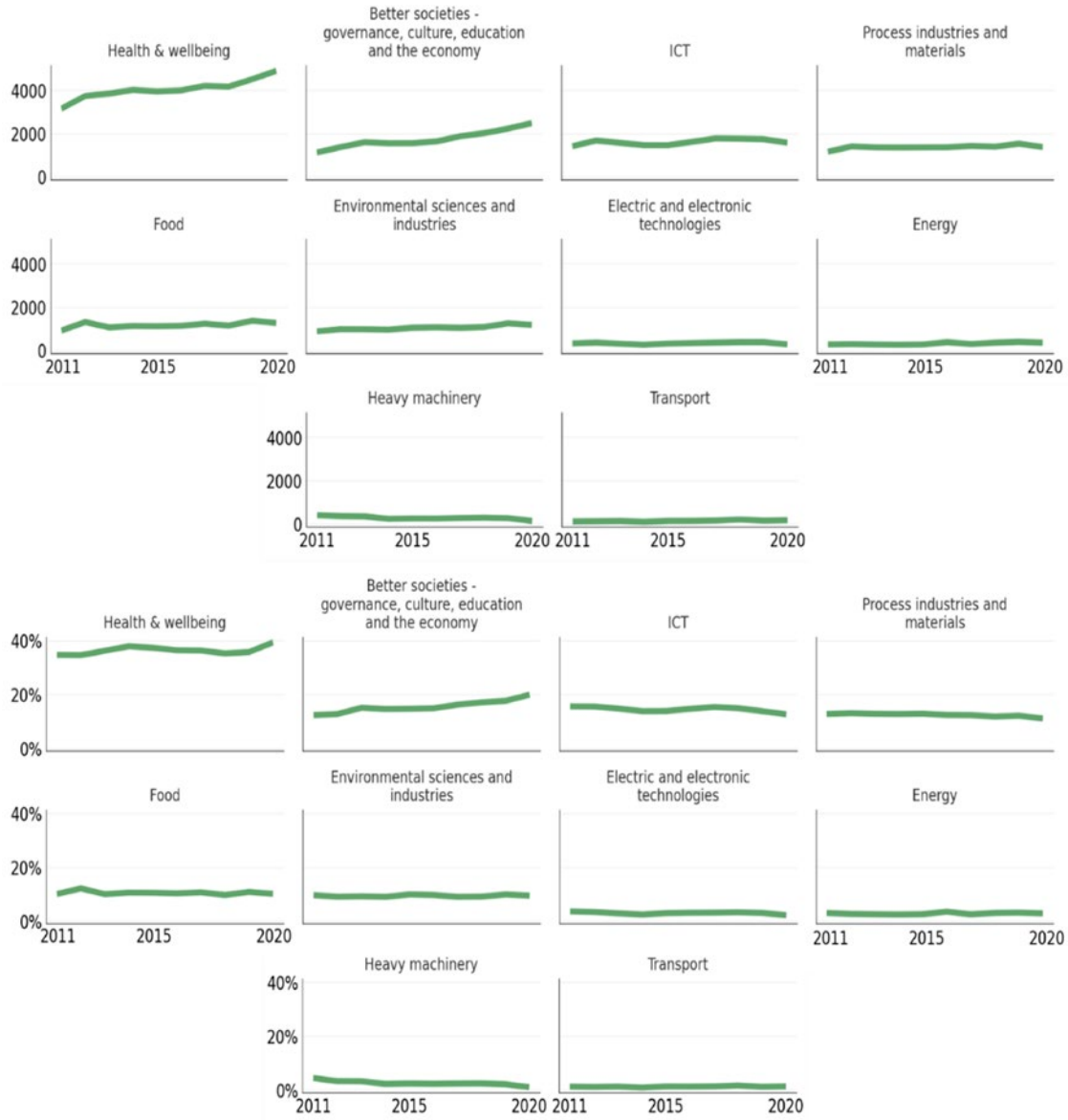
Figure 27 shows the observed trends for the different domains for all data sources aggregated together. The value reported is normalised over the total number of records observed each year.

An increasing trend can be observed for the domains Better societies - governance, culture, education and the economy and Health and wellbeing, respectively. Most of the remaining domains have a rather stable trend: a peak in production could be detected for Food in 2012 and for Energy in 2016.

Declining trends are detected instead for the domains Process industries and materials, Electric and electronic technologies and Heavy machinery, respectively. ICT shows an oscillating behaviour, but appears to also be declining overall.

The trend analysis can be also performed by keeping track of the source of all analysed data: by inspecting trends in scientific publications ver-

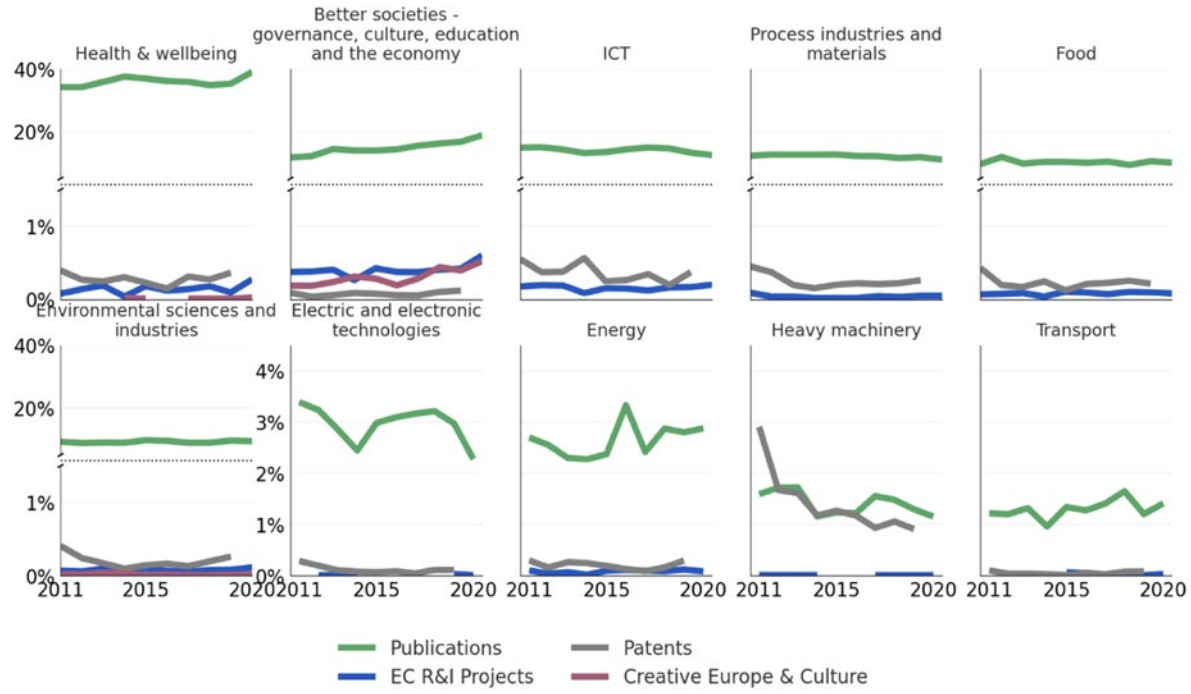
Figure 27. Absolute number and percentage of records in each preliminary specialisation domain (all sources combined), showing the temporal evolution of their absolute and relative importance in the WB region



sus, e.g., patents, one can gain an intuition of the shifts from scientific push to technological pull.

One of the main conclusions one can draw by looking at the graphs is that the number of publications is rather stable during our observation period in the five of top six domains, with 'Better societies- governance, culture, education and the economy' demonstrating an increasing trend. Patent trends are either stable or declining in almost every domain except for Health & Wellbeing, a finding that confirms once again the importance of this domain for the WB R&D ecosystem. It is also worth noting that the majority of projects funded via FP7, H2020 and Creative Europe were used for the development of the domain Better societies - governance, culture, education and the economy. Specifically, the Creative Europe framework seems to have a steadily increasing contribution in the region. Another aspect worth commenting on is that Heavy machinery has passed from being an essentially technological (i.e. patent-dominated) domain, to a rather scientific one, witnessing a decline in the innovative activity of the sector.

Figure 28. Percentage of records in each preliminary specialisation domain, segmented by source, showing the temporal evolution of their relative importance in the WB region



4.2.4 Main actors in the Western Balkans and their contribution to the preliminary priority domains

Table 22 presents the top 5 actors in each of the preliminary priority domains. It is apparent the relevance of academic actors, due to the importance of the publications data source in the analysis, and the centrality of Serbian actors. In particular, all top actors are universities.

This general pattern is observed in all but the more technology / industry preliminary domains. In fact, when filtering out publications and Individual applicants, domains such as Heavy Machinery, Electric and electronic technologies, Energy or even ICT have a large presence of private companies, both in patenting and in European projects.

In the more science-oriented preliminary domains, after filtering out Individual applicants, universities, their R&D institutes and their in-houses or spin-offs (such as RT-RK Computer Based Systems, connected to University of Novi Sad) are also top actors in patenting. In European projects universities are also very active, although public administrations, autonomous research institutions and some companies also have relevance.

Transformation and improvement roadmaps in university policy, university strategy and academic organisation and regulation towards excellence and stronger engagement of the higher education ecosystem, will further contribute to the economic, social and inclusive growth and development of WB economies. Such improvements will also help curtail the significant brain drain that limits WB growth horizon and increases EU-wide inequalities.

Nevertheless, as presented in the recently published JRC document Higher Education for Smart Specialisation Handbook[25], higher education engagement and contribution to regional development is limited by multiple challenges involving policy mis-alignments (making S3 compatible with an academic career, designing appropriate policy instruments for universities, how to steer university programme portfolios and lifelong

(25) See Edwards and Marinelli (eds) (2018)

learning offering, amongst others) and lack of understanding between regions and universities (academic freedom, internal organisation and autonomy, how to engage with the multilevel university governance, amongst others). Such elements should be considered to maximise the contribution of WB universities and avoid inefficiency and frustration.

Thus, EDP, priority-setting, policy mix and policy instrument design, governance, implementation and monitoring of S3 strategies in the Western Balkans must:

- fully integrate and engage with academic actors at all levels and through diverse channels, acknowledging and dealing with the specific challenges and opportunities of such a collaboration,
- consider the different orientation and presence of non-academic institutions in the domains, especially private companies, aiming at better representation of the diverse institutional typologies and actively seeking hidden champions in the private, public and non-for-profit sectors.

Table 22. Top 5 actors per domain, all data sources combined

Domain	Actor	Economy
Better societies - governance, culture, education and the economy	University of Belgrade	Serbia
	University of Novi Sad	Serbia
	Ss. Cyril and Methodius University of Skopje	North Macedonia
	University of Sarajevo	Bosnia and Herzegovina
	University of Montenegro	Montenegro
Electric and electronic technologies	University of Belgrade	Serbia
	University of Novi Sad	Serbia
	Institut za Nuklearne Nauke Vinca	Serbia
	University of Niš	Serbia
	Ss. Cyril and Methodius University of Skopje	North Macedonia
Energy	University of Belgrade	Serbia
	University of Novi Sad	Serbia
	University of Niš	Serbia
	Ss. Cyril and Methodius University of Skopje	North Macedonia
	Institut za Nuklearne Nauke Vinca	Serbia

Domain	Actor	Economy
Environmental sciences and industries	University of Belgrade	Serbia
	University of Novi Sad	Serbia
	University of Montenegro	Montenegro
	University of Niš	Serbia
	Ss. Cyril and Methodius University of Skopje	North Macedonia
Food	University of Belgrade	Serbia
	University of Novi Sad	Serbia
	University of Niš	Serbia
	University of Kragujevac	Serbia
	Ss. Cyril and Methodius University of Skopje	North Macedonia
Health & wellbeing	University of Belgrade	Serbia
	University of Novi Sad	Serbia
	Clinical Center of Serbia	Serbia
	University of Niš	Serbia
	University of Kragujevac	Serbia
Heavy machinery	University of Belgrade	Serbia
	University of Novi Sad	Serbia
	University of Kragujevac	Serbia
	University of Niš	Serbia
	Ss. Cyril and Methodius University of Skopje	North Macedonia
ICT	University of Belgrade	Serbia
	University of Novi Sad	Serbia
	University of Niš	Serbia
	Ss. Cyril and Methodius University of Skopje	North Macedonia
	University of Sarajevo	Bosnia and Herzegovina

Domain	Actor	Economy
Process industries and materials	University of Belgrade	Serbia
	Institut za Nuklearne Nauke Vinca	Serbia
	University of Novi Sad	Serbia
	University of Niš	Serbia
	University of Kragujevac	Serbia
Transport	University of Belgrade	Serbia
	University of Novi Sad	Serbia
	Polytechnic University of Tirana	Albania
	Ss. Cyril and Methodius University of Skopje	North Macedonia
	University of Sarajevo	Bosnia and Herzegovina

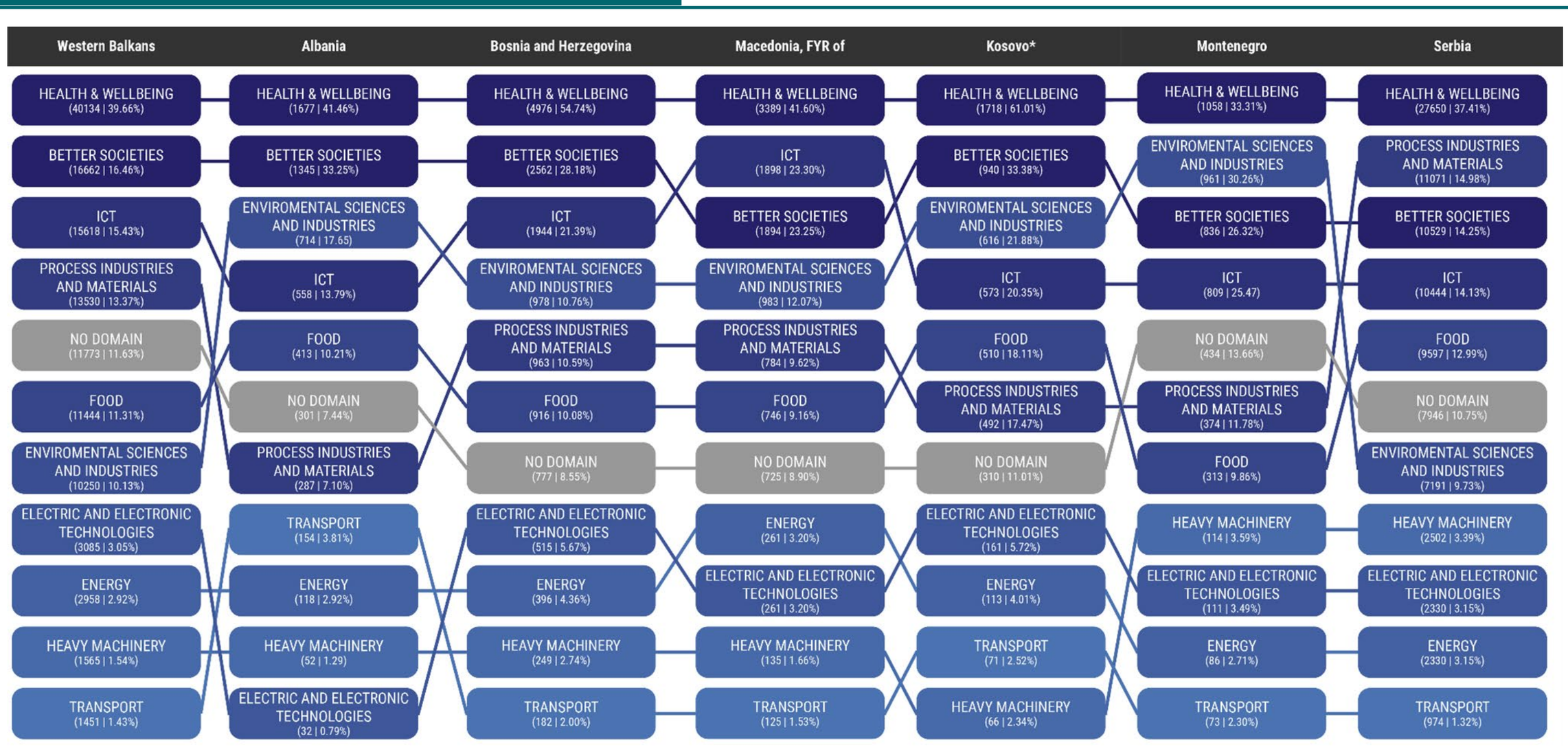
4.2.5 Transversal domains of the Western Balkans: current patterns and potential for regional collaboration

The six Western Balkan economies share a general specialisation pattern. Figure 29 presents in a parallel chart the ranking of the preliminary specialisation domains in the WB region and in each of the six WB economies.

As it can be observed, Health & wellbeing is the top domain, by number of records, in all the economies but Montenegro, where it appears third. ICT is an important domain in all the economies, ranking higher in Montenegro and lower in Albania and Kosovo. Process industries and materials is also a relevant domain for all the economies, although presenting more diversity; it is most relevant in Kosovo and Serbia. Better societies is consistently in the middle of the table, standing out in Albania. A similar pattern can be observed for the Food domain, which stands out in Serbia and Montenegro. Environmental sciences and industries ranks rather high in all economies, but is less present in Serbia (which is the largest ecosystem, dragging the average for this domain down in the aggregate WB region). The remaining domains all rank consistently low.

To identify co-authorship patterns within WB and with the rest of the world per domain, we have calculated for each economy and each domain the ratio of the papers co-authored with all other WB economies and with the rest of the world over the total number of publications in each domain and each WB economy. To estimate the intensity of co-authorships within WB, we have averaged the five ratios. Figure 30 plots for each WB economy the average share of scientific publications co-authored within the other five economies versus the share of scientific publications co-authored by each WB economy with the rest of the

Figure 29. Ranking of preliminary specialisation domains in the WB region and in each of the six WB economies, by number and percentage of records

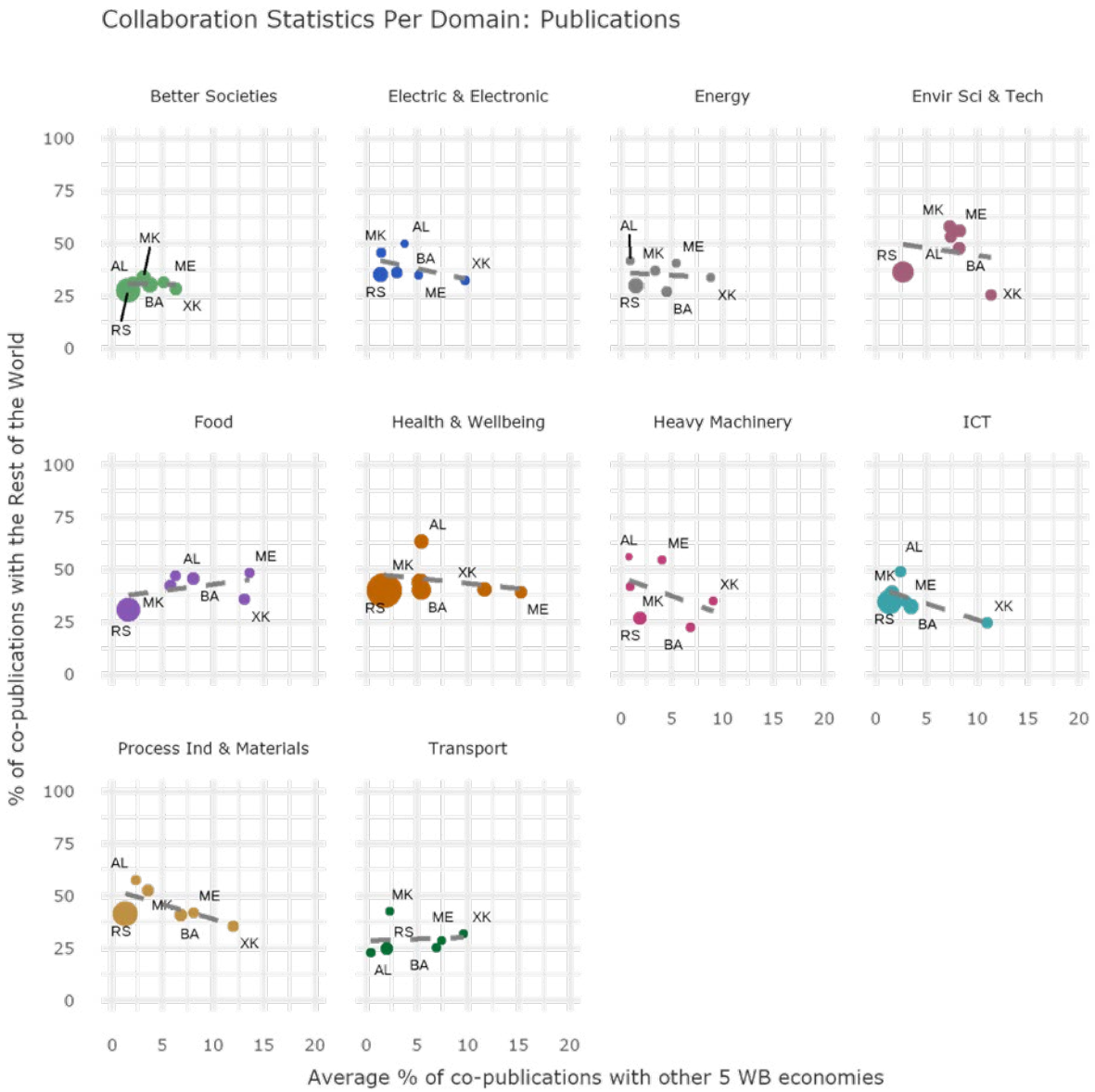


world per domain. The size of the disk describes the volume of scientific publications per domain per economy.

From Figure 30 the same pattern of Serbia being on the left side (lower collaboration intensity with the other 5 WB economies) and Kosovo on the right side (highest collaboration with the other 5 WB economies) persists, but with different slopes for each domain. Better Societies is the domain with the least exposure to intra-regional co-authorships, while Food is where most intra-regional co-authorships are found. Finally, Energy and Process Industries & Materials are the two domains where international co-authorships are stronger.

Figure 31 highlights the centrality of Serbia in the WB research and innovation system. The strong collaboration between RS and XK is the most frequent pattern, appearing in 10 out of 10 domains, followed by RS-ME (7 in 10) and RS-BA (3 of 10). Albania is the most peripheral actor in this network being only weakly connected (not shown) to the other economies in 7 out of 10 domains, followed by North Macedonia (6 of 10). The domains with stronger collaboration are Environmental Sciences and Industries and Process Industries and Materials. Stronger collaboration could be

Figure 30. Collaboration intensity per domain in terms of publications



developed in all preliminary domains, where currently intermediate linkages already exist, and where their disconnected economies have important domain activity.

Figure 32 and Figure 33 present the intra-regional collaborations in terms of publications and projects, respectively, in more detail.

The colour scale represents collaboration intensity, computed as the percentage of co-authored publications for each pair of economies, over the total number of co-authored publications of the left economy (row-wise).

Figure 33 presents the intra-WB collaboration intensity in terms of EU-funded projects across domains. It is clear that Better Societies and ICT are the two transversal themes of higher demonstrated capacity for collaboration among all six WB economies.

The colour scale represents collaboration intensity, computed as the percentage of projects in collaboration for each pair of economies, over the total number of projects in collaboration of the left economy (row-wise).

Overall, findings suggest that although there exists plenty of potential for collaboration in terms of cognitive proximity, i.e. in common knowledge bases as described by the semantic content that characterises the specialisation domains, this potential remains rather untapped within the six WB economies as a whole, but it appears very strong at the bilateral level (e.g., the links between Serbia and Montenegro, Serbia and Kosovo and to lower degree, between North Macedonia and Albania).

Figure 31. Collaboration network of WB economies by domain

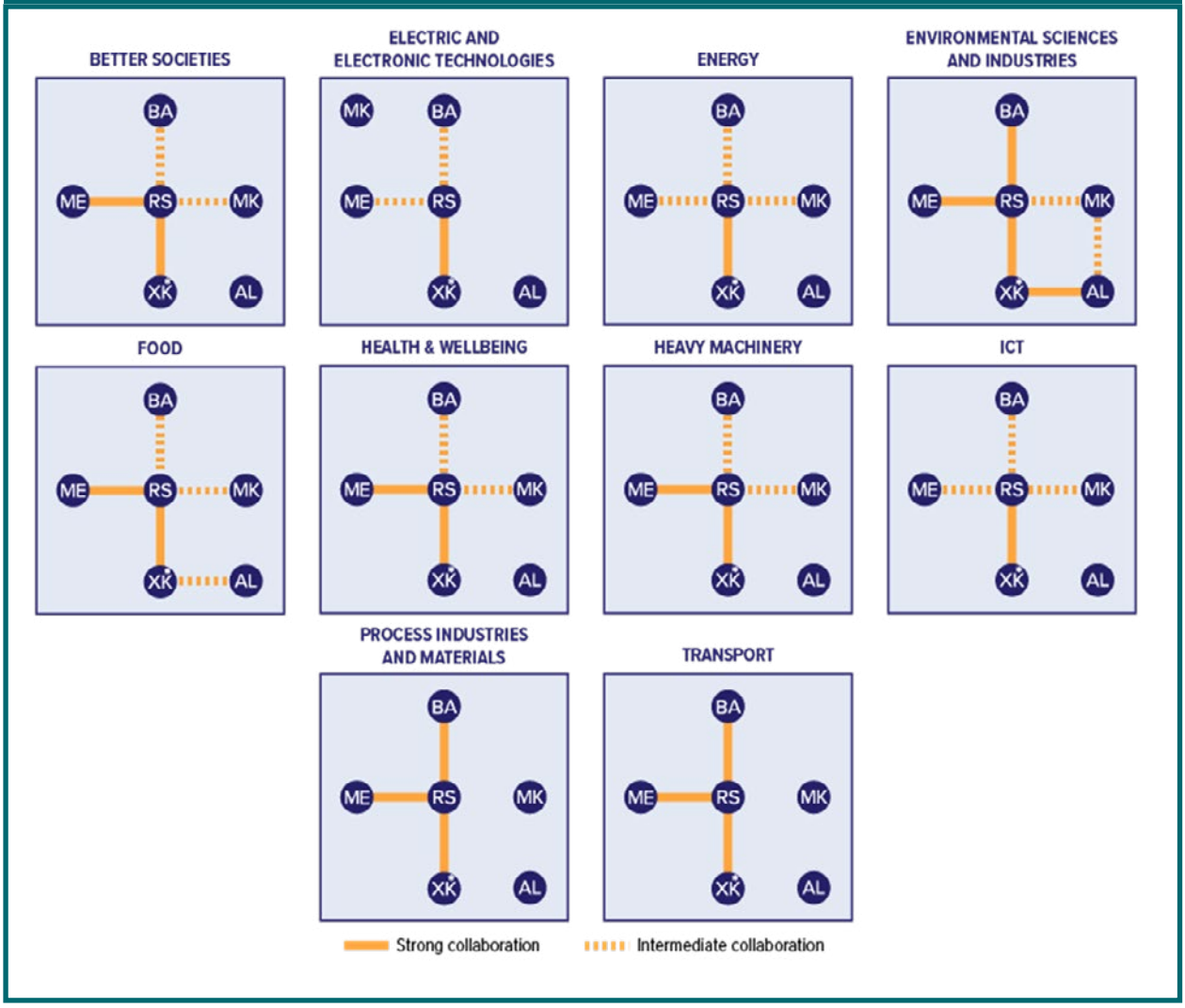


Figure 32. Number of co-authored publications across WB economies, by domain and pair of economies

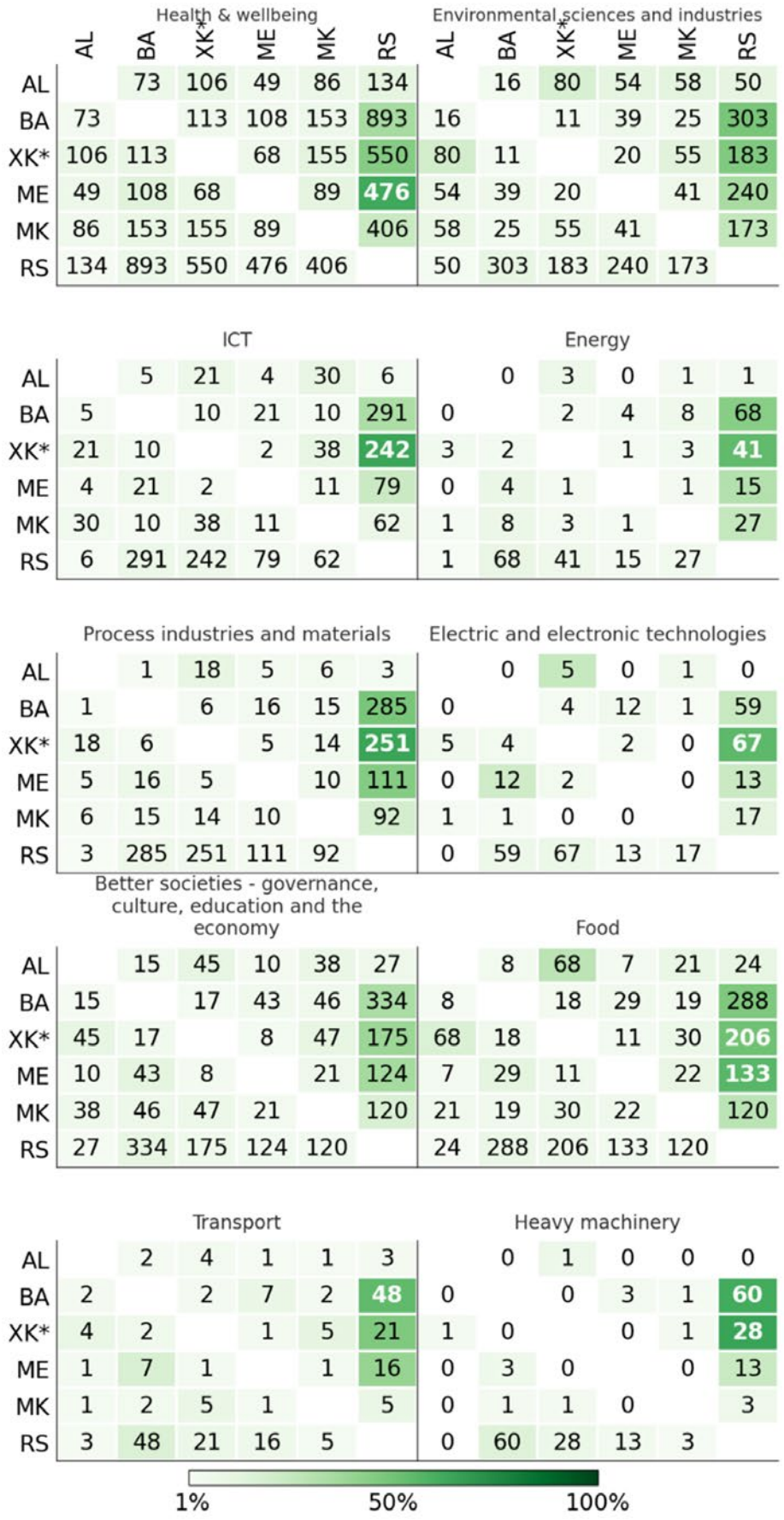
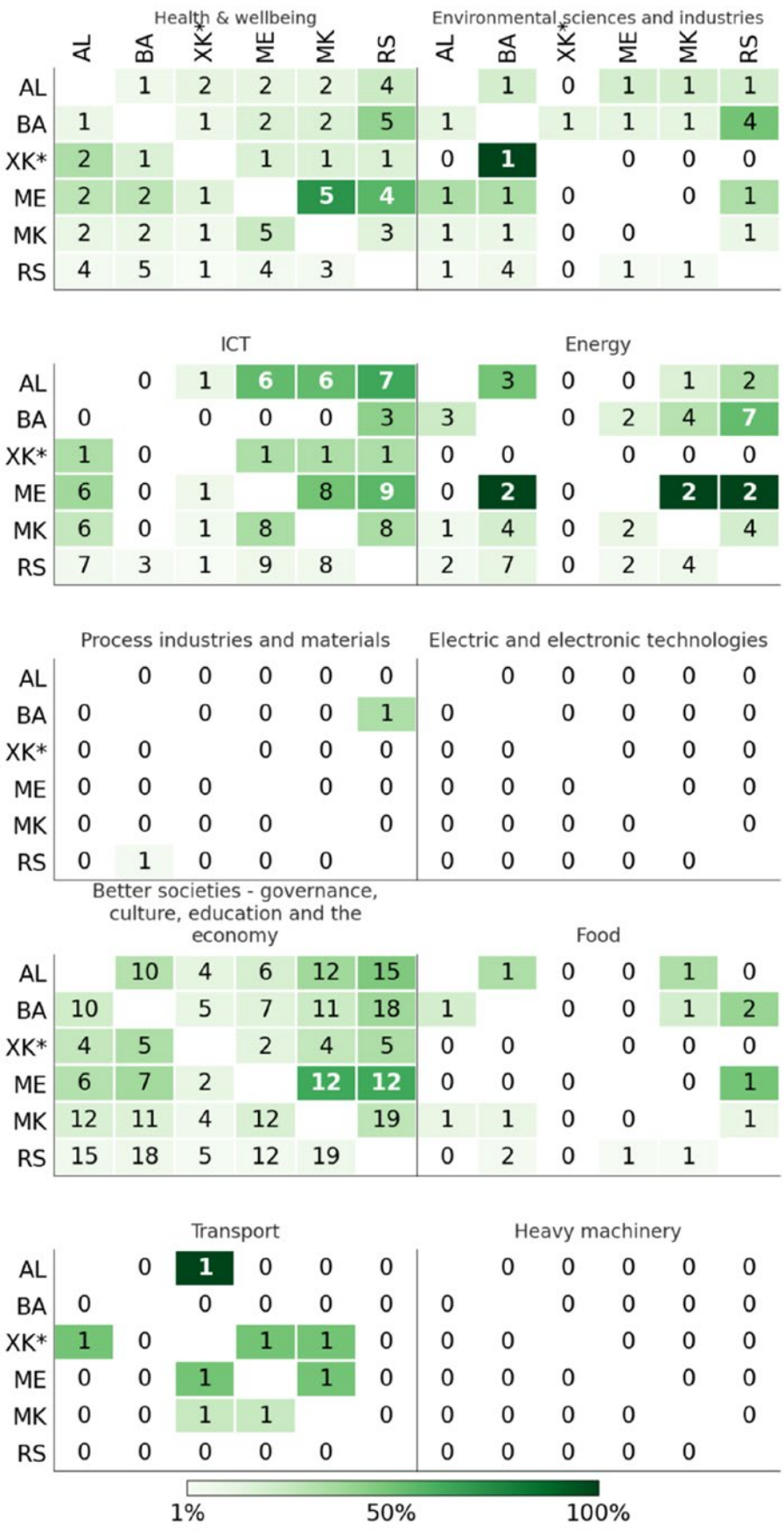


Figure 33. Number of projects in collaboration across WB economies, by domain and pair of economies



4.2.6 Extra-regional collaboration patterns

To acquire a deeper understanding on what collaboration with the rest of the world actually means, we have computed the geographic distribution of records from all sources per domain in terms of an extended neighbourhood (i.e. the countries neighbouring Western Balkans) and also the same for all countries in the world in terms of decreasing order of collaboration. The results are shown in Figure 34 and Figure 35, respectively.

The colour scale represents collaboration intensity, computed row-wise as the percentage of records in collaboration with each country, over the total number of records in collaboration in each domain. With a focus, first, on the extended neighbourhood, we notice that the stronger ties in terms of publications are identified with Croatia and Slovenia. From the 40.134 records in Health & Wellbeing, the 2073 co-authored with Croatia are 5.17% of the total, with Greece following with 3.33%, and Slovenia with 3.13%. In terms of research and innovation projects, Greece seems to be, by far, the major partner within the extended neighbourhood followed by Romania and Slovenia. Most probably, this has to do with the EU member status of these countries. Croatia and Slovenia regain their status as most frequent partners in terms of Creative Europe and Culture projects.

The colour scale represents collaboration intensity, computed row-wise as the percentage of records in collaboration with each country, over the total number of records in collaboration for a domain.

By examining the top 10 collaboration partners per source (see Figure 35) we notice, in terms of publications, a moderate integration of WB to the research networks of EU-27 and the United States that varies across domains. No other major research power (i.e. China, Switzerland, Israel, Russia) appear in the list. The relatively high rankings of Croatia and Slovenia (numbers 5 and 6 in the top 10, respectively) are also noticed. In terms of EU-funded research and innovation projects, the top 10 partners reflect more or less the EU member state rankings within the FP7 and H2020 budget allocations[26], with relatively higher representation of Spain, Italy and Greece.

*(26) See: Horizon Dashboard, **https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/horizon-dashboard***

Figure 34. Aggregate WB number of internationally co-authored publications and collaborative projects, by domain and neighbourhood country

	Publications									EC R&I Projects								
	Croatia	Slovenia	Greece	Turkey	Hungary	Romania	Bulgaria	Ukraine	Moldova	Greece	Romania	Slovenia	Hungary	Bulgaria	Croatia	Turkey	Ukraine	Moldova
Better societies - governance, culture, education and the economy	556	390	181	178	195	203	134	60	8	185	105	94	93	82	75	55	22	16
Electric and electronic technologies	92	78	23	25	26	15	36	4	0	1	3	2	1	1	0	0	0	0
Energy	108	81	49	29	36	30	19	5	0	30	21	28	17	23	25	8	9	1
Environmental sciences and industries	703	536	340	213	299	207	266	117	9	35	21	18	21	14	13	7	5	1
Food	554	360	278	241	191	113	165	31	8	40	14	18	21	13	9	12	6	3
Health & wellbeing	2073	1258	1335	942	784	870	679	286	81	63	29	20	25	16	17	19	4	6
Heavy machinery	75	28	3	4	11	23	11	2	0	1	2	2	1	0	2	1	0	0
ICT	371	339	176	204	113	119	88	38	2	96	36	35	31	34	27	20	10	8
Process industries and materials	483	698	133	139	156	176	179	59	9	13	10	6	7	5	4	5	0	0
Transport	41	19	3	25	3	7	8	3	1	7	3	5	5	1	1	4	0	1

Western Balkan economies show a high collaboration intensity with the extended neighbourhood, consisting of both EU Member-States (i.e. Croatia, Slovenia, Greece, Bulgaria, Romania, Hungary) and third countries (Turkey, Moldova and Ukraine), generally higher towards its Western neighbours. Croatia and Slovenia present the highest number of co-authored publications, and Greece and Romania the largest number of joint projects.

We also examined more geographically distant linkages based on collaboration intensity. Co-publications are driven by the social proximity of researchers. We have not disambiguated the individual researchers in our dataset and therefore we cannot argue whether the strong ties between WB and EU-27 are the effects of the WB researchers' diaspora or true cross-border interpersonal relationships. Italy, the United States, Germany, the United Kingdom, Croatia and Slovenia present the largest number of co-authored publications with WB actors. The presence of Italy is notable, given the smaller size of its science base, compared to the three following countries.

In terms of joint projects, Spain, Germany and Italy are the 3 top partners followed by 7 more EU member-states. Italy is present again, but the amount of project collaborations with Spain is most noteworthy.

In terms of potential for collaboration, the number of internationally co-authored publications and collaborative projects, by partnering country and by domain, provide a useful entry towards sectoral/technology/challenge oriented cooperation. As illustrative examples, collaborations with Food with the Netherlands, Croatia and Italy, in Transport with Spain, in ICT with the United States and the UK or with Process industries and materials with Slovenia are relatively more intense, hinting at potential bilateral or multilateral connections that could be leveraged towards more structured cooperation.

Figure 35. Aggregate WB number of internationally co-authored publications and collaborative projects, by domain and with top-10 countries per source

	Italy	United States	Germany	United Kingdom	Croatia	Slovenia	Spain	France	Austria	Greece	Spain	Germany	Italy	United Kingdom	France	Belgium	Greece	Netherlands	Austria	Portugal
	Publications										EC R&I Projects									
Better societies - governance, culture, education and the economy	529	645	519	688	556	390	274	340	270	181	259	241	254	233	202	190	185	171	151	115
Electric and electronic technologies	66	146	116	89	92	78	42	91	98	23	4	4	3	2	2	2	1	2	1	4
Energy	74	83	86	62	108	81	33	35	51	49	58	61	46	38	38	33	30	22	34	19
Environmental sciences and industries	628	378	664	373	703	536	391	409	356	340	57	57	52	57	45	35	35	34	36	24
Food	515	388	367	270	554	360	328	244	218	278	64	52	63	52	45	52	40	48	32	34
Health & wellbeing	3538	3209	2988	2637	2073	1258	1925	1766	1086	1335	103	97	96	104	76	65	63	74	46	36
Heavy machinery	40	39	28	52	75	28	12	16	28	3	4	3	4	6	3	2	1	2	1	1
ICT	486	807	499	562	371	339	328	352	231	176	117	116	110	118	95	73	96	76	67	55
Process industries and materials	454	597	640	314	483	698	272	301	223	133	22	25	21	21	19	12	13	14	13	10
Transport	28	37	34	33	41	19	64	25	20	3	15	14	14	15	7	12	7	6	10	4

4.3 Specialisation analysis of the Western Balkan economies

4.3.1 Specialisation analysis of Albania

The scientific output of Albania in terms of publications during our observation period is mainly driven by Medicine (1782 publications between 2011-2020), Environmental Science (1144) and Social Science (1069). Agricultural and Biological Sciences (687), Arts and Humanities (667), Economics, Econometrics and Finance (650) and Computer Science (646) constitute the second tier of subject areas with considerable scientific output.

Of the above (see Figure 36), Albania is characterized by persistent and strong specialisation (LQ>1.5 in both 5-yr periods) in:

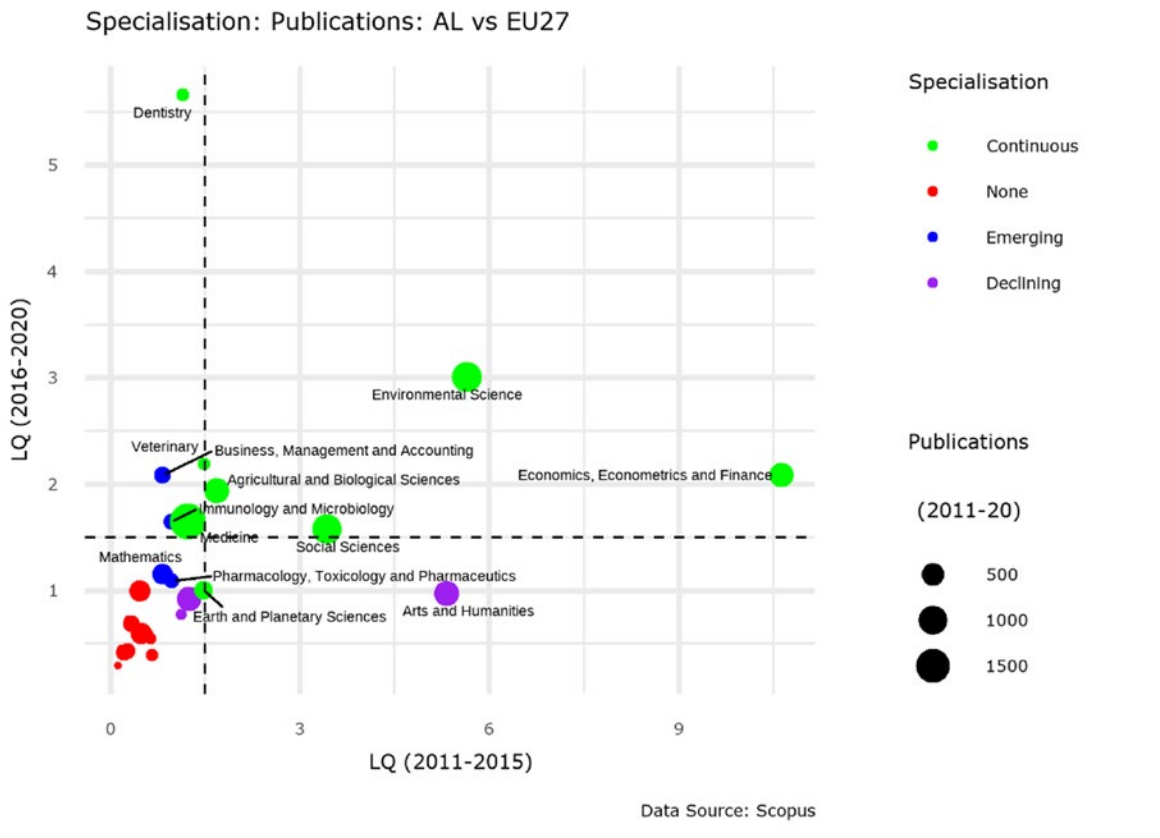
- Environmental Sciences,
- Social Sciences,
- Agricultural and Biological Sciences,
- Economics, Econometrics and Finance.

The overall number of EU patents granted to Albanian applicants between 2010 and 2019 is 58, which is low. There are only 40 IPC level-2 codes associated with these patents, 7 of them having non-zero values in both intervals, with F03 (9), Y02 (7), Y10 (6), A61, F16, B65, A47, and F05 (5 each) being the most popular ones (see Figure 36). Of these:

- F03 (Machines or Engines for Liquids; Wind, Spring or Weight Motors etc),
- Y10,
- B65 (Conveying; Packing; Storing; Handling Thin or Filamentary Material) and
- A47 (Furniture; Domestic Articles or Appliances, etc)

are strongly specialized vs EU-27 (LQ>1.5) in both 5-yr periods.

Figure 36. Specialisation trends for all subject areas calculated over two 5-year periods for Albania



The number of trademarks registered to Albanian residents during the reference period is 4,294. The most frequent Nice Classes were:

- 35 Advertising; business management, organization and administration; office functions (876),
- 41 Education; providing of training; entertainment; sporting and cultural activities (570),
- 43 Services for providing food and drink; temporary accommodation (507),
- 30 Foodstuffs of plant origin, except fruits and vegetables, prepared or preserved for consumption, as well as auxiliaries intended for the improvement of the flavour of food (488) and
- 32 non-alcoholic beverages and beer (329).

Figure 27 presents the specialisation statistics. The strong specialisations in both 5-year intervals are Nice Classes:

- 32 non-alcoholic beverages and beer (329),
- 34 tobacco and articles used for smoking, as well as certain accessories and containers related to their use (114),
- 4 industrial oils and greases, fuels and illuminants (95)

while classes:

- 43 Services for providing food and drink; temporary accommodation (507) and
- 30 Foodstuffs of plant origin, except fruits and vegetables, prepared or preserved for consumption, as well as auxiliaries intended for the improvement of the flavour of food (488)

are emerging strong specialisations, both being associated with a significant number of trademarks.

Figure 37. Specialisation trends for all IPC codes calculated over two 5-year periods for Albania

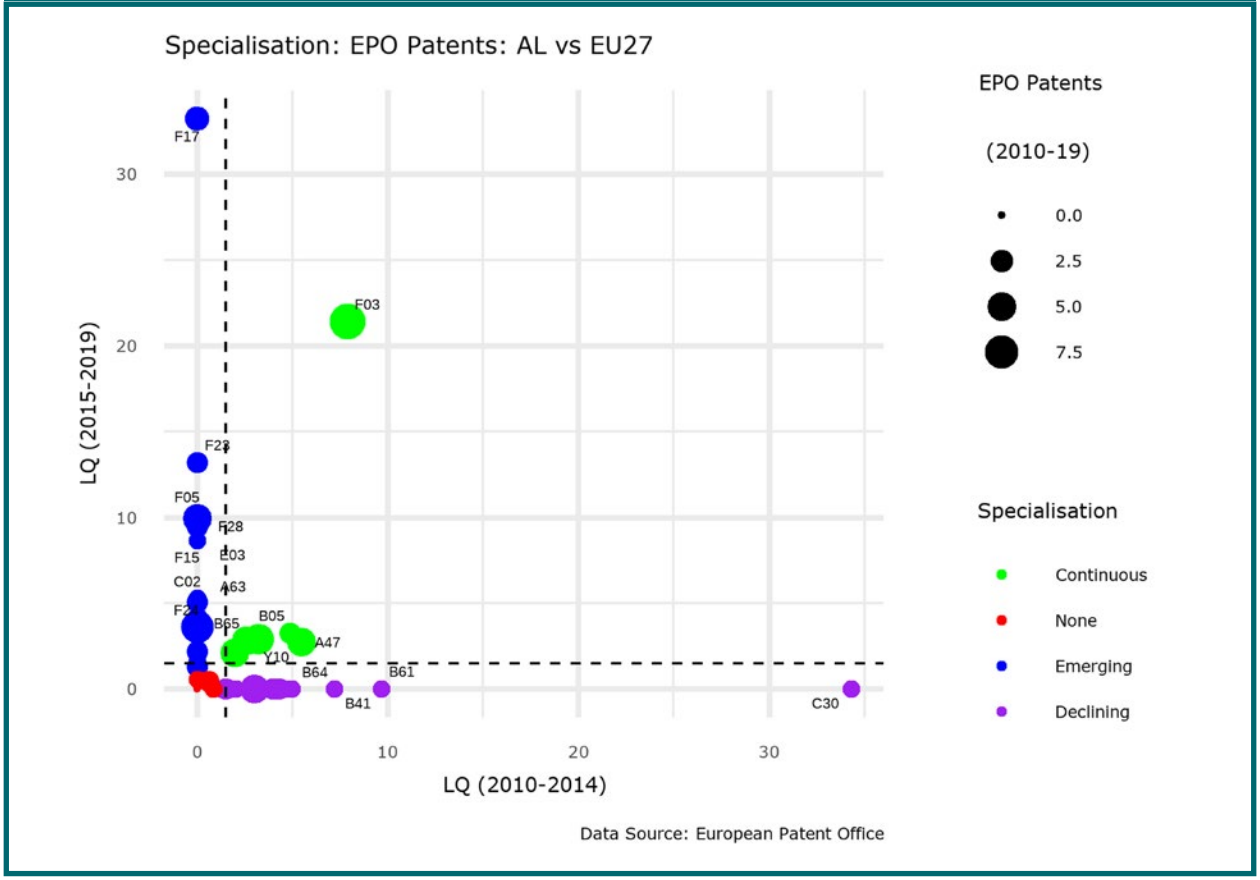
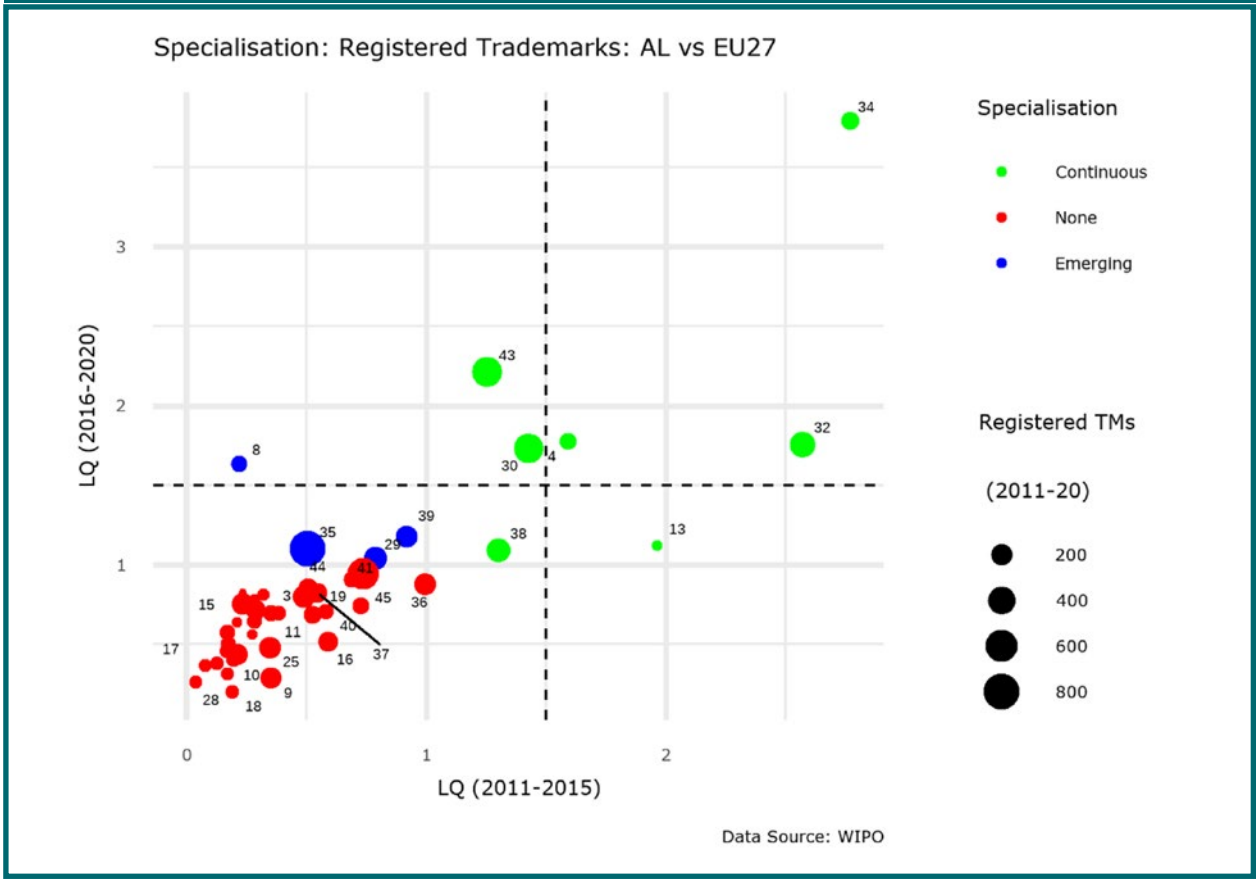


Figure 38. Specialisation trends for all Nice Classification codes calculated over two 5-year periods for Albania



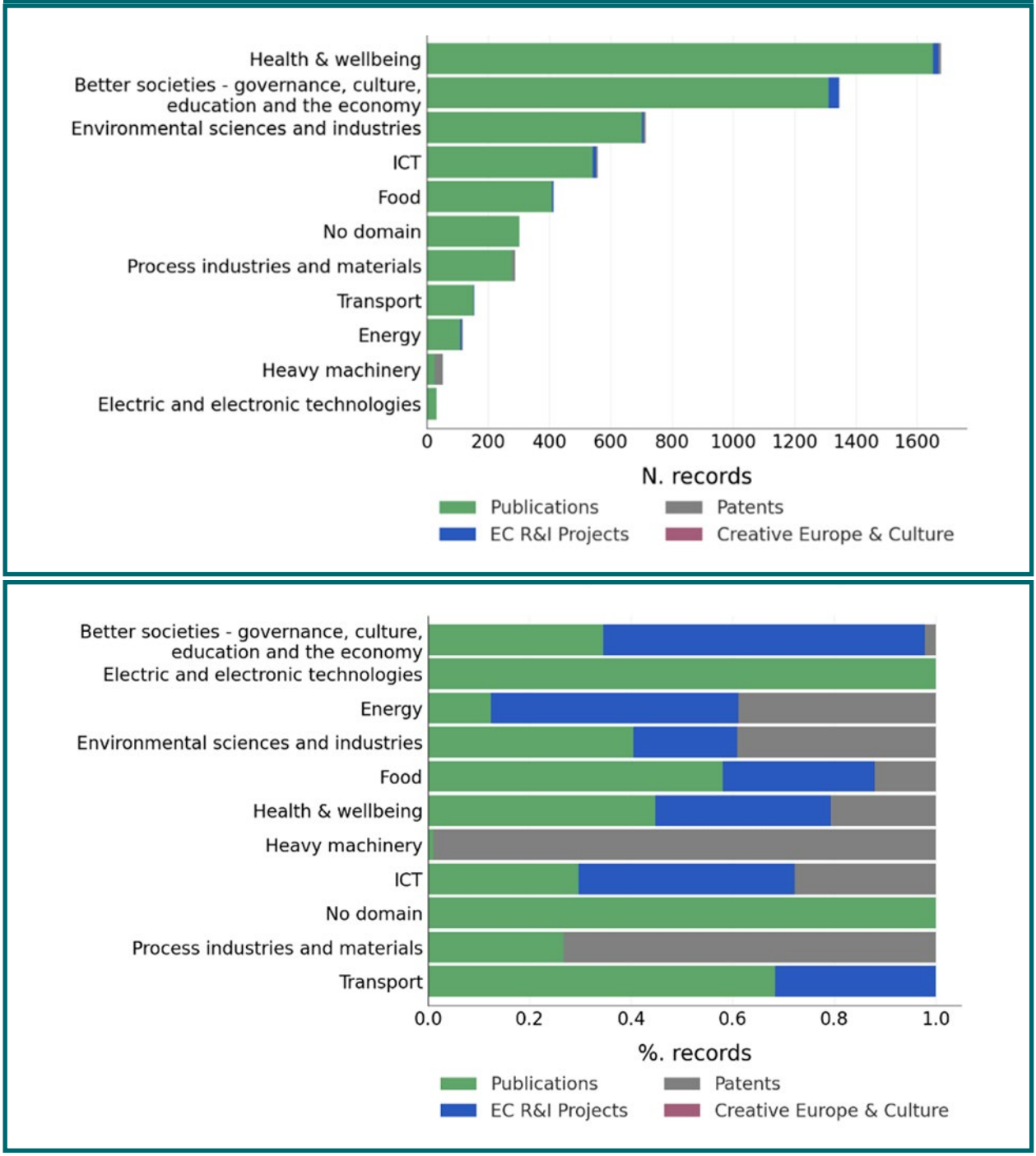
The classification of all the records from Albania into domains provides the counts shown in Figure 39. Health & Wellbeing is at the top of the list, just like the aggregate values for Western Balkans, with Albania's contribution being approximately 4% of the WB output. However, Better Societies and Environmental Sciences / Industries are in second and third place, respectively, and this marks the differentiation of Albania when compared to WB. ICT is fourth, with the output being approximately 3.5% of the WB output.

The semantic content of each of the specialisation domains for Albania is shown in Table 23. Comparing the semantic content for Albania with WB we note that the records associated with Energy address environmental and sustainability issues (e.g. aerosol, ash, particles, etc) while all the others are more or less similar. Finally, it seems that the records that were not associated with a domain are mainly in the fields of mathematics and computational intelligence.

The temporal evolution of the preliminary specialisation domains for Albania is characterised by strong variations in the yearly output in three of the four main domains (Health & Wellbeing, Better Societies and Environmental Sciences and Industries), which suggest that a robust research base has not been established in the country yet. Moreover, the output in ICT is declining over time while the same in the remaining domains is rather stable and low.

For each WB economy, we extracted the most active actors per domain. These actors may be linked with records pertaining to any of the data sources used in this study. Figure 41 shows the corresponding results, for the case of Albania, where the top 10 pertinent organisations are shown in decreasing order of associated records. All but one of these actors are university institutions, with the exception of the Albanian national institute of public health, which is ranked tenth. By inspecting the graph, one sees that the

Figure 39. Albania - Total output per domain and data source-size normalized results



three most active actors we could identify in Albania are the University of Tirana (primary national contributor in the domains Better Societies, Environmental Sciences and industries, Process industries and materials and Electric/Electronic Technology), followed by the Polytechnic University of Tirana (whose primary contributions at the national level lie in the domains ICT, Transport, Energy and Heavy machinery) and the Agricultural University of Tirana (which, not surprisingly, is the main actor in the Food domain).

Table 23. Albania - The semantic content of the specialisation domains

Domain	Keywords
Better societies - governance, culture, education and the economy	social, economic, language, educational, market, policy, law, process, public, society, financial, service, political, economy, social, business, life, educational-research, management, bank
Energy	energy, temperature, material, source, aerosol, solar, power, ash, gas, consumption, process, air, cement, radiation, heat, system, concentration, particle, surface, voltage
Environmental sciences and industries	water, environment, urban, land, specie, city, management, population, tourism, resource, human, concentration, rural, process, data, river, plant, natural, economic, metal
Food	food, consumer, product, milk, fruit, safety, farmer, olive, farm, preference, quality, cultivar, tree, plant, soil, data, treatment, meat, consumption, organic
Health & wellbeing	patient, health, child, age, disease, treatment, woman, data, population, care, clinical, hospital, medical, control, prevalence, female, individual, cell, drug, survey
Heavy machinery	rotor, system, cylinder, shaft, energy, layer, power, device, motor, textile, motion, blade, engine, fluid, composite, piston, fibre, lag, square, turbine
ICT	system, data, network, algorithm, simulation, service, communication, image, node, mobile, platform, protocol, process, environment, sensor, processing, quality, security, software, satellite
Process industries and materials	extraction, compound, surface, corrosion, steel, inhibitor, acid, carbon, concentration, organic, reaction, extract, mercury, liquid, pesticide, exposure, hydrogen, dose, product, electrode
No domain	space, fuzzy, hyperideals, semihypergroups, prime, notion, semigroups, hyperideal, operator, soft, generalised, mathematical, semihypergroup, mapping, semigroup, inequality, lattice, fixed, green, ternary-semihypergroups

Figure 40. Albania - Temporal evolution of the preliminary specialisation domains

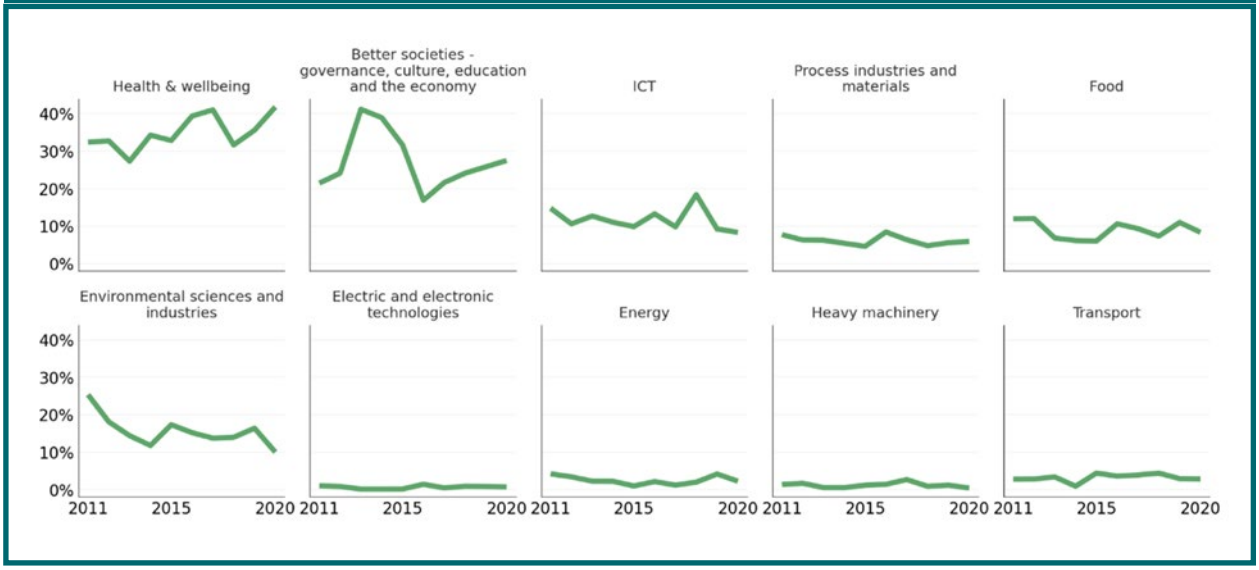


Figure 41. Top actors across domains for the case of Albania by number of records (all sources)

	Health & wellbeing	Better societies - governance, culture, education and the economy	Environmental sciences and industries	ICT	Food	Process industries and materials	Transport	Energy	Electric and electronic technologies	Heavy machinery
University of Tirana	244	339	235	97	124	92	7	29	16	1
Polytechnic University of Tirana	24	93	149	235	12	73	81	54	15	20
Agricultural University of Tirana	131	132	189	14	219	13	2	9	1	1
University Hospital Center of Tirana "Mother Theresa" (QSUT)	496	13	1	11	11	3	0	2	0	1
Epoka University	22	83	13	60	5	24	6	11	1	1
Aleksander Moisiu University Durres	19	102	20	16	3	2	48	4	0	1
European University of Tirana	22	122	5	18	3	1	2	1	0	0
University of Medicine, Tirana	126	9	4	9	9	7	0	1	0	0
Catholic University Our Lady of Good Counsel	118	8	4	6	4	10	0	0	0	0
Albanian National Institute of Public Health	112	5	17	1	7	1	0	0	0	0

Colour indicates relative contribution, computed column-wise.

We then analysed collaboration patterns beyond the WB region for each of the economies, by computing again the geographic distribution of records from all sources per domain. We did so in terms of an extended neighbourhood (i.e. the countries neighbouring Western Balkans) and by considering worldwide collaborations, by decreasing intensity of collaboration. The results are shown in Figure 42 and Figure 43, respectively.

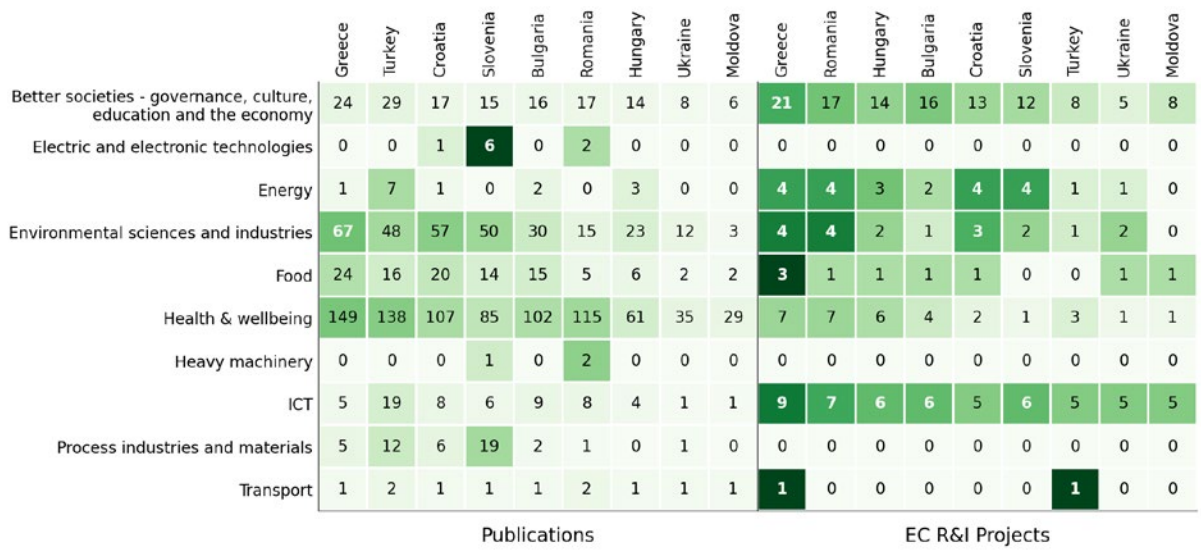
By analysing first, the extended neighbourhood, we could see that the stronger connections in terms of publications are with Greece and Turkey. The collaboration with Greece happens especially in the Health & wellbeing and Environmental Sciences and industries domains, respectively. A significant number of co-publications with Turkey could be identified in the same domains. These ties are fairly strong: the figure observed for Greece corresponds roughly to 8% of the total Albanian collaboration beyond the WB for both domains, while the relationship with Turkey equals 12% of all Albanian collaborations beyond the WB, for both domains.

Looking at collaborations in research and innovation projects funded by European competitive schemes, Greece emerges as the strongest partner in the extended neighbourhood, followed by Romania, Hungary and Bulgaria: most of the collaborations happen in the domain Better societies. The observed patterns are most probably shaped by the membership of the EU of the top collaborators and by the scope of the calls that fund those projects, that often aim at fostering capacity building in the neighbourhood countries.

When looking at worldwide collaboration patterns per domain and data source (see Figure 43), one sees that relationships in scientific publications are more intense with Italy, the United States, Spain and Germany. Collaborations happen especially in the Health & wellbeing and Environmental sciences and industries domains. A noticeable interaction with Japan in the ICT domain can also

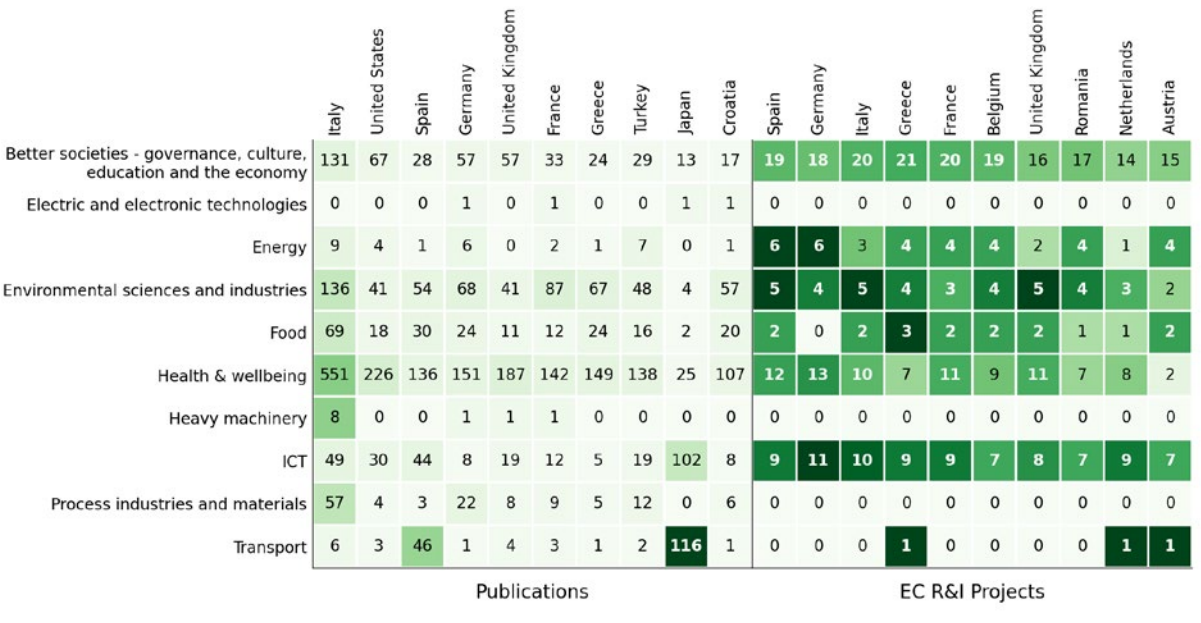
be detected. For what concerns FP7, H2020 European projects, one sees that the picture does not vary much with respect to the analysis carried out previously for the neighbourhood countries: most of the key interactions happen with Spain, Germany Italy and Greece. Again, most of the collaboration in those projects do happen in the Better societies and the ICT domains.

Figure 42. Albanian international collaborators per domain, presented as number of records (all sources), within the WB extended geographic neighbourhood



Colour indicates collaboration intensity, computed row-wise.

Figure 43. Albanian international collaborators per domain, presented as number of records (all sources), worldwide



Colour indicates collaboration intensity, computed row-wise.

4.3.2 Specialisation analysis of Bosnia and Herzegovina

The scientific output of Bosnia and Herzegovina in terms of publications during our observation period is mainly driven by Medicine (5163 publications between 2011-2020), Engineering (2948), and Computer Science (2887). Agricultural and Biological Sciences (1266) and Social Sciences (1189) constitute the second tier of subject areas with considerable scientific output.

Of the above (see Figure 44), Bosnia and Herzegovina is characterized by consistent and strong specialisation and significant output in Medicine and Computer Science. Engineering is very close to the specialisation threshold with LQ > 1.45 for both periods, also having a significant output.

The overall number of EU patents granted to Bosnians between 2010 and 2019 is 140, which is low. There are only 62 IPC level-2 codes associated with these patents, 42 of them having non-zero values in both intervals. There are four IPC codes having more than 10 patents associated with them in our 10-year observation period. These are A61 (23), Y02 (19), F03 and B60 (10).

In terms of patent specialisation, we find that 12 IPC classes are strongly specialised in both 5-year intervals (see Figure 45). Of these:

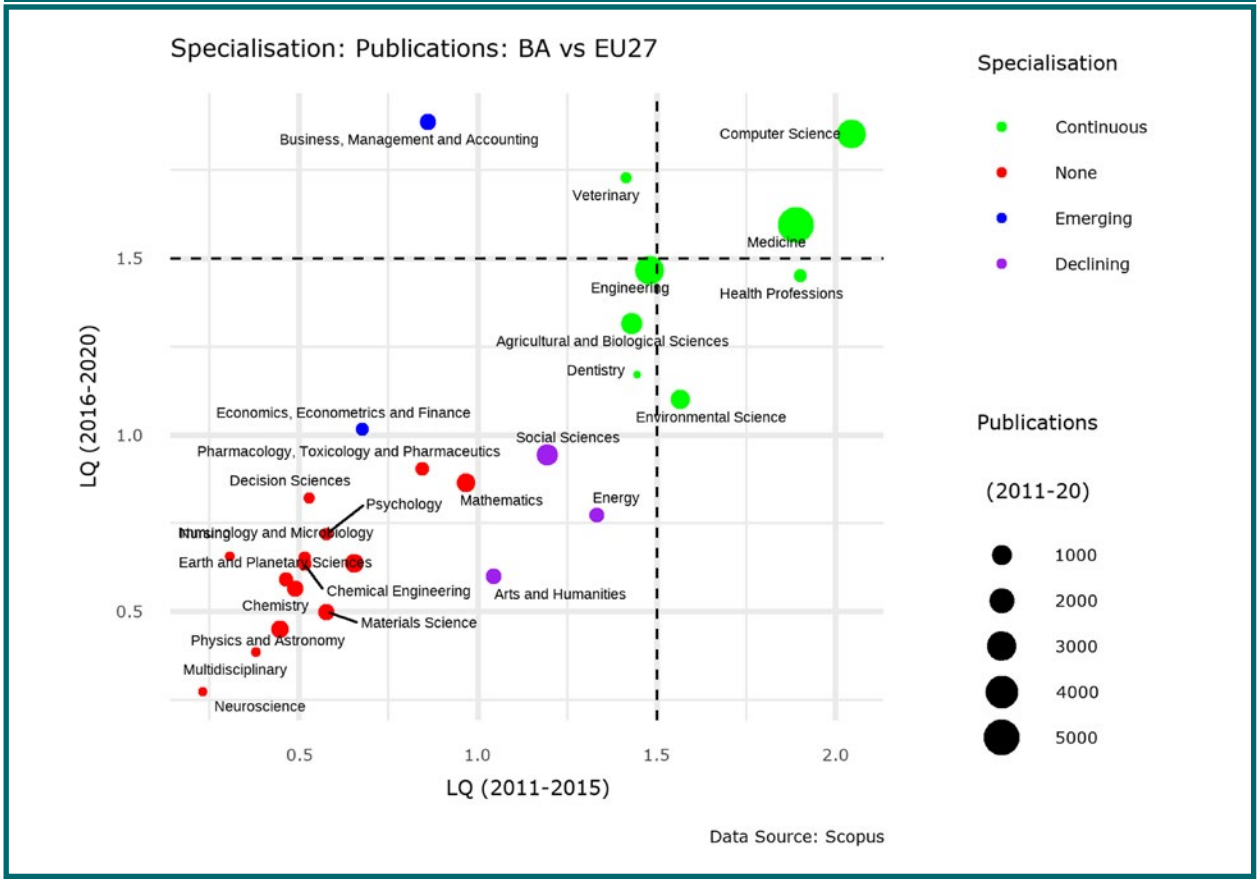
- A61 Medical or Veterinary Science, Hygiene (23),
- Y02 (19), and
- F03 Machines or Engines for Liquids; Wind, Spring or Weight Motors etc (10),

are found to be strongly specialised in both halves of the reference period also having considerable number of patents associated with them, while:

- B60 Vehicles in general (10) and
- A01 Agriculture; Forestry; Animal husbandry; Hunting; Trapping; Fishing (6)

are strong emerging specialisations.

Figure 44. Specialisation trends for all subject areas calculated over two 5-year periods for Bosnia and Herzegovina



The number of EU trademarks registered in Bosnia and Herzegovina during the reference period is 576, which is low. In the 45 codes of the Nice classification, Bosnia and Herzegovina was active in 41. The most frequent Nice Classes were:

- 5 pharmaceuticals and other preparations for medical or veterinary purposes (273),
- 30 foodstuffs of plant origin, except fruits and vegetables, prepared or preserved for consumption, as well as auxiliaries intended for the improvement of the flavour of food (93), and
- 35 Advertising; business management, organization and administration; office functions (68).

Of these, as shown in Figure 45, Nice Classes 5 and 30 are the only strong specialisations in both 5-year intervals.

The classification of all the records from Bosnia and Herzegovina into domains provides the counts shown in Figure 47. Health & Wellbeing is at the top of the list, just like the aggregate values for Western Balkans, with Bosnia and Herzegovina's contribution being approximately 12.86% of the aggregate WB output. Better Societies is second in the list with 50% less output and ICT is in third place. The remaining seven domains are characterised by significantly lower outputs. Except from Process Industries and Materials, which is under-represented in Bosnia and Herzegovina's research output, the country seems to be in line with the aggregate WB region domain rankings.

Figure 45. Specialisation trends for all IPC codes calculated over two 5-year periods for Bosnia and Herzegovina

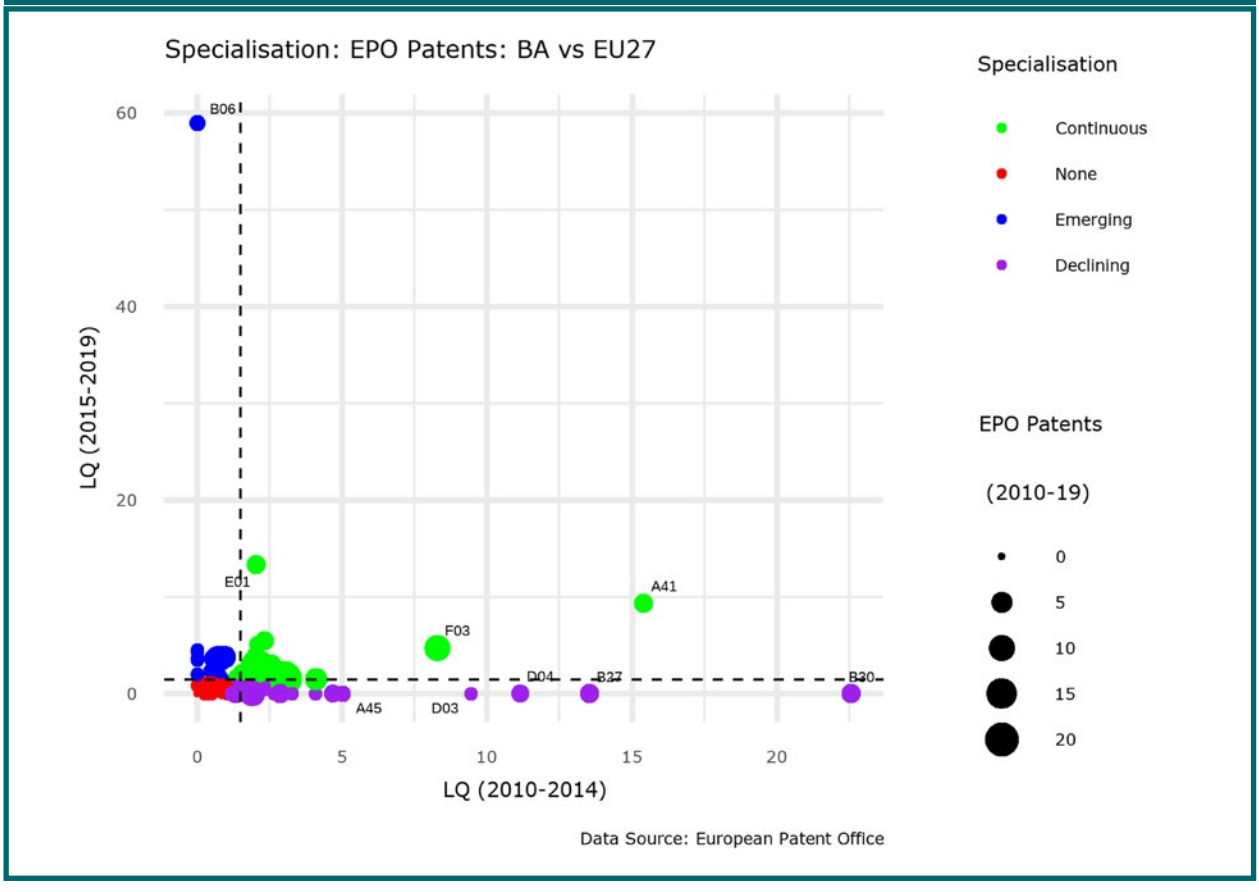
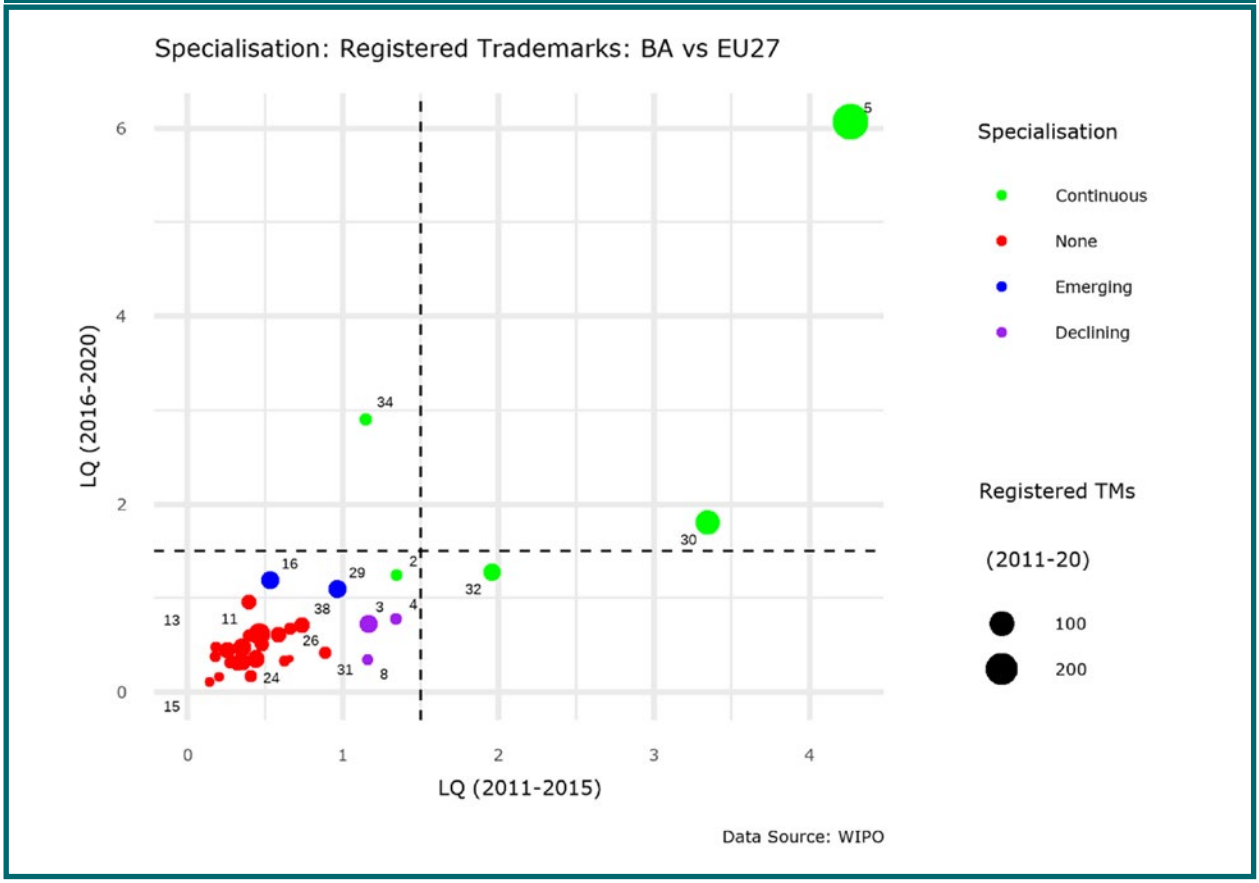


Figure 46. Specialisation trends for all Nice Classification codes calculated over two 5-year periods for Bosnia and Herzegovina



The semantic content of each of the specialisation domains for Bosnia and Herzegovina is shown in Table 24. Comparing the semantic content for Bosnia and Herzegovina with WB we note that the records associated with Better Societies are mostly related to social sciences than humanities, Heavy Machinery has to do with furniture while all the others are more or less similar. Finally, it seems that the records that were not associated with a domain most probably describe research in the field of physics.

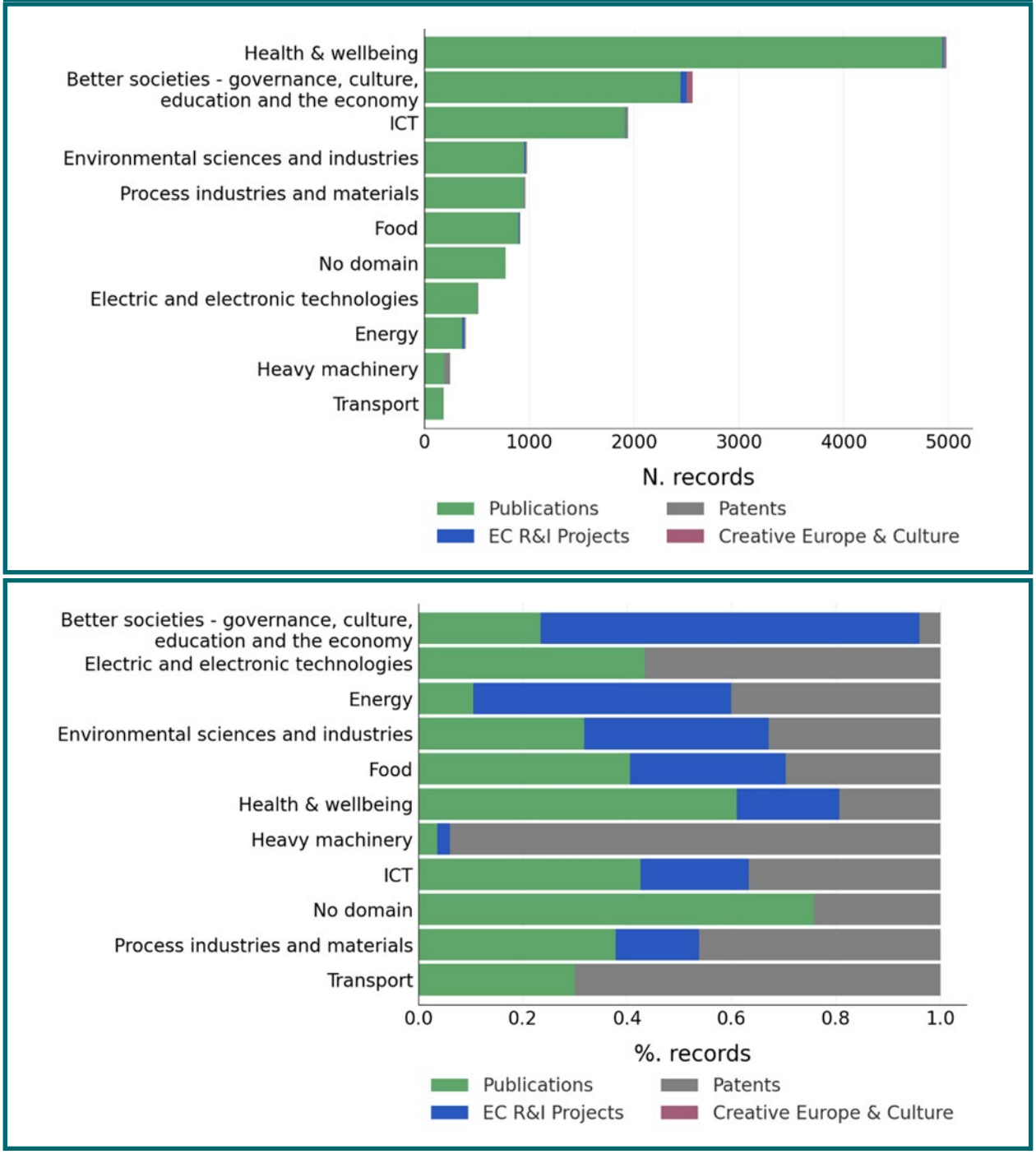
The temporal evolution of the preliminary specialisation domains for Albania is characterised by considerable variations in the yearly output in Health & Wellbeing and ICT and a growing trend in Better Societies. The annual output in all the other domains remain rather flat, which suggests that Bosnia and Herzegovina has established a functioning, albeit small, research base in them.

We extracted, for Bosnia and Herzegovina, the most active actors per domain from all data sources. The corresponding results are shown in Figure 49, where the 10 most active institutions are sorted by decreasing order of associated records.

For the case of Bosnia and Herzegovina, all top 10 actors are universities, the most active one of them being the University of Sarajevo. Albeit being multidisciplinary, the University of Sarajevo seems to be the primary contributor in all ten domains, followed by University of Banja Luka, whose output is considerable in five domains, namely ICT, Food, Environmental Sciences, Process Industries and Materials and Heavy Machinery.

We then studied the connectedness of Bosnia and Herzegovina with international R&D collaboration networks, by focusing, again, on the WB extended neighbourhood and the whole world. Results are reported in Figure 50 and Figure 51 for the former and the latter case, respectively.

Figure 47. Bosnia and Herzegovina - Total output per domain and data source-size normalized results



For collaborations within the extended neighbourhood, Croatia emerges clearly as the main partner for the case of publications, followed by Slovenia and Turkey. Collaborations with all those countries are especially concentrated in the domains of Health & Wellbeing, Environmental sciences and industries, Food and Better Societies. When looking at collaborations in R&D projects funded by European competitive schemes, one finds Greece to be the main partner of Bosnia and Herzegovina, followed by Croatia and Romania. Collaborations happen mainly in the domains Better society, Energy, Health & wellbeing: it remains to be seen what is the role played by the scope and design of the calls funding those projects in shaping these observed patterns.

Table 24. Bosnia and Herzegovina - The semantic content of the specialisation domains

Domain	Keywords
Better societies - governance, culture, education and the economy	process, business, economic, management, quality, market, social, company, public, policy, product, society, financial, economy, system, political, customer, human, strategy, consumer
Energy	power, energy, system, coal, plant, wind, rotor, voltage, electrical, turbine, generator, electric, fuel, source, consumption, quality, solar, construction, circuit, material
Environmental sciences and industries	specie, water, soil, forest, concentration, river, population, metal, tree, natural, data, climate, basin, temperature, fish, air, plant, rock, process, surface
Food	food, plant, product, oil, milk, extract, concentration, antioxidant, fruit, compound, seed, quality, cultivar, cow, peptide, leaf, protein, water, meat, cheese
Health & wellbeing	patient, treatment, disease, age, clinical, health, therapy, child, medical, control, population, data, woman, female, diagnosis, male, surgery, hospital, surgical, disorder
Heavy machinery	hole, surface, assembly, chair, fabric, material, process, fluid, layer, electrode, contact, roller, belt, rail, stair, screw, monitor, bar, workpiece, seat
ICT	system, data, network, control, software, process, algorithm, tool, environment, computer, service, quality, signal, web, simulation, neural, communication, prediction, database, management
Process industries and materials	temperature, material, process, surface, heat, film, particle, steel, water, latex, chemical, carbon, thermal, polymer, cement, gas, pressure, alloy, liquid, metal
Transport	water, air, vehicle, system, weight, vessel, engine, car, motor, mass, river, pipe, dam, shaft, box, spring, wheel, channel, tyre, carrier
No domain	laser, energy, electron, radiation, light, wavelength, molecular, ionisation, beam, threshold, molecule, frequency, philtre, crystal, wave, society, atom, process, interaction, source

Figure 48. Bosnia and Herzegovina - Temporal evolution of the preliminary specialisation domains

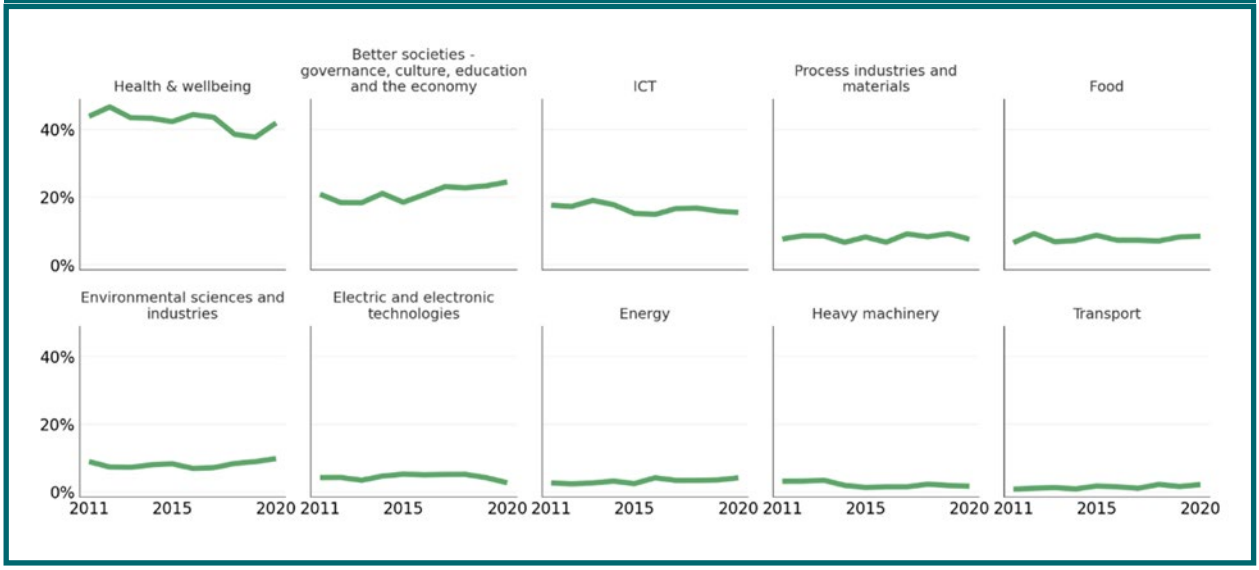


Figure 49. Top actors across domains for the case of Bosnia and Herzegovina by number of records (all sources)

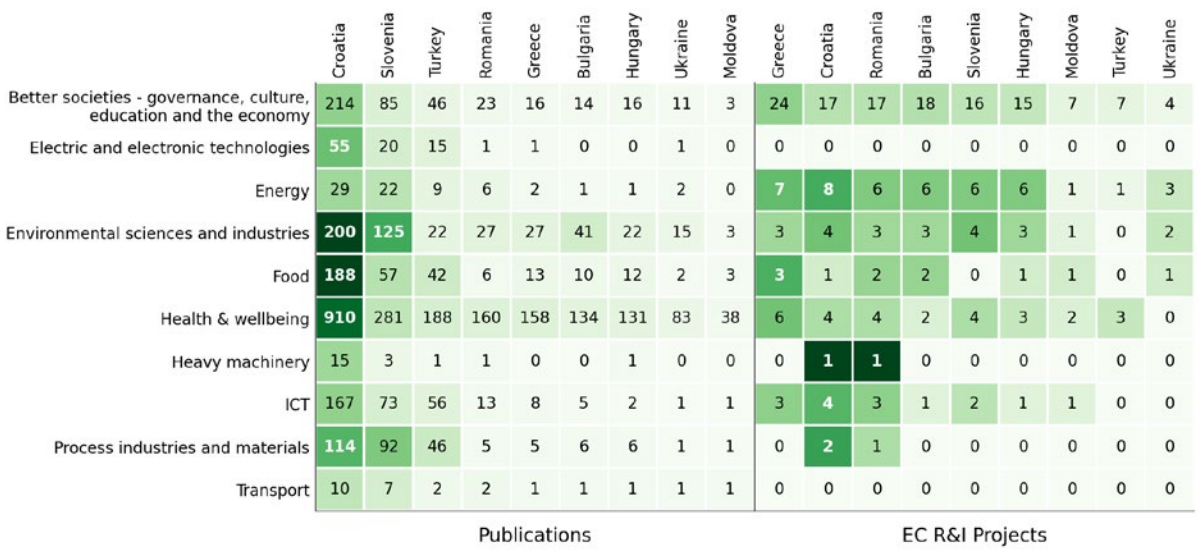
	Health & wellbeing	Better societies - governance, culture, education and the economy	ICT	Food	Environmental sciences and industries	Process industries and materials	Electric and electronic technologies	Energy	Heavy machinery	Transport
University of Sarajevo	1677	820	760	316	344	285	198	113	51	67
University of Banja Luka	556	282	309	229	226	212	56	52	51	23
University of Tuzla	431	199	186	62	108	66	62	41	17	13
University of East Sarajevo	235	197	123	91	56	114	42	30	16	25
University of Mostar	371	124	44	71	46	49	9	5	6	7
University Clinical Center of Tuzla	543	61	17	9	4	4	1	2	1	0
International Burch University	218	112	134	21	8	5	28	25	5	2
International University of Sarajevo	116	105	109	16	14	49	31	21	1	1
University Clinical Center of Sarajevo	284	13	8	13	0	1	0	0	1	0
University of Bihac	41	47	54	50	30	30	2	4	8	6

Colour indicates relative contribution, computed column-wise.

Interestingly, the main international partners in scientific publications of Bosnia and Herzegovina remain Croatia and Slovenia, even when looking beyond the extended neighbourhood. As commonly observed even for other economies, Germany, the United States and Italy rise as three of the main collaborators in scientific publications.

Collaboration patterns in R&D projects funded by competitive European schemes are instead found to change significantly when including partnerships beyond the WB-extended neighbourhood: indeed, one finds in this case that Germany, Italy and Spain are the main partners of Bosnia and Herzegovina. Significant collaborations in the Energy and ICT domains are found with Germany and Austria.

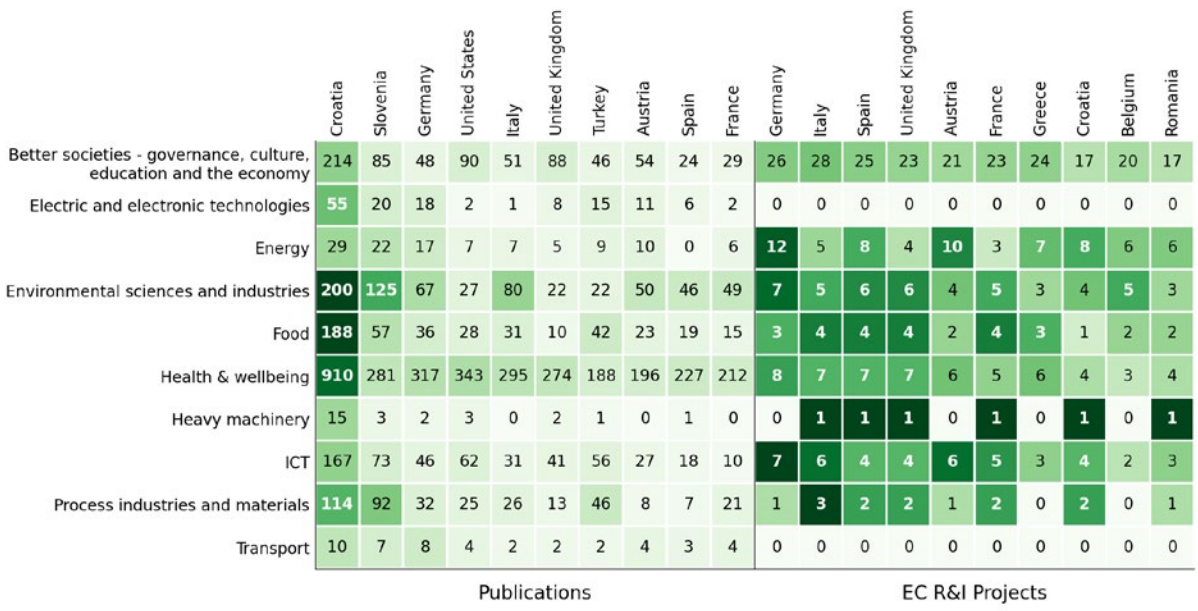
Figure 50. Bosnia and Herzegovina international collaborators per domain, presented as number of records (all sources), within the WB extended geographic neighbourhood



	Publications									EC R&I Projects								
	Croatia	Slovenia	Turkey	Romania	Greece	Bulgaria	Hungary	Ukraine	Moldova	Greece	Croatia	Romania	Bulgaria	Slovenia	Hungary	Moldova	Turkey	Ukraine
Better societies - governance, culture, education and the economy	214	85	46	23	16	14	16	11	3	24	17	17	18	16	15	7	7	4
Electric and electronic technologies	55	20	15	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0
Energy	29	22	9	6	2	1	1	2	0	7	8	6	6	6	6	1	1	3
Environmental sciences and industries	200	125	22	27	27	41	22	15	3	3	4	3	3	4	3	1	0	2
Food	188	57	42	6	13	10	12	2	3	3	1	2	2	0	1	1	0	1
Health & wellbeing	910	281	188	160	158	134	131	83	38	6	4	4	2	4	3	2	3	0
Heavy machinery	15	3	1	1	0	0	1	0	0	0	1	1	0	0	0	0	0	0
ICT	167	73	56	13	8	5	2	1	1	3	4	3	1	2	1	1	0	0
Process industries and materials	114	92	46	5	5	6	6	1	1	0	2	1	0	0	0	0	0	0
Transport	10	7	2	2	1	1	1	1	1	0	0	0	0	0	0	0	0	0

Colour indicates collaboration intensity, computed row-wise.

Figure 51. Bosnia and Herzegovina international collaborators per domain, presented as number of records (all sources), worldwide



	Publications										EC R&I Projects									
	Croatia	Slovenia	Germany	United States	Italy	United Kingdom	Turkey	Austria	Spain	France	Germany	Italy	Spain	United Kingdom	Austria	France	Greece	Croatia	Belgium	Romania
Better societies - governance, culture, education and the economy	214	85	48	90	51	88	46	54	24	29	26	28	25	23	21	23	24	17	20	17
Electric and electronic technologies	55	20	18	2	1	8	15	11	6	2	0	0	0	0	0	0	0	0	0	0
Energy	29	22	17	7	7	5	9	10	0	6	12	5	8	4	10	3	7	8	6	6
Environmental sciences and industries	200	125	67	27	80	22	22	50	46	49	7	5	6	6	4	5	3	4	5	3
Food	188	57	36	28	31	10	42	23	19	15	3	4	4	4	2	4	3	1	2	2
Health & wellbeing	910	281	317	343	295	274	188	196	227	212	8	7	7	7	6	5	6	4	3	4
Heavy machinery	15	3	2	3	0	2	1	0	1	0	0	1	1	1	0	1	0	1	0	1
ICT	167	73	46	62	31	41	56	27	18	10	7	6	4	4	6	5	3	4	2	3
Process industries and materials	114	92	32	25	26	13	46	8	7	21	1	3	2	2	1	2	0	2	0	1
Transport	10	7	8	4	2	2	2	4	3	4	0	0	0	0	0	0	0	0	0	0

Colour indicates collaboration intensity, computed row-wise.

4.3.3 Specialisation analysis of Kosovo

The scientific output of Kosovo in terms of the 4669 publications within our observation period is mainly driven by Medicine (1780 publications between 2011-2020), and Engineering (1143). Environmental Science (687), Social Sciences (661), Agricultural and Biological Sciences (601) and Computer Science (535) constitute the second tier of subject areas with considerable scientific output.

Of the above (see Figure 52), Kosovo is characterised by strong and consistent specialisation in both 5-yr periods only in Environmental Science, Agricultural and Biological Sciences, Economics Econometrics and Finance and Veterinary Sciences, the last two with small output. Engineering is very close to the specialisation threshold, having LQ > 1.4 in both 5-year periods and significant output.

There is no data available for EU patents and Trademarks with applicants in Kosovo.

The classification of all the records from Kosovo into domains provides the counts shown in Figure 53. Health & Wellbeing is at the top of the list, with its output being 3 times bigger than that of the other domains. Kosovo contributes approximately 3% of the WB output in this domain. Process industries is the second most significant domain in terms of output while Environmental Sciences, ICT and Better Society constitute the third tier of output.

The semantic content of each of the specialisation domains for Kosovo is shown in Table 25. Comparing the semantic content for Kosovo with WB we note that electric/electronic technologies and ICT have a clear focus on digital telecommunication systems, process industries focus on chemical engineering and Better Societies focus on management/business administration.

Finally, it seems that the records that were not associated with a domain are mainly in the fields of mechanical engineering and materials.

Figure 52. Specialisation trends for all subject areas calculated over two 5-year periods for Kosovo

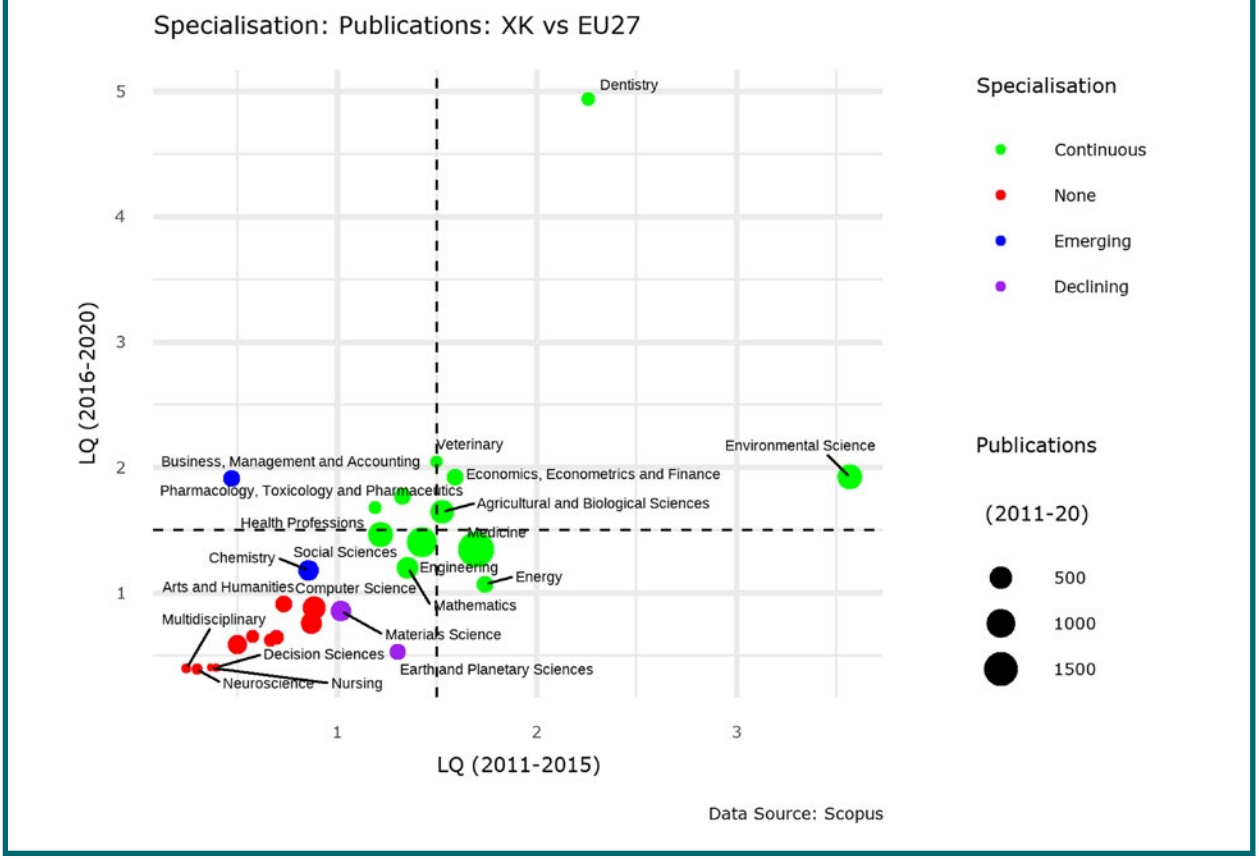
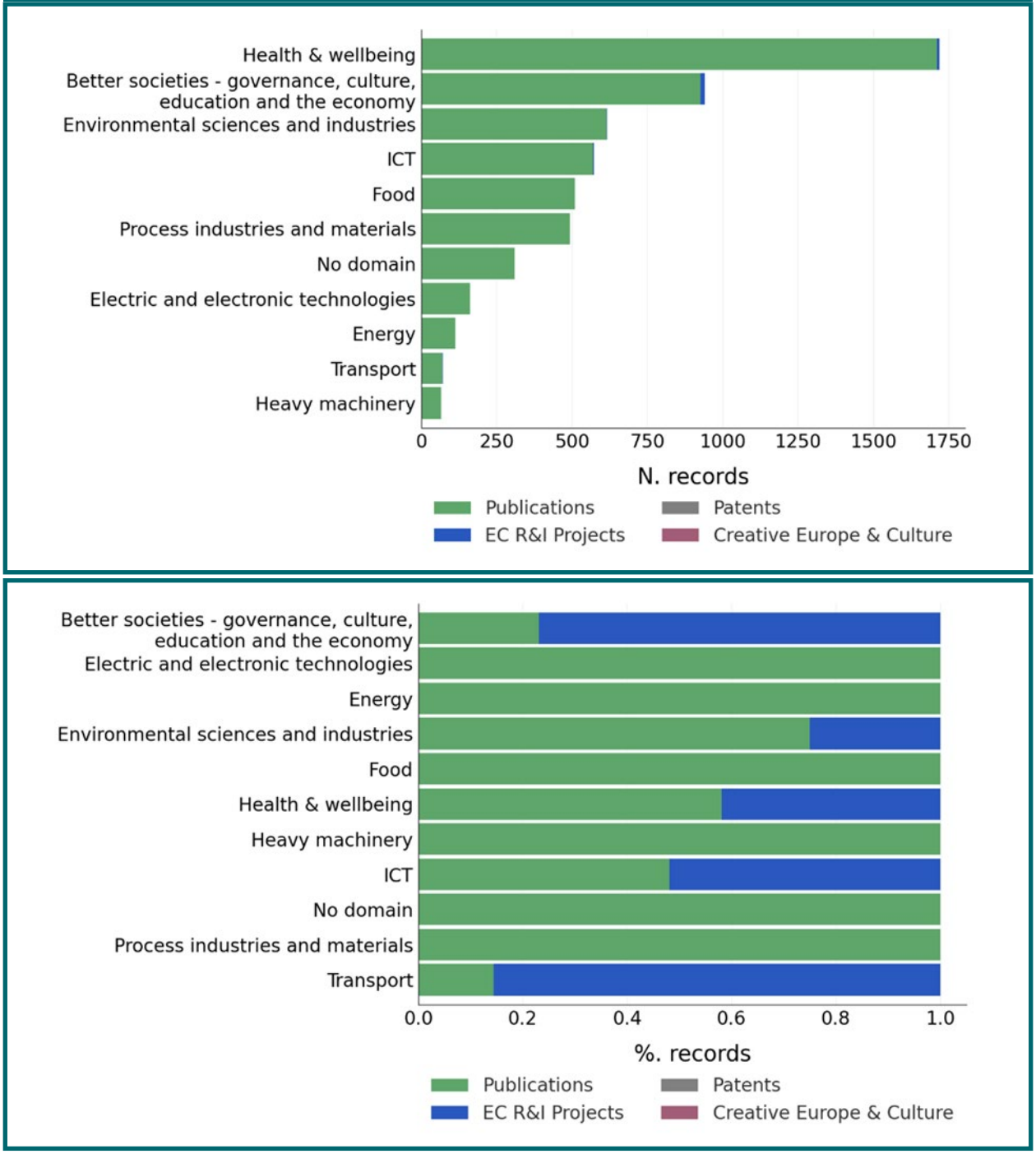


Figure 53. Total output per domain and data source-size normalized results



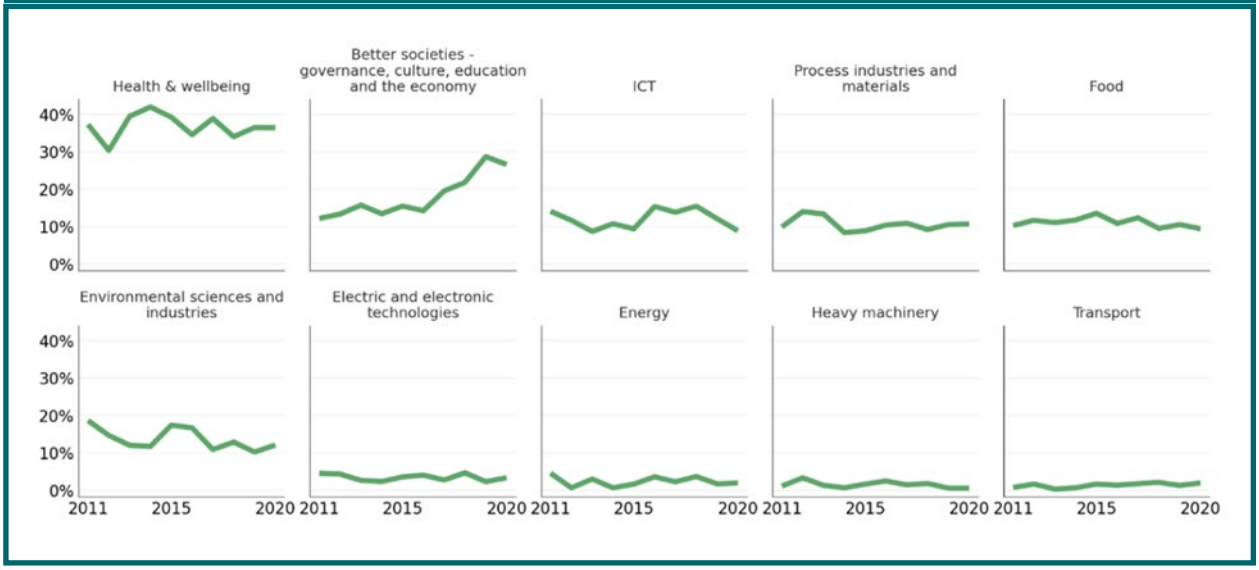
The temporal evolution of the preliminary specialisation domains for Kosovo is characterised by considerable variations in the yearly output in eight out of ten domains. Better Societies seems to be growing, while Environmental Sciences declines over time. All these suggest that Kosovo's research base has not formed critical cores around the primary specialisation domains yet.

We present in this section the main local and international contributors to each domain, for the case of Kosovo. We look first at the main Kosovar actors active in the different domains, for all analysed data sources. The main results are summarised in Figure 55, where we show the top 10 institutions in terms of associated records. In the case of Kosovo, we find, among the top ten actors, universities, as well as public agencies and institutes and private companies.

Table 25. Kosovo - The semantic content of each of the specialisation domains

Domain	Keywords
Better societies - governance, culture, education and the economy	system, management, data, economic, network, business, service, process, quality, policy, tool, social, web, environment, product, market, strategy, government, industry, bank
Electric and electronic technologies	system, fading, signal, channel, receiver, interference, numerical, bit, macrodiversity, environment, random, gamma, sir, performance-analysis, cdf, communication, image, modulation, multipath, outage
Energy	system, power, algorithm, energy, network, wind, control, electricity, generation, robot, vehicle, software, machine, turbine, voltage, process, circuit, data, soft, device
Environmental sciences and industries	water, concentration, river, plant, metal, specie, waste, population, pollution, environmental, material, environment, air, ash, quality, process, natural, chemical, coal, industrial
Food	compound, concentration, oil, plant, leaf, extract, radon, antioxidant, cultivar, grain, acid, antimicrobial, fruit, weight, essential-oil, seed, strain, flavonoid, reaction, antibacterial
Health & wellbeing	patient, age, child, disease, treatment, clinical, infection, male, complication, female, woman, diagnosis, health, data, tumour, control, cancer, therapy, cell, disorder
ICT	satellite, data, human, frequency, station, exposure, communication, mhz, sar, electromagnetic, forest, mobile, earth, maintenance, system, phone, process, tree, derivative, antenna
Process industries and materials	surface, temperature, process, heat, material, acid, thermal, flow, oil, reaction, mass, transfer, electrode, kinetic, concentration, energy, ion, society, water, pressure
No domain	system, space, temperature, alloy, operator, thermodynamic, process, sequence, data, motion, microscopy, causality, translocation, material, polynomial, hardness, molar, dta, plane, sem

Figure 54. Kosovo - Temporal evolution of the preliminary specialisation domains



Specifically, the main actors in terms of associated records are found to be the University of Pristina in Pristina and the University of Pristina in Kosovska Mitrovica. They collectively produce Kosovo's output across all priority domains. The third most significant actor in Kosovo is the University Clinical Center of Kosovo, which, not surprisingly, is almost entirely framed within the Health & wellbeing domain. We then examined the Kosovar international collaboration patterns, for scientific publications and R&D projects funded by competitive European schemes. We did so once again by looking at the WB extended neighbourhood first and at worldwide collaboration next.

Within the WB extended neighbourhood, Croatia emerges as the main Kosovar collaborator in scientific publications. The bond seems to be especially strong in the domains Health & wellbeing, Energy, Environmental sciences and industries and Food and. Slovenia is the second partner country in terms of co-authorship of scientific publications. The collaborations between Kosovo and Slovenia are strong in the Better societies, Energy, Health & Wellbeing and Heavy Machinery. Turkey emerges as the third most frequent partner country, with significant collaborations figures in the Health & wellbeing domain. When analysing collaborations in European R&D projects, the main partner countries in the WB extended neighbourhood are Greece, Turkey, Bulgaria, Hungary and Slovenia, with most collaborations being in the domain Better societies.

We examined Kosovar collaborations in scientific publications and European R&D projects beyond the WB extended neighbourhood. For publications, Croatia remains the main collaborator with

Figure 55. Top actors across domains for the case of Kosovo by number of records (all sources)

	Health & wellbeing	Better societies - governance, culture, education and the economy	Environmental sciences and industries	ICT	Food	Process industries and materials	Electric and electronic technologies	Energy	Transport	Heavy machinery
University of Pristina in Pristina	747	486	343	232	301	178	67	42	35	28
University of Priština in Kosovska Mitrovica	354	139	158	254	144	234	68	34	19	18
University Clinical Center of Kosovo (UCCK)	404	6	4	4	15	2	0	1	0	1
UBT - Higher Education Institution	25	69	25	21	9	9	3	9	2	1
University "Haxhi Zeka"	5	62	50	6	11	1	0	3	0	0
University of Mitrovica "Isa Boletini"	11	11	37	5	9	10	3	4	1	2
National Institute of Public Health of Kosovo	70	5	4	1	6	0	0	1	1	0
High Technical School of Professional Studies	1	4	1	9	0	25	2	2	2	7
Health Center	34	2	0	3	1	0	1	0	0	0
Electric Power Industry of Serbia	1	2	6	2	0	10	7	7	0	3

Colour indicates relative contribution, computed column-wise.

the United States and Germany emerging in second and third place. For the case of R&D projects funded by competitive European schemes, we find the United Kingdom to be the main Kosovar partner beyond the WB extended neighbourhood, followed by Spain and Germany. All those collaborations are found in the Better societies, Health & wellbeing and ICT domains.

Figure 56. Kosovar international collaborators per domain, presented as number of records (all sources), within the WB extended geographic neighbourhood

	Croatia	Slovenia	Turkey	Bulgaria	Romania	Greece	Hungary	Moldova	Ukraine	Greece	Turkey	Bulgaria	Hungary	Slovenia	Romania	Ukraine	Moldova	Croatia
	Publications									EC R&I Projects								
Better societies - governance, culture, education and the economy	18	28	12	15	8	5	13	4	3	6	4	5	3	3	2	1	1	2
Electric and electronic technologies	4	0	1	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Energy	11	8	2	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0
Environmental sciences and industries	43	16	15	11	6	5	10	2	1	1	0	0	0	0	0	0	0	0
Food	14	10	10	7	0	8	5	1	1	0	0	0	0	0	0	0	0	0
Health & wellbeing	156	74	86	43	51	45	32	18	16	1	1	1	1	0	0	0	0	0
Heavy machinery	1	5	0	0	3	0	1	0	1	0	0	0	0	0	0	0	0	0
ICT	7	8	8	4	2	4	2	1	1	1	0	1	1	2	1	1	0	0
Process industries and materials	18	16	12	1	5	1	4	0	2	0	0	0	0	0	0	0	0	0
Transport	3	2	8	2	1	2	1	1	1	1	2	0	1	0	0	0	1	0

Colour indicates collaboration intensity, computed row-wise.

Figure 57. Kosovar international collaborators per domain, presented as number of records (all sources), worldwide

	Croatia	United States	Germany	Italy	Austria	Slovenia	United Kingdom	Turkey	France	Russian Federation	United Kingdom	Spain	Germany	Belgium	Netherlands	France	Greece	Italy	Bulgaria	Turkey
	Publications										EC R&I Projects									
Better societies - governance, culture, education and the economy	18	46	23	26	19	28	43	12	7	14	8	8	8	8	6	7	6	7	5	4
Electric and electronic technologies	4	3	1	0	5	0	0	1	20	0	0	0	0	0	0	0	0	0	0	0
Energy	11	5	1	0	2	8	0	2	1	1	0	0	0	0	0	0	0	0	0	0
Environmental sciences and industries	43	14	16	14	17	16	4	15	4	5	0	1	1	0	0	1	1	0	0	0
Food	14	35	20	25	32	10	7	10	3	6	0	0	0	0	0	0	0	0	0	0
Health & wellbeing	156	112	143	108	72	74	89	86	51	46	6	3	4	4	4	3	1	1	1	1
Heavy machinery	1	0	2	1	1	5	0	0	0	1	0	0	0	0	0	0	0	0	0	0
ICT	7	13	7	11	21	8	9	8	3	8	1	3	2	2	3	0	1	0	1	0
Process industries and materials	18	8	9	10	4	16	4	12	20	12	0	0	0	0	0	0	0	0	0	0
Transport	3	0	2	2	3	2	2	8	1	7	1	1	0	0	1	1	1	1	0	2

Colour indicates collaboration intensity, computed row-wise.

4.3.4 Specialisation analysis of Montenegro

The scientific output of Montenegro in terms of its 4263 publications during our observation period is mainly driven by Agricultural and Biological Sciences (1213 publications between 2011 and 2020), Engineering (1209), Computer Science (1191) and Medicine (1125). Moreover, Environmental Science (834) and Social Sciences (514) constitute the second tier of subject areas with considerable scientific output.

Of the above (see Figure 58), Montenegro is characterised by strong and consistent specialisation (LQ>1.5 for both 5-yr periods) in:

- Agricultural and Biological Sciences,
- Computer Science,
- Environmental Sciences.

Engineering just missed the specialisation threshold in the second 5-year period. Moreover,

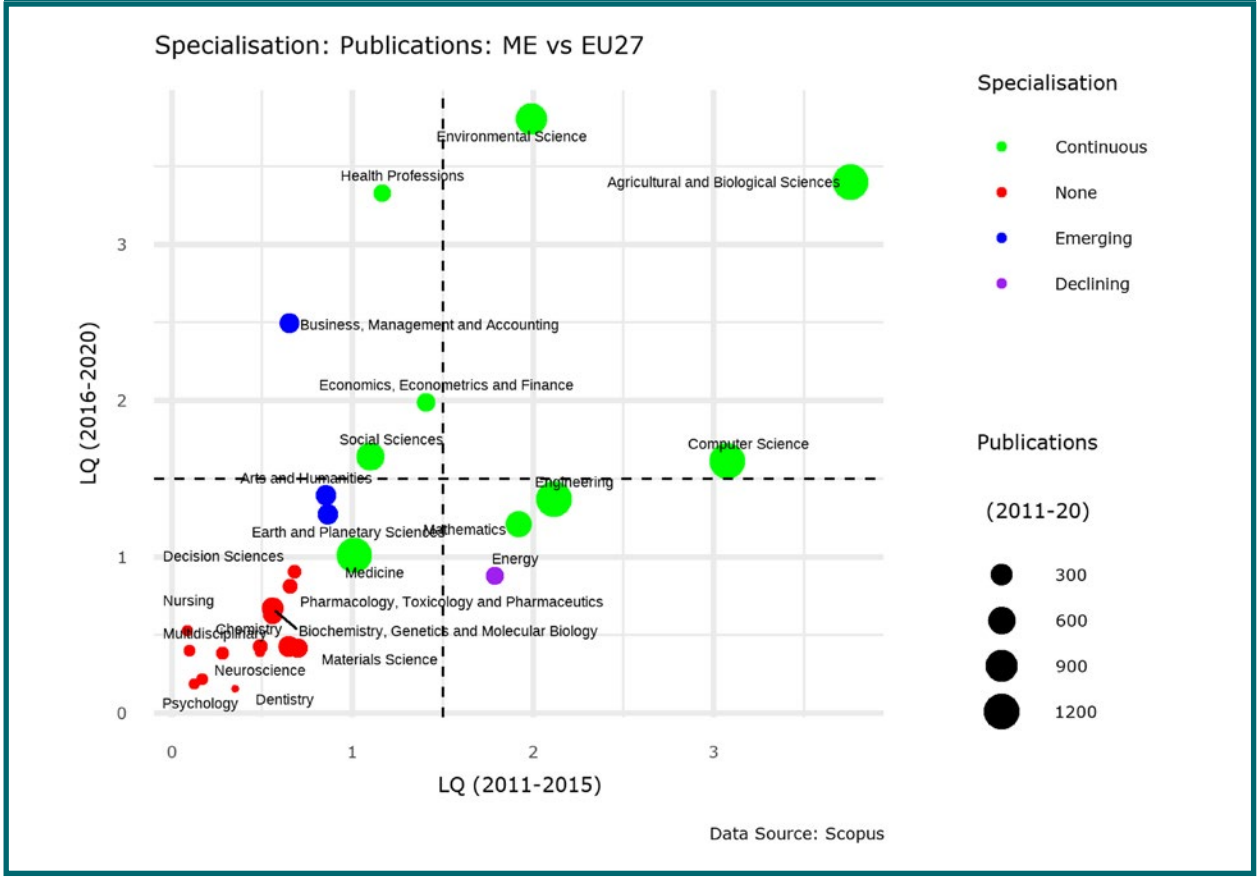
- Social Sciences (624),
- Business Management and Accounting (239), and
- Economics (181),
- Health Professions (138)

can be considered as emerging specialisations (LQ>1.5 during the second 5-yr period).

The overall number of EU patents granted to Montenegro between 2010 and 2019 is 95, which is low. There are 28 IPC level-2 codes associated with these patents, 8 of them having non-zero values in both 5-year intervals. There are six IPC codes having 5 or more patents associated with them in our 10-year observation period. These are:

- A61 Medical or Veterinary Science, Hygiene (17),
- H01 Basic electric elements (12),
- A01 Agriculture; Forestry; Animal Husbandry; Hunting; Trapping; Fishing (9),

Figure 58. Specialisation trends for all subject areas calculated over two 5-year periods for Montenegro



- Y02 (6),
- G06 Computing; Calculating; Counting (5) and
- H02 Generation, conversion, or distribution of electric power (5).

Of the adobe, A61 is the most significant, in terms of output, area of strong specialisation in both time intervals (see Figure 59), with:

- H01 Basic electric elements (12),
- A01 Agriculture; Forestry; Animal Husbandry; Hunting; Trapping; Fishing (9),
- H02 Generation, conversion, or distribution of electric power (5),
- H05 Electric techniques not otherwise provided for (4), and
- C02 Treatment of water, waste water, sewage, or sludge (4),

being strong emerging specialisation areas having LQ > 1.5 in the second time interval and a considerable number of patents associated with them.

The number of EU trademarks registered in Montenegro during the reference period is 196, the lowest performance within the Western Balkans. In the 45 codes of the Nice classification, Montenegro was active in 44. The most frequent Nice Classes were:

- 41 Education; providing of training; entertainment; sporting and cultural activities (58),
- 36 Services relating to banking and other financial transactions, financial valuation services, as well as insurance and real estate activities (54),
- 35 Advertising; business management, organization and administration; office functions (51),
- 39 Transport; packaging and storage of goods; travel arrangements (48),
- 43 Services for providing food and drink; temporary accommodation (45),

Figure 59. Specialisation trends for all IPC codes calculated over two 5-year periods for Montenegro

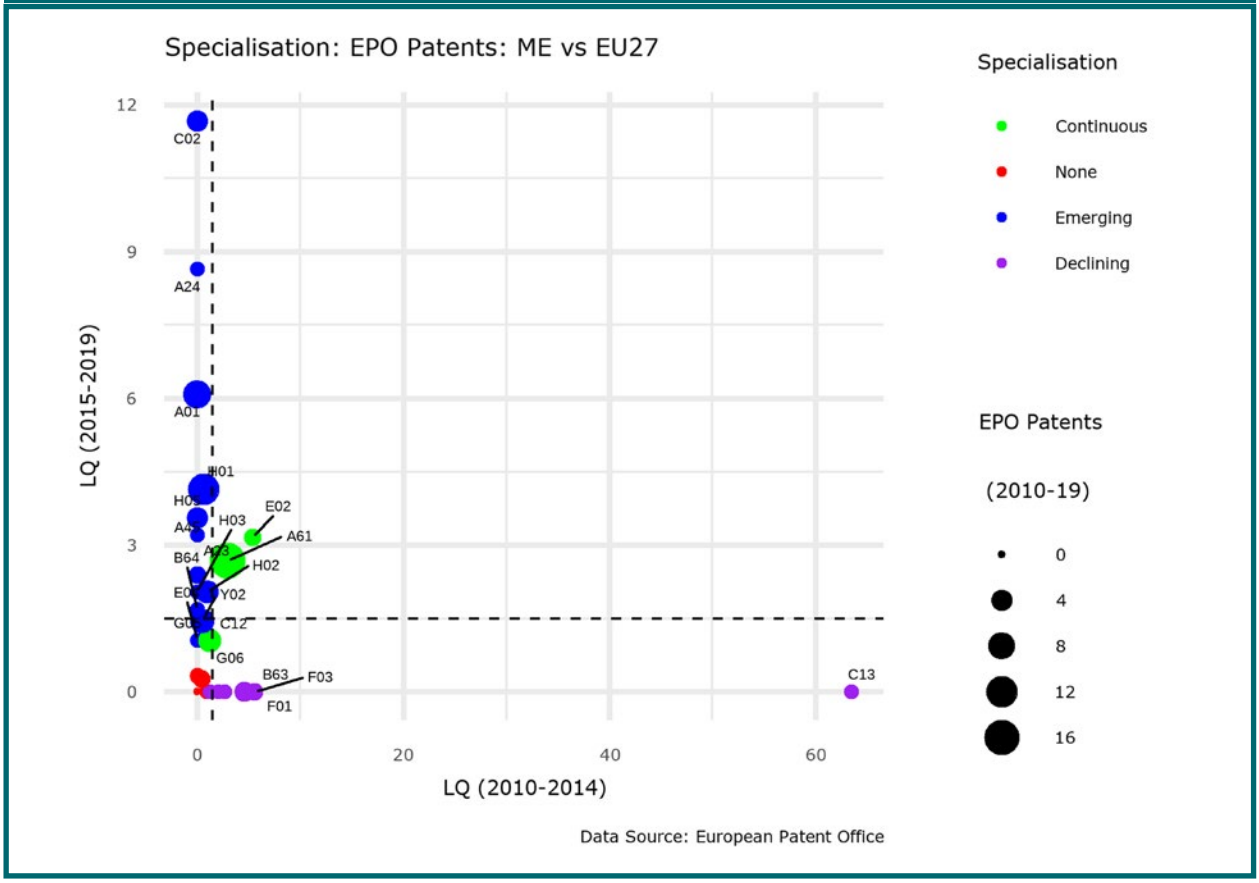
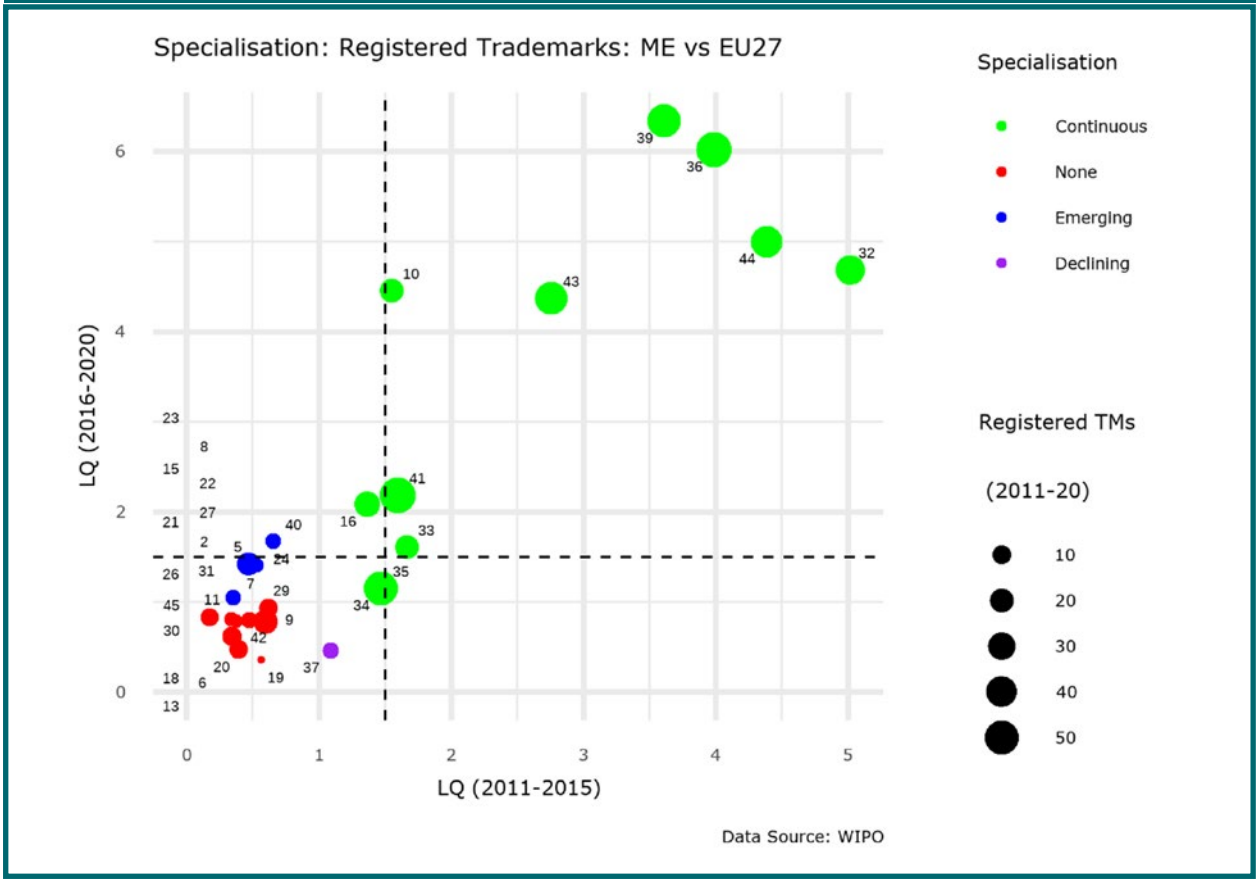


Figure 60. Specialisation trends for all Nice Classification codes calculated over two 5-year periods for Montenegro



- 44 Medical services; veterinary services; hygienic and beauty care for human beings or animals; agriculture, aquaculture, horticulture and forestry services (41) and
- 32 non-alcoholic beverages and beer (36),

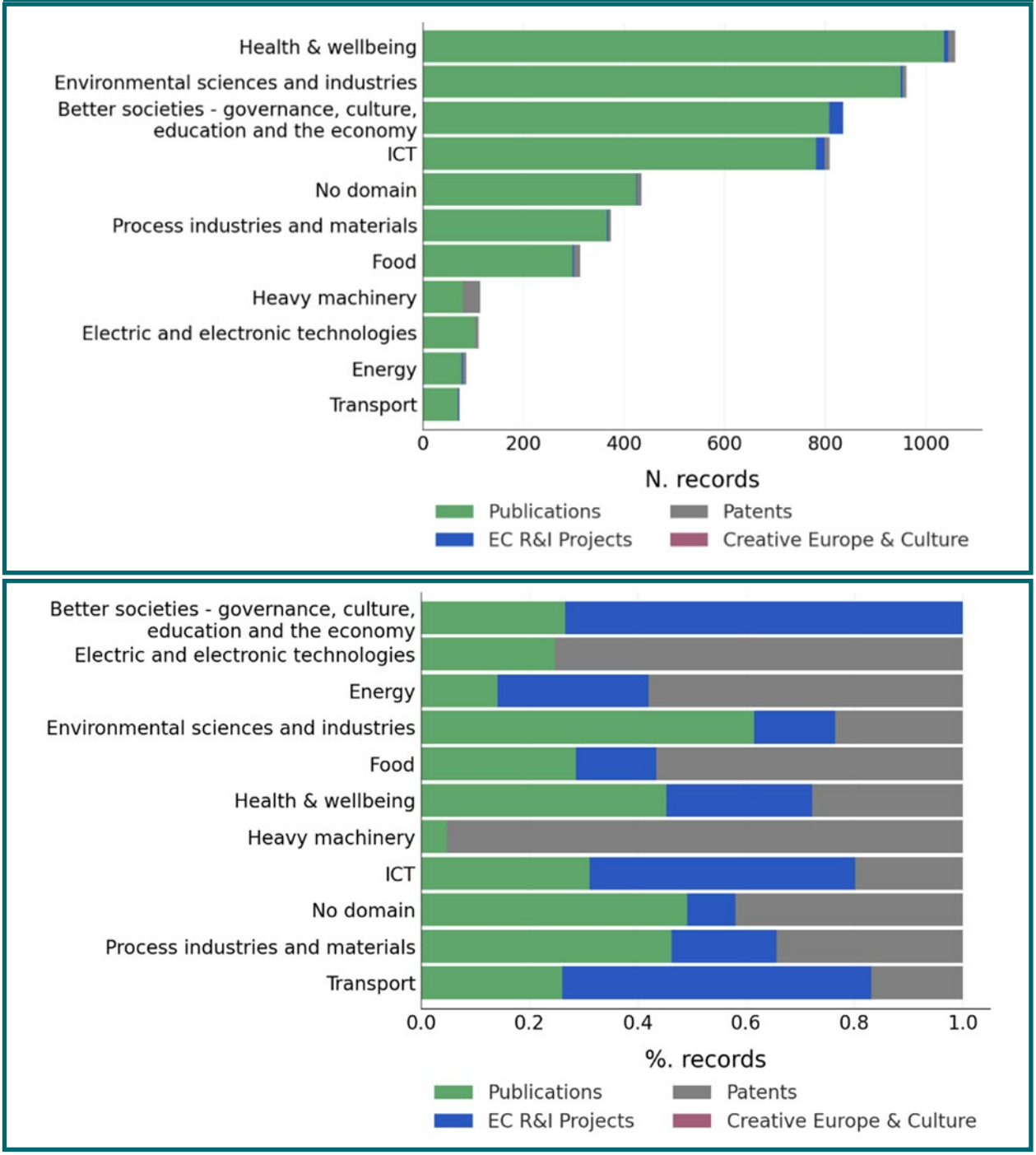
Figure 56 presents the specialisation statistics. There are 8 Nice Classes of strong specialisation in both 5-year intervals that include all of the above except class 35 and moreover,

- 10 surgical, medical, dental and veterinary apparatus, instruments and articles (20), and
- 33 Alcoholic beverages, except beers; alcoholic preparations for making beverages (20).

The classification of all the records from Montenegro into domains provides the counts shown in Figure 61. Health & Wellbeing is yet another time the top-ranking domain, followed by Environmental Sciences and Better Societies.

The semantic content of each of the specialisation domains for Montenegro is shown in Table 26. Comparing the semantic content for Montenegro with WB we note that the records associated with Energy focus on Power Systems, Environmental Sciences focus on Marine Biology and Water Resources, ICT focuses on Signal Processing and Digital Communications and Process Industries/ Materials focus on metals. While all the others are more or less similar. Finally, it seems that the records that were not associated with a domain are mainly in the field of mechanics.

Figure 61. Montenegro - Total output per domain and data source-size normalized results

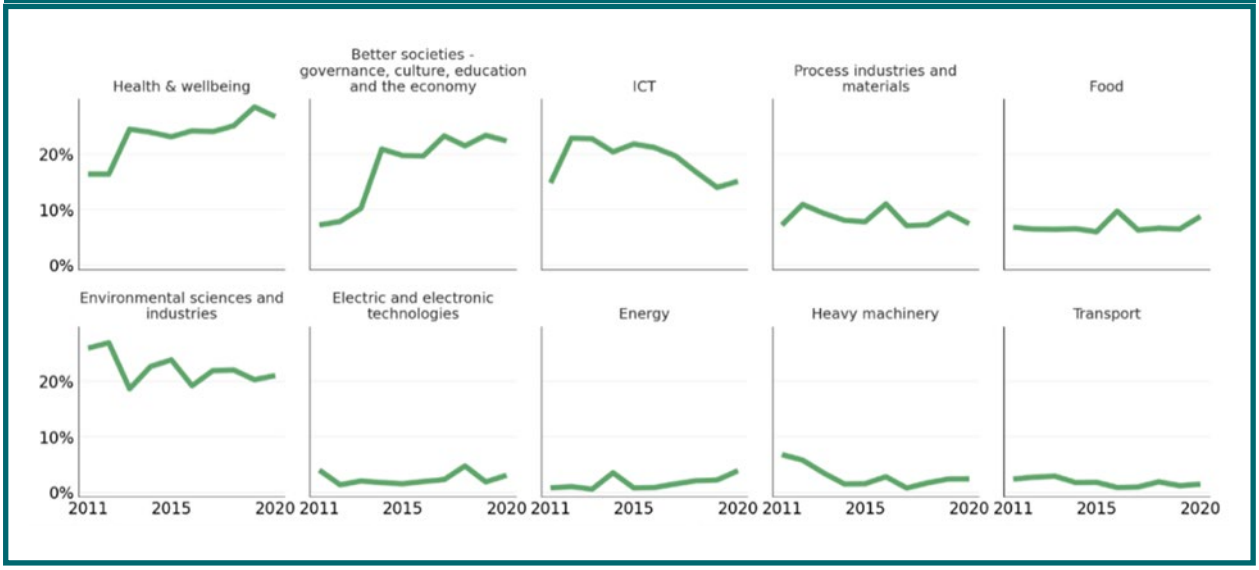


The temporal evolution of the preliminary specialisation domains for Montenegro (see Figure 62) suggests that a growth trend can be found in the Health & Welfare and in the Better Societies domains. On the other hand, ICT seems to be in decline. For the remaining domains, there are considerable variations in the yearly output around a more or less stable baseline. All these suggest that the Montenegrin research system is still evolving, having not reached a steady state yet.

Table 26. Montenegro - The semantic content of each of the specialisation domains

Domain	Keywords
Better societies - governance, culture, education and the economy	process, management, system, quality, economic, social, market, business, strategy, company, sustainable, policy, service, tourism, data, environment, cultural, political, customer, economy
Energy	power, energy, rotor, machine, voltage, generator, system, wind, fault, control, simulation, electric, engine, vane, speed, turbine, generation, circuit, device, stator
Environmental sciences and industries	specie, water, sea, genus, data, bay, population, mite, soil, family, river, surface, lake, process, natural, metal, first-time, viets, sediment, temperature
Food	fruit, genetic, cultivar, oil, plant, genotype, population, gene, extract, leaf, acid, milk, treatment, compound, strain, sequence, grapevine, grape, wine, phenolic
Health & wellbeing	patient, treatment, age, disease, clinical, child, health, data, male, control, therapy, hospital, body, cell, female, woman, tumour, blood, cancer, mortality
ICT	signal, frequency, system, algorithm, data, noise, reconstruction, transform, network, image, compressive, processing, fourier, tool, sensing, estimator, communication, simulation, polynomial, control
Process industries and materials	flow, numerical, temperature, process, alloy, heat, liquid, water, fluid, surface, solid, material, energy, sensor, simulation, friction, particle, probe, speed, gas
Transport	port, maritime, ship, safety, simulation, algorithm, container, sport, transport, bulk, data, berth, fuzzy, maintenance, railway, seaport, parallel, queue, system, car
No domain	stress, boundary, space, mapping, gev, norm, surface, data, energy, inequality, constant, graph, plane, disc, displacement, shear, mathematical, weak, strain, mass

Figure 62. Montenegro - Temporal evolution of the preliminary specialisation domains



We present here the analysis of the main local actors and international collaborators, for the case of Montenegro. Again, we extracted the most active local actors per domain, across all sources and we looked at collaborations in scientific publications and in R&D projects funded by competitive European schemes. For the case of local actors, according to the sources analysed we found the University of Montenegro to be by far the most RDI active actor in all current domains.

The second and third most prolific institutions in Montenegro appear to be the University of Donja Gorica and the Mediterranean University, both being active in nine out of ten domains, albeit with considerably lower output than the University of Montenegro. We next looked at Montenegrin international collaborations. As usual, we first looked at collaboration patterns within the WB extended neighbourhood.

When limiting the analysis to this geographical area, we found Croatia to be the main Montenegrin partner country for scientific publications, followed by Slovenia and Greece. Significant collaboration intensity in publications are found in all ten domains with Croatia, within eight domains with Slovenia and in the Environmental sciences and industries and Health & wellbeing domains with Greece. The main partners of Montenegro in European R&D projects from the WB extended neighbourhood are Greece, Romania, Bulgaria and Hungary. Significant collaborations with all of them are found in the domains Better societies and ICT: again, it should be emphasised that the observed patterns may be skewed by the scope and design of the calls funding these projects.

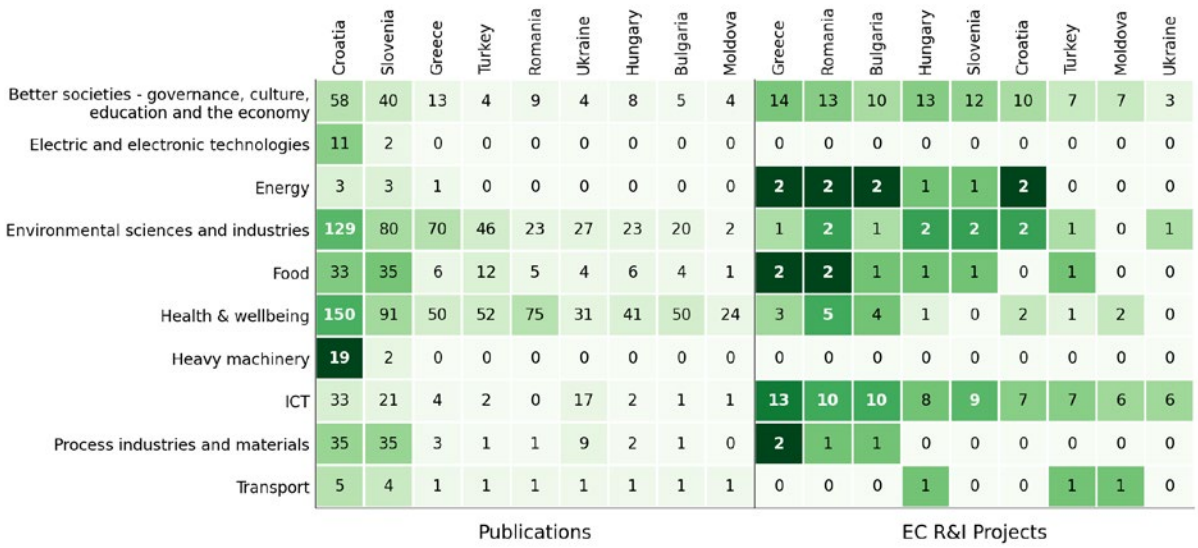
Finally, we studied Montenegro's collaboration patterns beyond the WB extended neighbourhood for scientific publications and European R&D pro-

Figure 63. Top actors across domains for the case of Montenegro by number of records (all sources)

	Environmental sciences and industries	Health & wellbeing	ICT	Better societies - governance, culture, education and the economy	Process industries and materials	Food	Electric and electronic technologies	Heavy machinery	Energy	Transport
University of Montenegro	790	787	715	635	314	244	88	73	65	64
University of Donja Gorica	21	34	27	39	9	15	4	2	3	0
Mediterranean University	16	11	28	65	6	0	9	2	3	1
Institute of Public Health of Montenegro	26	55	0	1	11	21	1	0	0	0
Institute of Marine Biology	44	12	0	1	3	1	0	0	0	0
Montenegrin Academy of Sciences and Arts	21	7	2	4	16	0	0	3	0	0
Clinical Center of Montenegro	0	46	4	2	0	0	0	0	0	0
Natural History Museum of Montenegro	34	0	0	1	1	2	0	0	0	0
Center for Ecotoxicological Research of Montenegro	12	4	0	1	4	5	0	1	0	0
JAVNA USTANOVA UNIVERZITET CRNE GORE PODGORICA	2	4	7	13	0	0	0	0	0	0

Colour indicates relative contribution, computed column-wise.

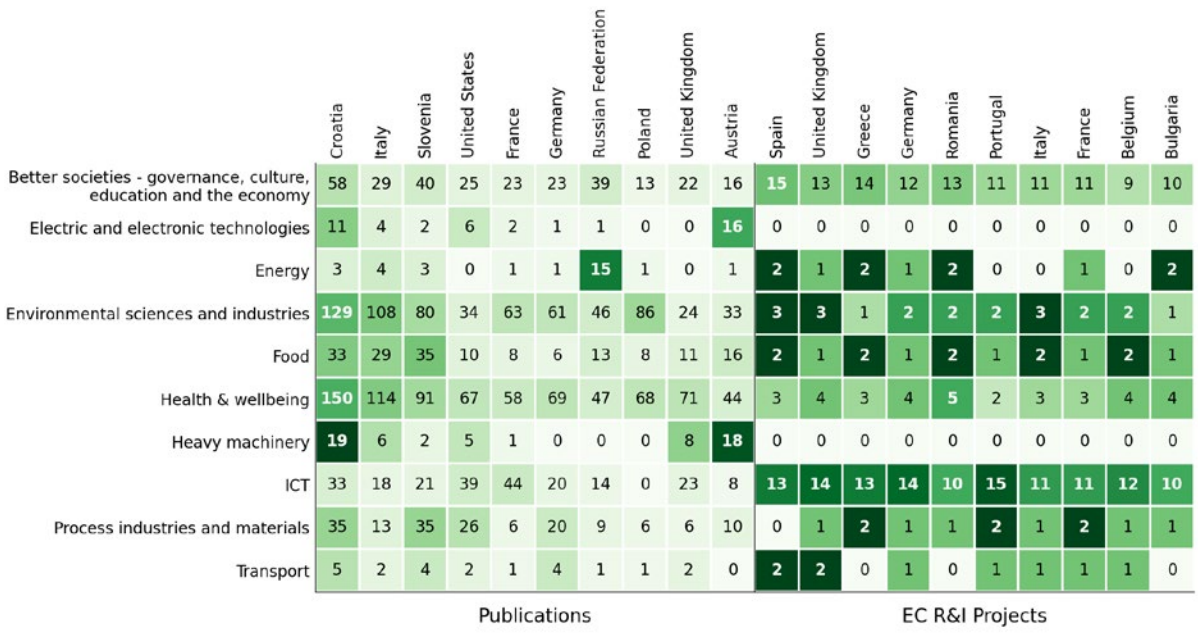
Figure 64. Montenegrin international collaborators per domain, presented as number of records (all sources), within the WB extended geographic neighbourhood



	Publications									EC R&I Projects								
	Croatia	Slovenia	Greece	Turkey	Romania	Ukraine	Hungary	Bulgaria	Moldova	Greece	Romania	Bulgaria	Hungary	Slovenia	Croatia	Turkey	Moldova	Ukraine
Better societies - governance, culture, education and the economy	58	40	13	4	9	4	8	5	4	14	13	10	13	12	10	7	7	3
Electric and electronic technologies	11	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Energy	3	3	1	0	0	0	0	0	0	2	2	2	1	1	2	0	0	0
Environmental sciences and industries	129	80	70	46	23	27	23	20	2	1	2	1	2	2	2	1	0	1
Food	33	35	6	12	5	4	6	4	1	2	2	1	1	1	0	1	0	0
Health & wellbeing	150	91	50	52	75	31	41	50	24	3	5	4	1	0	2	1	2	0
Heavy machinery	19	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ICT	33	21	4	2	0	17	2	1	1	13	10	10	8	9	7	7	6	6
Process industries and materials	35	35	3	1	1	9	2	1	0	2	1	1	0	0	0	0	0	0
Transport	5	4	1	1	1	1	1	1	1	0	0	0	1	0	0	1	1	0

Colour indicates collaboration intensity, computed row-wise.

Figure 65. Montenegrin international collaborators per domain, presented as number of records (all sources), worldwide



	Publications										EC R&I Projects									
	Croatia	Italy	Slovenia	United States	France	Germany	Russian Federation	Poland	United Kingdom	Austria	Spain	United Kingdom	Greece	Germany	Romania	Portugal	Italy	France	Belgium	Bulgaria
Better societies - governance, culture, education and the economy	58	29	40	25	23	23	39	13	22	16	15	13	14	12	13	11	11	11	9	10
Electric and electronic technologies	11	4	2	6	2	1	1	0	0	16	0	0	0	0	0	0	0	0	0	0
Energy	3	4	3	0	1	1	15	1	0	1	2	1	2	1	2	0	0	1	0	2
Environmental sciences and industries	129	108	80	34	63	61	46	86	24	33	3	3	1	2	2	2	3	2	2	1
Food	33	29	35	10	8	6	13	8	11	16	2	1	2	1	2	1	2	1	2	1
Health & wellbeing	150	114	91	67	58	69	47	68	71	44	3	4	3	4	5	2	3	3	4	4
Heavy machinery	19	6	2	5	1	0	0	0	8	18	0	0	0	0	0	0	0	0	0	0
ICT	33	18	21	39	44	20	14	0	23	8	13	14	13	14	10	15	11	11	12	10
Process industries and materials	35	13	35	26	6	20	9	6	6	10	0	1	2	1	1	2	1	2	1	1
Transport	5	2	4	2	1	4	1	1	2	0	2	2	0	1	0	1	1	1	1	0

Colour indicates collaboration intensity, computed row-wise.

jects. For publications, Croatia is found again to be the main partner and Slovenia the third most significant partner. Italy attains the second position in the rank when widening the analysis to the whole world. Collaboration with Italy is found to be strong in Environmental Sciences, Food, and Health & Wellbeing. Interestingly, for what concerns collaborations in European R&D projects, Spain, United Kingdom, Greece and Germany are in the first four places, with more or less equal linkages, mainly in Better Societies and ICT.

4.3.5 Specialisation analysis of North Macedonia

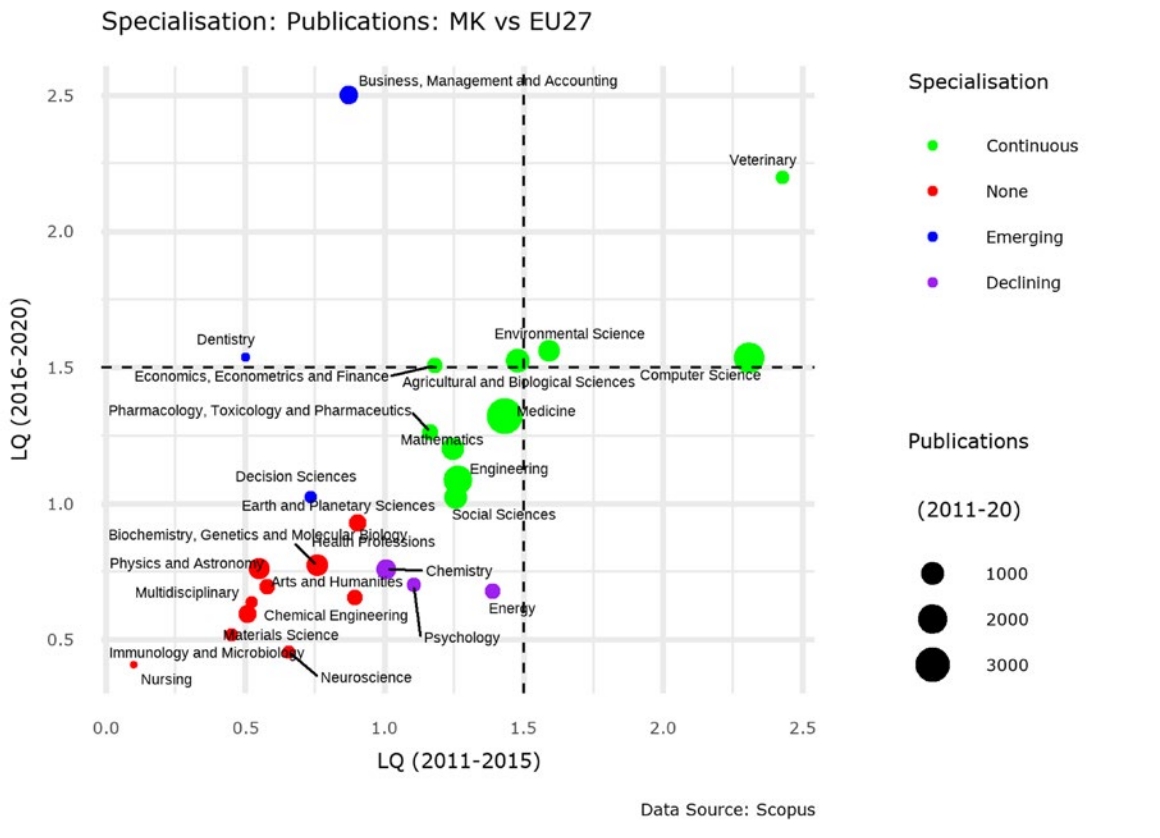
The scientific output of North Macedonia in terms of the 9152 publications during our observation period is mainly driven by Medicine (3281 publications between 2011-2020), Computer Science (2224), Engineering (1834), and Agricultural and Biological Sciences (1110) and Social Sciences (1005). Mathematics (912), Environmental Sciences (865) and Biochemistry, Genetics and Molecular Biology (827) constitute the second tier of subject areas with considerable scientific output.

Of the above (see Figure 66), North Macedonia is characterized by strong specialisation (LQ>1.5) and significant output, in both time periods, in Computer Science and Environmental Science. Medicine is also close to the specialisation thresholds in both periods. Veterinary Science is also strongly specialised in both 5-year periods, albeit with much smaller output of 174 publications.

The overall number of EU patents granted to North Macedonia between 2010 and 2019 is 55, which is very low. There are 27 IPC level-2 codes associated with these patents, 7 of them having non-zero values in both intervals. There are two IPC codes having more than 5 patents associated with them in our 10-year observation period. These are:

- A61 Medical or Veterinary Science, Hygiene (10) and
- G06 Computing; Calculating; Counting (7),
- which, as expected, constitute the most significant, in terms of output, areas of strong specialisation in both time intervals, with:
- B29 Working of plastics; working of substances in a plastic state in general (5),
- B61 Railways (4),
- E05 Locks; Keys; Window or door fittings; Safes (2),

Figure 66. Specialisation trends for all subject areas calculated over two 5-year periods for North Macedonia



also being strong specialisation areas, but with fewer patents each of them.

The 9 areas indicated as strong (LQ > 1.5) emerging specialisations in Figure 67 do not have more than 2 patents associated with them.

The number of EU trademarks registered in North Macedonia during the reference period is 7,289. The most frequent Nice Classes were:

- 35 Advertising; business management, organization and administration; office functions (2,093),
- 30 Foodstuffs of plant origin prepared for consumption or conservation as well as auxiliaries intended for the improvement of the flavour of food (1,073),
- 41 Education; providing of training; entertainment; sporting and cultural activities (788),
- 5 pharmaceuticals and other preparations for medical or veterinary purposes (714),
- 32 non-alcoholic beverages and beer (647) and
- 29 foodstuffs of animal origin, as well as vegetables and other horticultural comestible products which are prepared or preserved for consumption (608).

As shown in Figure 54, there are only two Nice Classes of strong specialisation in both 5-year intervals, namely 30 and 32. Both of them have a significant number of trademarks associated with them.

The classification of all the records from North Macedonia into domains provides the counts shown in Figure 69. Health & Wellbeing is at the top of the list, just like the aggregate values for Western Balkans, with the country's contribution being approximately 8.2% of the WB output. ICT is the second, with a significant contribution in the country's total output and 14.23% of the aggregate WB output. Better Societies is a close

Figure 67. Specialisation trends for all IPC codes calculated over two 5-year periods for North Macedonia

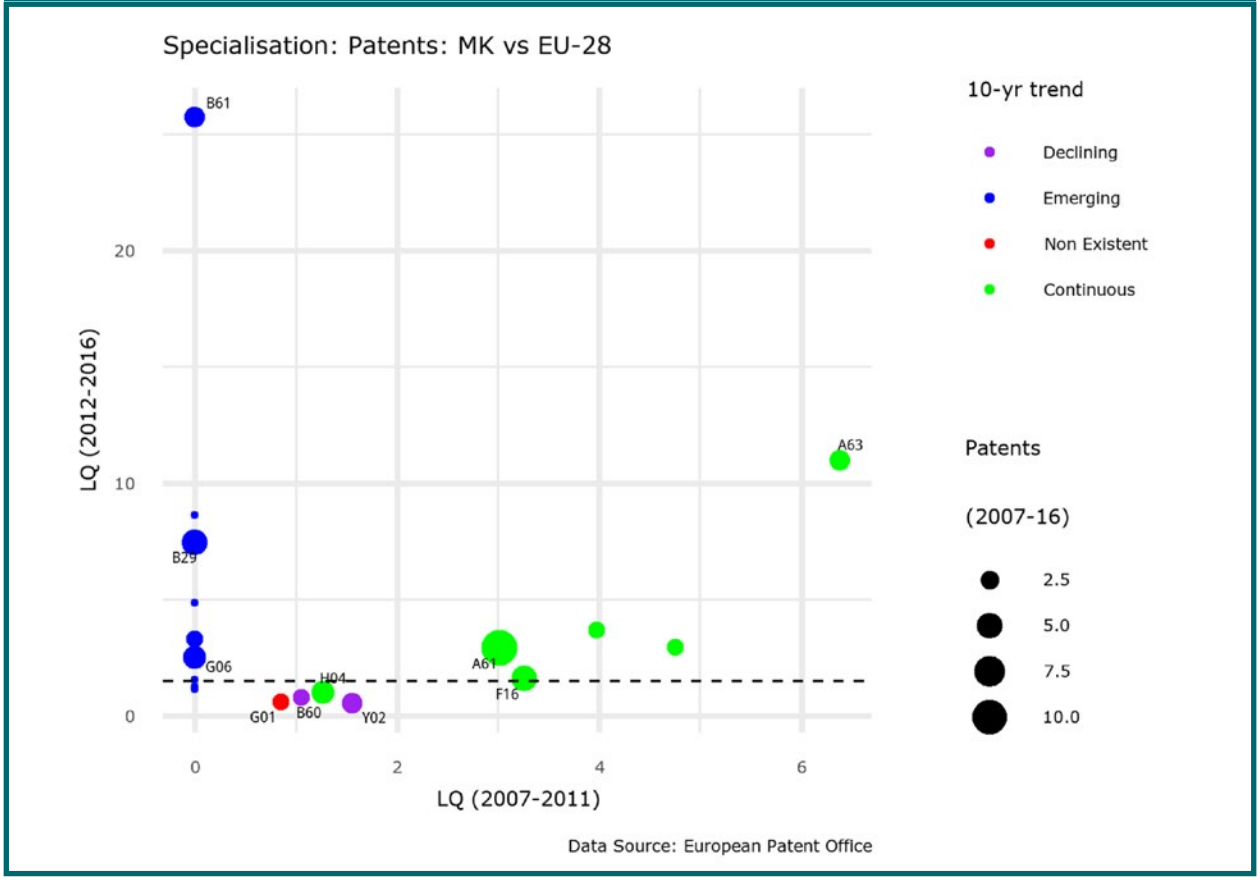
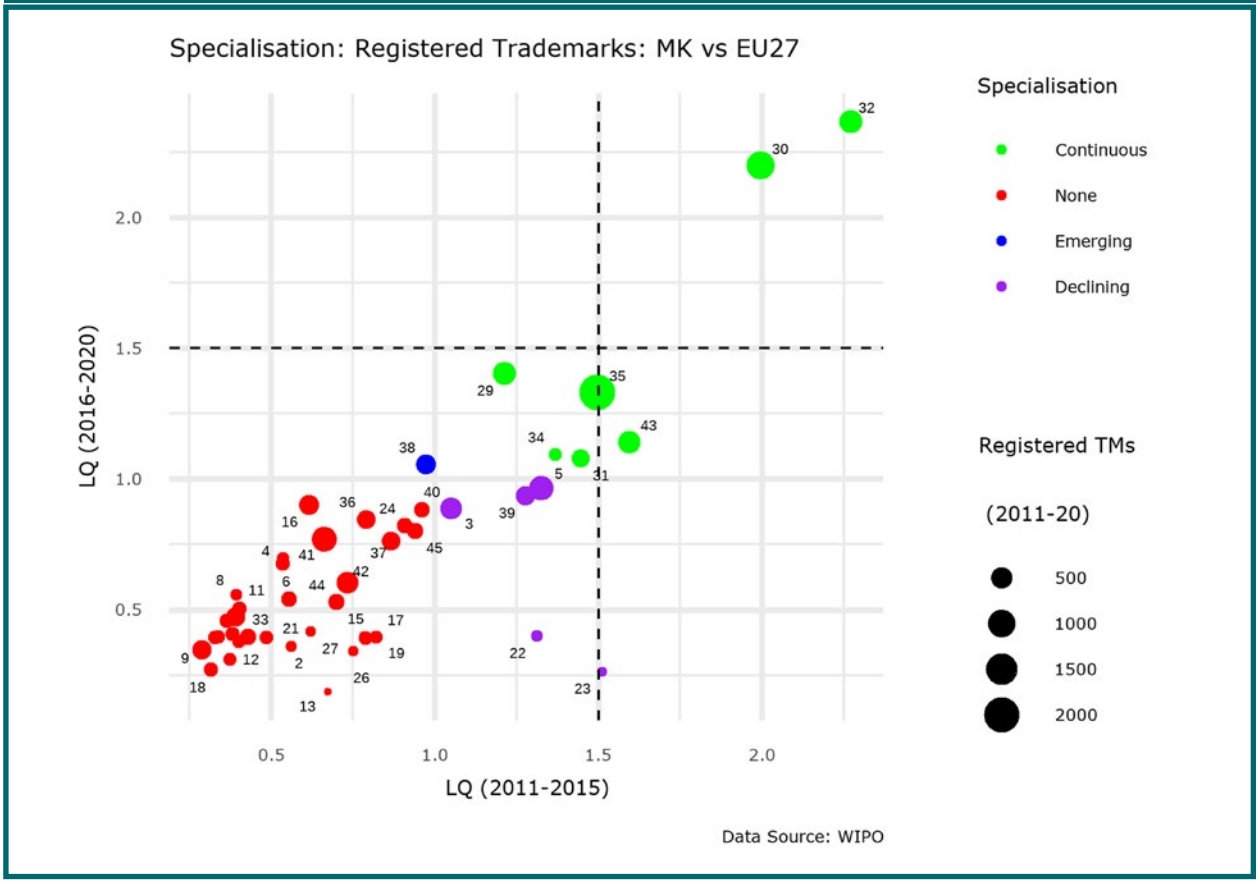


Figure 68. Specialisation trends for all Nice Classification codes calculated over two 5-year periods for North Macedonia



third and Environmental Sciences / Industries are in the fourth place.

The semantic content of each of the specialisation domains for the former North Macedonia is shown in Table 27. Comparing the semantic content for the country with the aggregates for WB we notice significant differentiations in Heavy Machinery, Process Industries/Materials and Transport, while all the others are more or less similar. Finally, it seems that the records that were not associated with a domain are mainly in the fields of physics.

The temporal evolution of the preliminary specialisation domains for North Macedonia is characterised by considerable variations in the yearly output in the top domain in terms of output (Health & Wellbeing), a growth trend in the third (Better Societies) and a declining trend in the second (ICT). The remaining domains seem to be stable across our observation period. These trends suggest an increasing focus mainly on social sciences and a state of stability in all other domains with significant outputs.

In Figure 71 we look at the main local stakeholders and international collaborations of North Macedonia across data sources, for all domains. The main contributors from North Macedonia to the different domains are found to be universities, hospitals and the Macedonian Academy of Sciences and Arts. In particular, the top 3 actors of North Macedonia are found to be the Saints Cyril and Methodius University of Skopje (the primary national performer, with a rather transversal output), the Goce Delčev University of Štip (also fairly domain-transversal, but with a faint skewness towards the domains Environmental sciences and industries and Food), the Macedonian Academy for Sciences and Arts (especially active in the domains Health & Wellbeing) and the South East European University (whose output falls especially in the domains Better societies and ICT).

Figure 69. North Macedonia - Total output per domain and data source-size normalized results

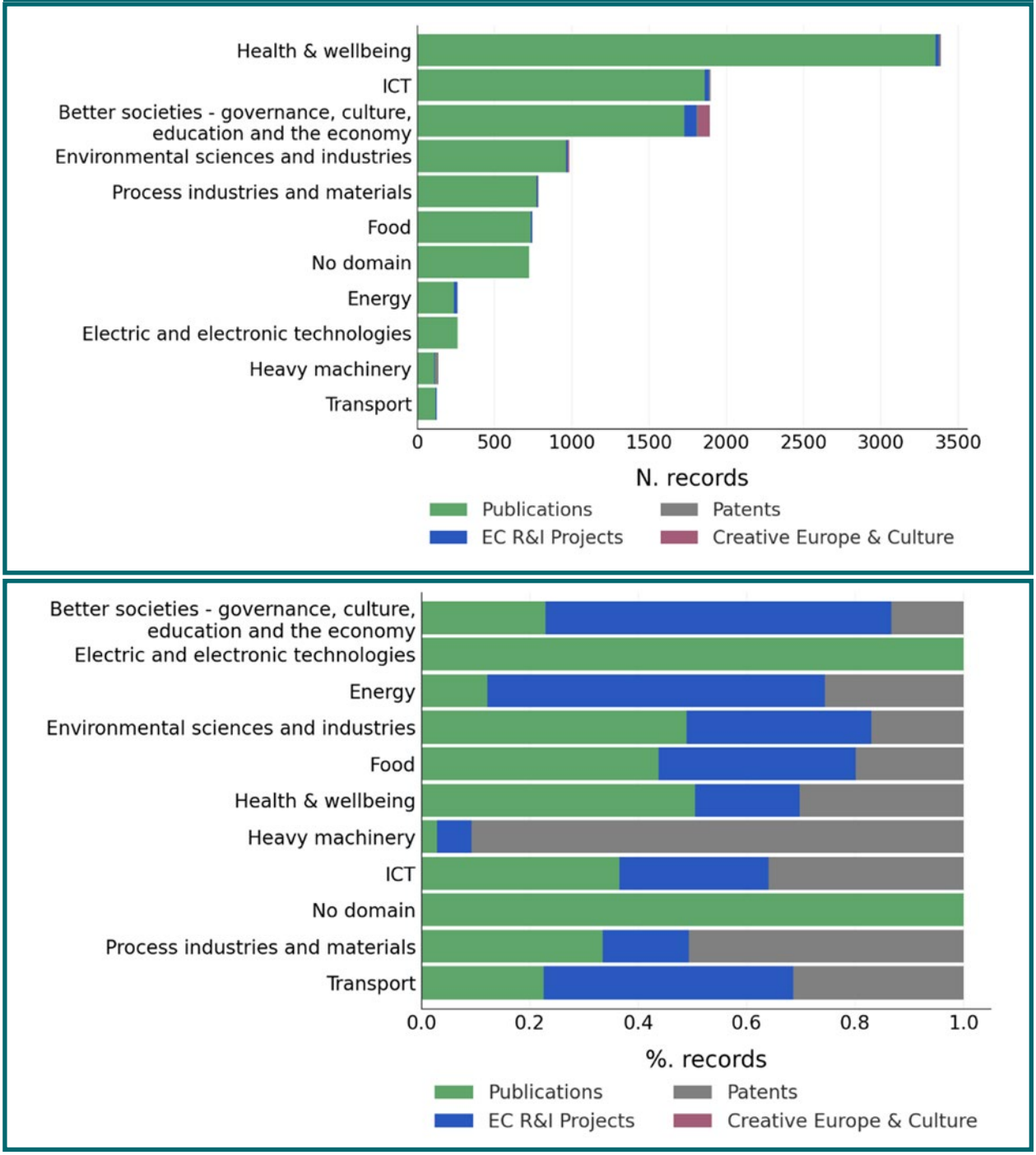
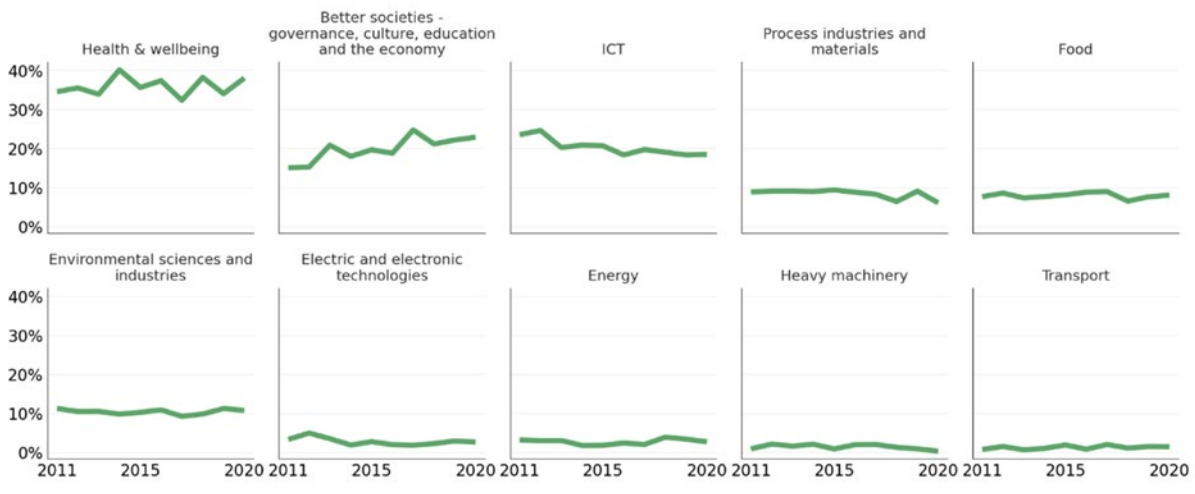


Table 27. North Macedonia - The semantic content of each of the specialisation domains

Domain	Keywords
Better societies - governance, culture, education and the economy	process, policy, social, business, economic, public, management, quality, market, system, strategy, company, service, teacher, educational, human, society, environment, economy, data
Energy	energy, power, system, waste, plant, consumption, source, wind, emission, generation, gas, voltage, electricity, quality, supply, renewable, signal, environmental, reduction, management
Environmental sciences and industries	specie, lake, water, soil, population, data, metal, concentration, river, earthquake, natural, ohrid, frequency, pollution, forest, system, traffic, moss, wave, sediment
Food	oil, acid, extract, seed, compound, plant, fruit, phenolic, concentration, wine, natural, cultivar, genotype, animal, cheese, food, cow, weight, extraction, organic
Health & wellbeing	patient, health, disease, treatment, child, age, clinical, data, cell, care, gene, control, medical, protein, cancer, population, diagnosis, female, therapy, male
Heavy machinery	heat, device, brake, system, lock, temperature, air, pump, pressure, cylinder, vehicle, valve, door, process, spring, fibre, safety, disc, lever, chamber
ICT	system, data, network, service, algorithm, cloud, mobile, web, environment, software, process, image, control, resource, communication, quality, sensor, device, platform, architecture
Process industries and materials	material, temperature, composite, water, film, reaction, polymer, raman, spectroscopy, chemical, ion, band, surface, thermal, acid, glass, layer, carbon, process, compound
Transport	motor, gas, charge, fire, process, magnetic, torque, permanent, magnet, combustion, flux, mass, material, stator, surface, power, resistance, electrical, layer, face
No domain	energy, electron, interaction, device, temperature, collision, magnetic, quantum, charge, frequency, crystal, excitation, molecular, plasma, particle, optical, process, thermal, simulation, society

Figure 70. North Macedonia - Temporal evolution of the preliminary specialisation domains



We then examined international collaborations in scientific publications and in R&D projects funded by European competitive schemes. We did so again by focusing first in the WB extended neighbourhood and then by looking at worldwide collaborations: results relative to the top collaborations are shown in Figure 72 and Figure 73 for the two cases, respectively.

For the case of collaborations in scientific publications within the WB extended neighbourhood, North Macedonia is found to have especially strong ties with Croatia, Bulgaria, and Slovenia. Collaborations with the top 3 partners seem to be consistent across all domains. Bulgaria is the prime collaborator in Process Industries and Materials and Electric/Electronic technologies. When looking at partnerships in European R&D projects, Greece emerges as the main collaborator (with marked relationships in the ICT, Health & wellbeing and Better Societies), followed by Romania and Slovenia.

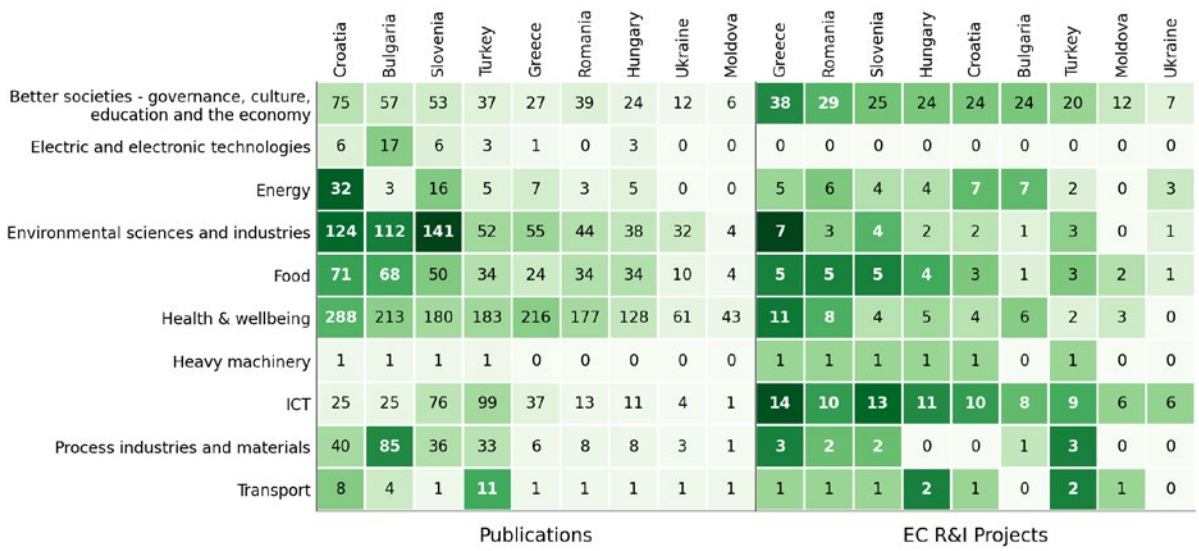
When analysing collaborations beyond the WB extended neighbourhood, interesting patterns emerge for North Macedonia. In the case of publications, at odds with most of the other WB economies, the main two partners do not belong to the geographic neighbourhood of the WB. Specifically, Germany and the United States are found to be the main collaborators of North Macedonia in publications. Significant collaborations with Germany are found in the Health & wellbeing and Environmental Sciences and Technologies domains. Publications co-authored with US institutions are within the Health & wellbeing and ICT domains. The main partner in European R&D projects is found to be Spain, with the United Kingdom and Germany being the second and third most prominent partners having similar participations across all domains.

Figure 71. Top actors across domains for the case of North Macedonia by number of records (all sources)

	Health & wellbeing	ICT	Better societies - governance, culture, education and the economy	Environmental sciences and industries	Process industries and materials	Food	Electric and electronic technologies	Energy	Transport	Heavy machinery
Ss. Cyril and Methodius University of Skopje	2384	1378	905	601	616	519	219	154	77	77
Goce Delcev University of Shtip	256	111	170	158	98	110	49	10	2	25
Macedonian Academy for Sciences and Arts	170	51	46	42	77	25	18	37	1	0
South East European University	45	126	238	19	2	1	7	7	5	3
St. Clement of Ohrid University of Bitola	62	55	75	28	21	52	5	14	15	4
University of Information Science and Technology "St. Paul The Apostle"	23	125	23	13	14	8	7	9	9	0
State University of Tetova	61	18	43	20	9	23	2	1	2	0
Institute of Public Health of the Republic of Macedonia	60	7	22	18	3	22	1	1	0	0
Clinic for Children's Diseases	114	1	1	1	0	1	0	0	0	1
University American College Skopje	23	11	76	1	0	0	1	1	2	0

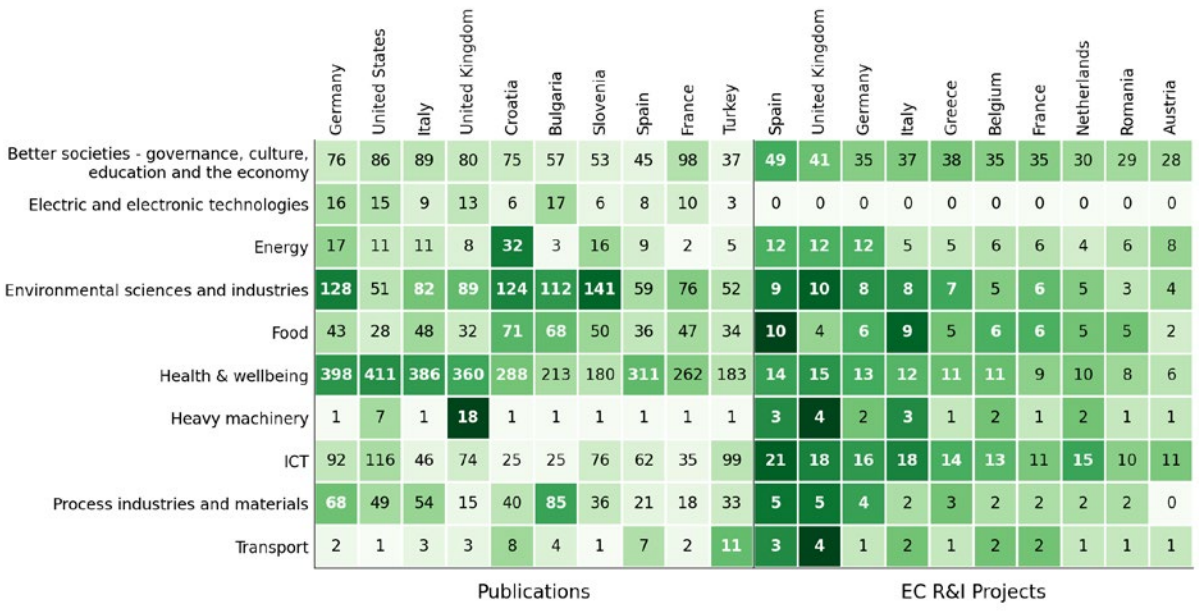
Colour indicates relative contribution, computed column-wise.

Figure 72. North Macedonia international collaborators per domain, presented as number of records (all sources), within the WB extended geographic neighbourhood



Colour indicates collaboration intensity, computed row-wise.

Figure 73. North Macedonia international collaborators per domain, presented as number of records (all sources), worldwide



Colour indicates collaboration intensity, computed row-wise.

4.3.6 Specialisation analysis of Serbia

The scientific output of Serbia in terms of its 73,908 publications during our observation period is mainly driven by Medicine (28,816 publications between 2011-2020) and Engineering (18,458). Computer Science (10,786), Biochemistry and Molecular Biology (10,786), Agricultural and Biological Sciences (10,378), Physics and Astronomy (9,849), Chemistry (9,616), Mathematics (9,209) and Materials Science (9,176) constitute the second tier of subject areas with considerable scientific output.

Of the above (see Figure 74), Serbia is characterised by strong and consistent specialisation (LQ>1.5 for both 5-yr periods) in the following areas in decreasing output:

- Agricultural and Biological Sciences,
- Chemistry,
- Environmental Sciences (7,805),
- Pharmacology, Toxicology and Pharmaceutics (3,970),
- Veterinary Sciences (703).

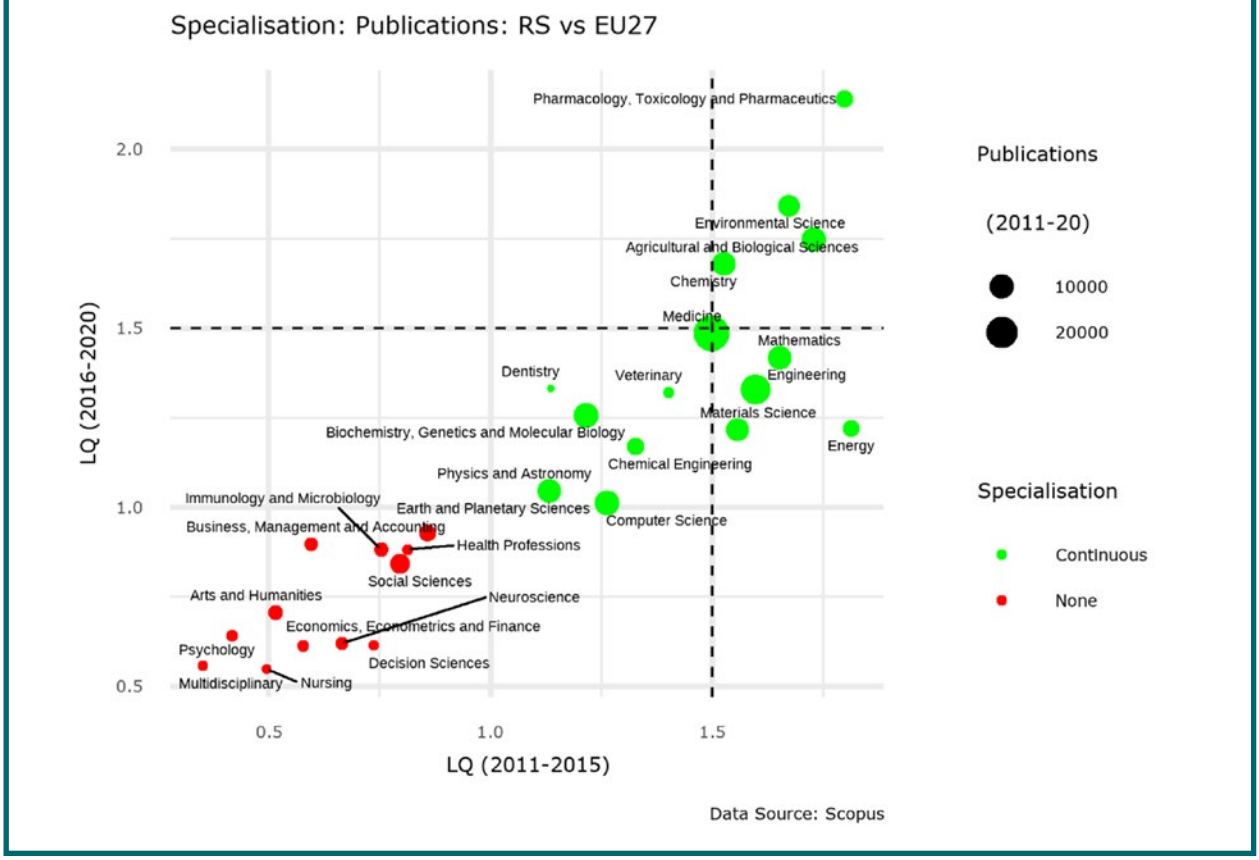
Medicine, Engineering and Mathematics are very close to the specialisation threshold in the second 5-year period. No emerging or declining specialisation has been identified.

Serbia, with 2595 patents between 2010 and 2019, was found to be the strongest performer in terms of EU patents in the region, and its performance clearly influences the overall specialisation figures for Western Balkans. There are 110 IPC codes in our dataset for Serbia, 75 of those having non-zero values in both 5-year intervals.

During the reference period, the patenting performance in Serbia was mainly focused on nine IPC codes: A61 (referenced in 211 patents), Y02 (200), F03 (153), G06 (126), A01 (99), H02 (86), G01 (81), H01 and B65 (78). Of these (see Figure 75),

- F03 Machines or engines for liquids etc,

Figure 74. Specialisation trends for all subject areas calculated over two 5-year periods for Serbia



is strongly specialised with LQ > 1.5 in both 5-yr intervals and has a considerable number of patents associated with it, while

- A63 Sports; Games; Amusements (29),
- E03 Water supply; Sewerage (21),
- F26 Drying (13),

constituting the second tier, in terms of patents, of strong specialisation. Moreover, of the 14 IPC classes where LQ turned greater than one in the second interval,

- E02 Hydraulic engineering; Foundations; Soil-shifting (19)
- G09 Educating; Cryptography; Display; Advertising; Seals (16),
- B42 Bookbinding; Albums; Files; Special Printed Matter (14)
- B27 Working or preserving wood or similar material; Nailing or stapling machines in general (12) and
- B67 Opening or closing bottles, jars or similar containers; Liquid handling (10)

are the strong emerging specialisations that have a considerable number of patents associated with them.

The number of trademarks registered in Serbia during the reference period is 13,001. The most frequent Nice Classes were:

- 5 pharmaceuticals and other preparations for medical or veterinary purposes (2653),
- 35 advertising; business management, organization and administration; office functions (2590),
- 30 foodstuffs of plant origin, except fruits and vegetables, prepared or preserved for consumption, as well as auxiliaries intended for the improvement of the flavour of food (2214),
- 41 Education; providing of training; entertainment; sporting and cultural activities (1632),

Figure 75. Specialisation trends for all IPC codes calculated over two 5-year periods for Serbia

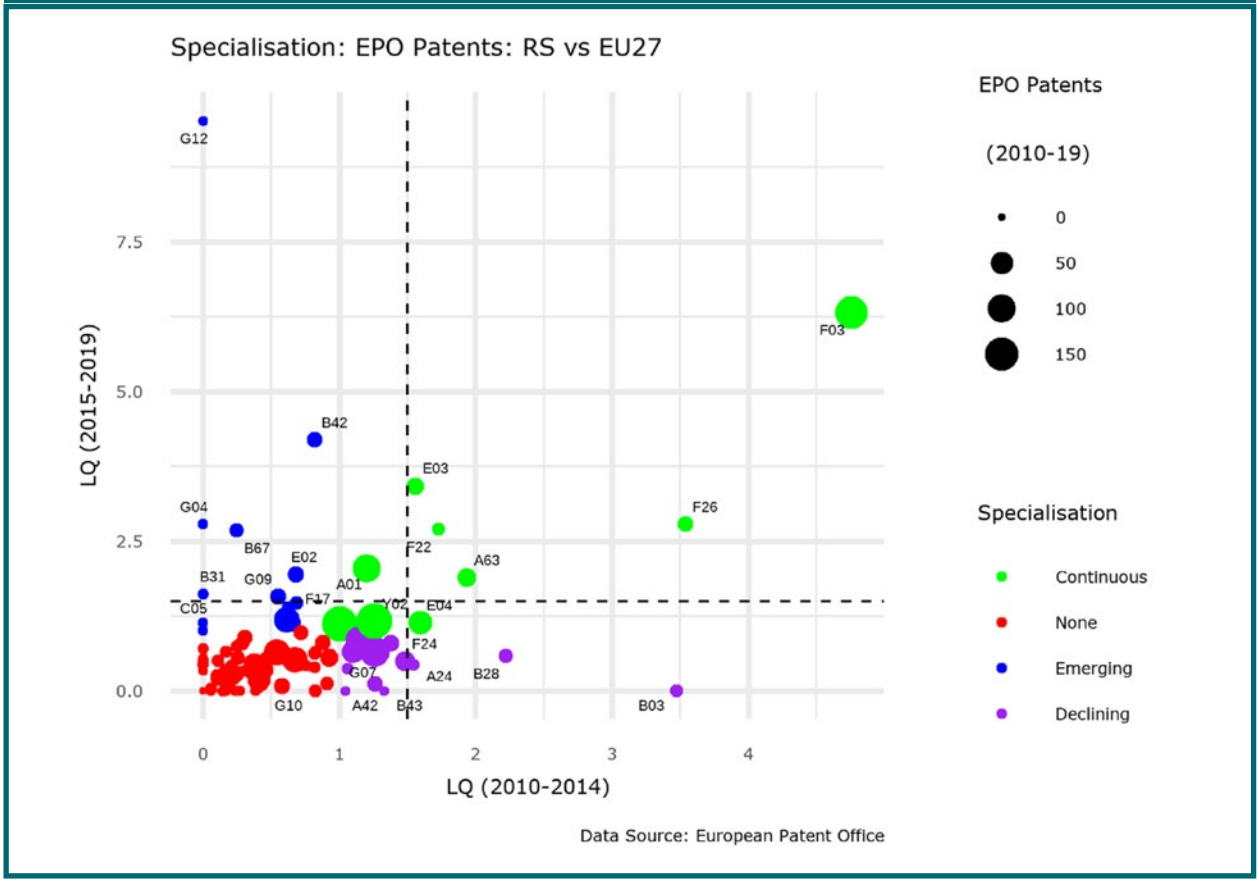
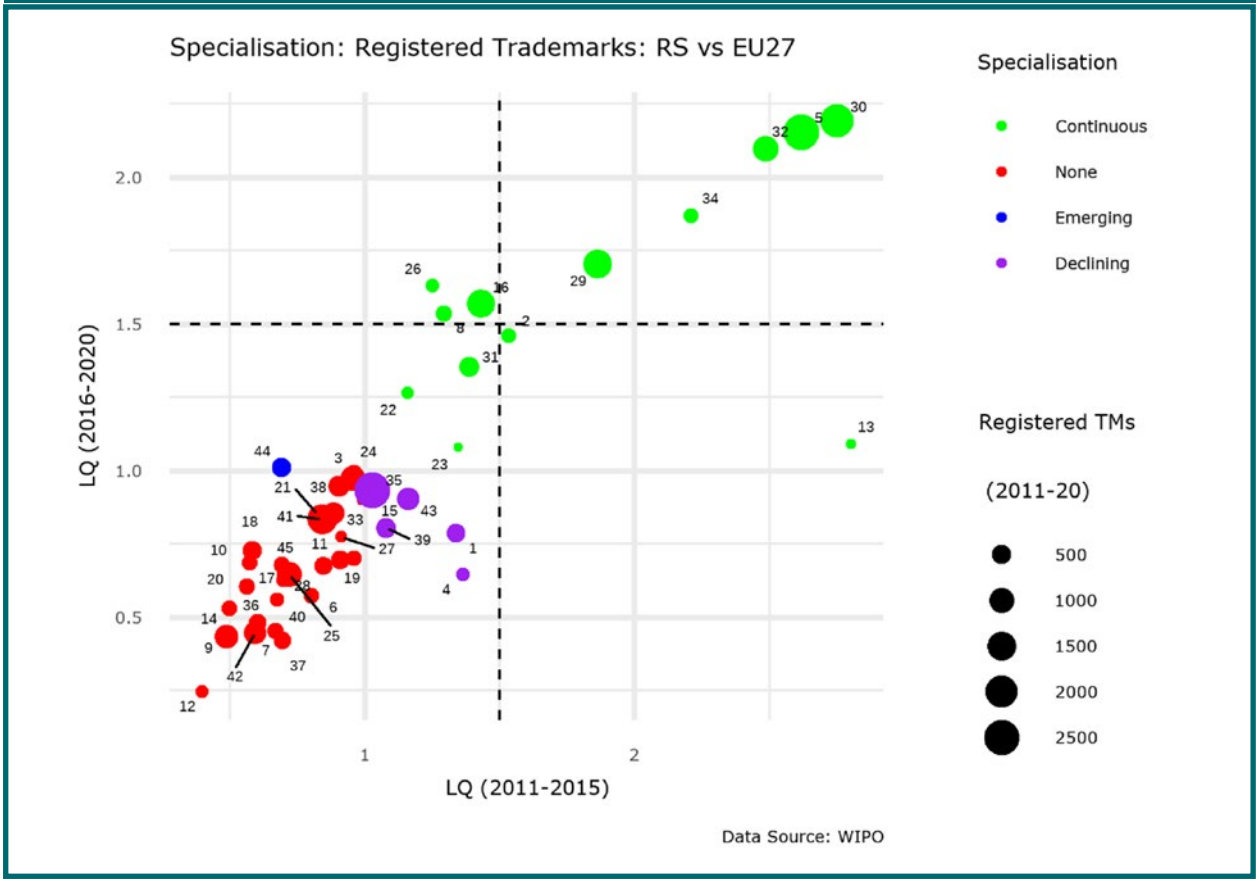


Figure 76. Specialisation trends for all Nice Classification codes calculated over two 5-year periods for Serbia



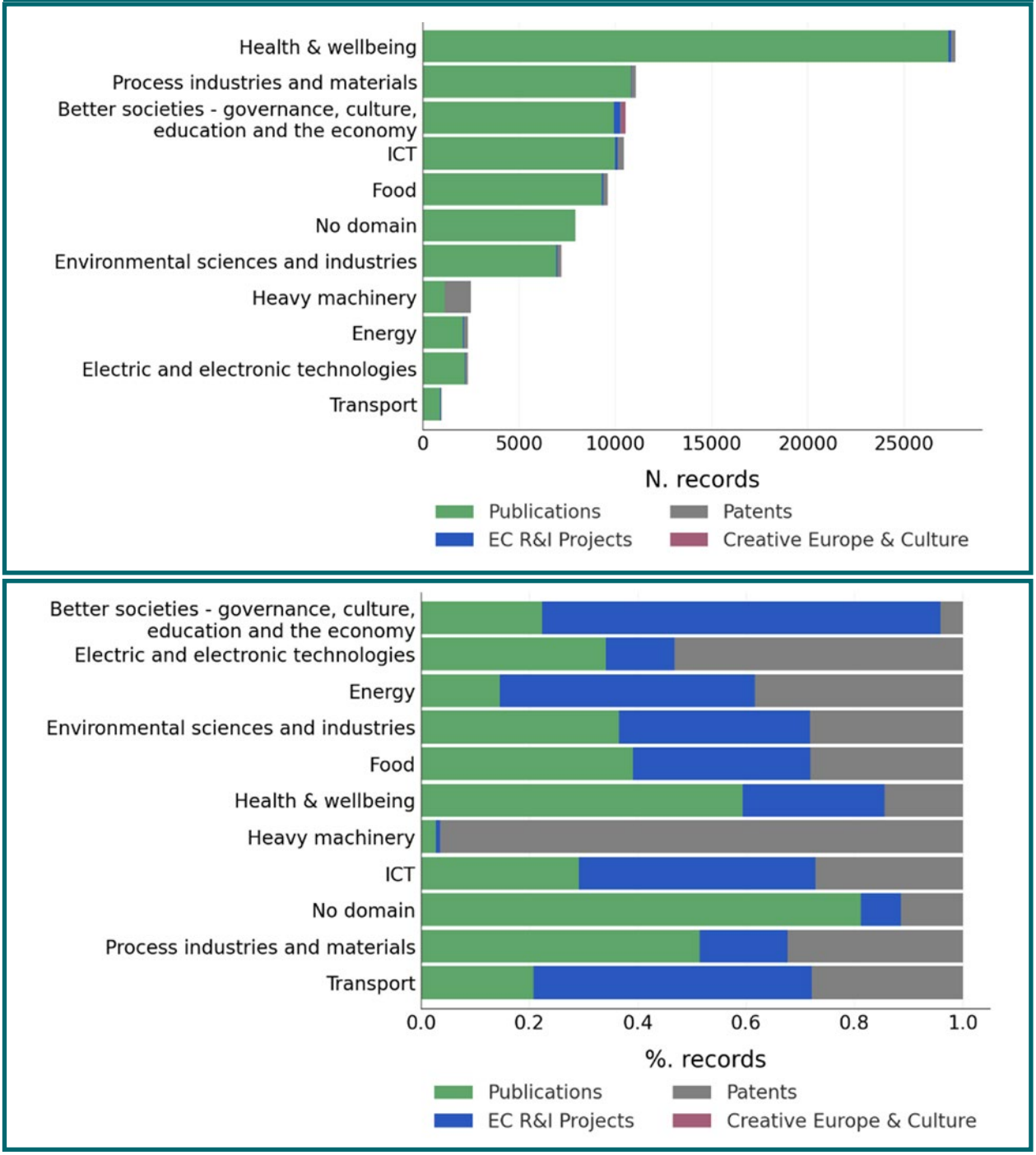
- 29 foodstuffs of animal origin, as well as vegetables and other horticultural comestible products which are prepared or preserved for consumption (1462), and
- 16 paper, cardboard and certain goods made of those materials, as well as office requisites (1367).

Figure 76 presents the specialisation analysis. There are five Nice Classes with strong specialisation in both 5-year intervals, of which three (5, 30, and 29) with a significant number of registered trademarks and two more (32-Non alcoholic beverages and beer, 1124 trademarks; 34-tobacco and articles used for smoking, as well as certain accessories and containers related to their use, 213 trademarks) with a smaller number of trademarks associated with them. Moreover, Nice Class 2 (paints, colorants and preparations used for protection against corrosion) is very close to the specialisation threshold, albeit with a small number of trademarks (214).

The classification of all the records from Serbia into domains provides the counts shown in Figure 77. Since Serbia is by far the largest contributor to the regional output, the Figure coincides in its structure with the regional aggregate previously presented, with the minor exception of the transposition of Energy and Electric/Electronic Technologies.

The same observation as above holds for the semantic content of the specialisation domains for Serbia shown in Table 28. The records that were not associated with any other domain seem to belong to a blend of mathematics, mechanics and electronic technology.

Figure 77. Serbia - Total output per domain and data source-size normalized results



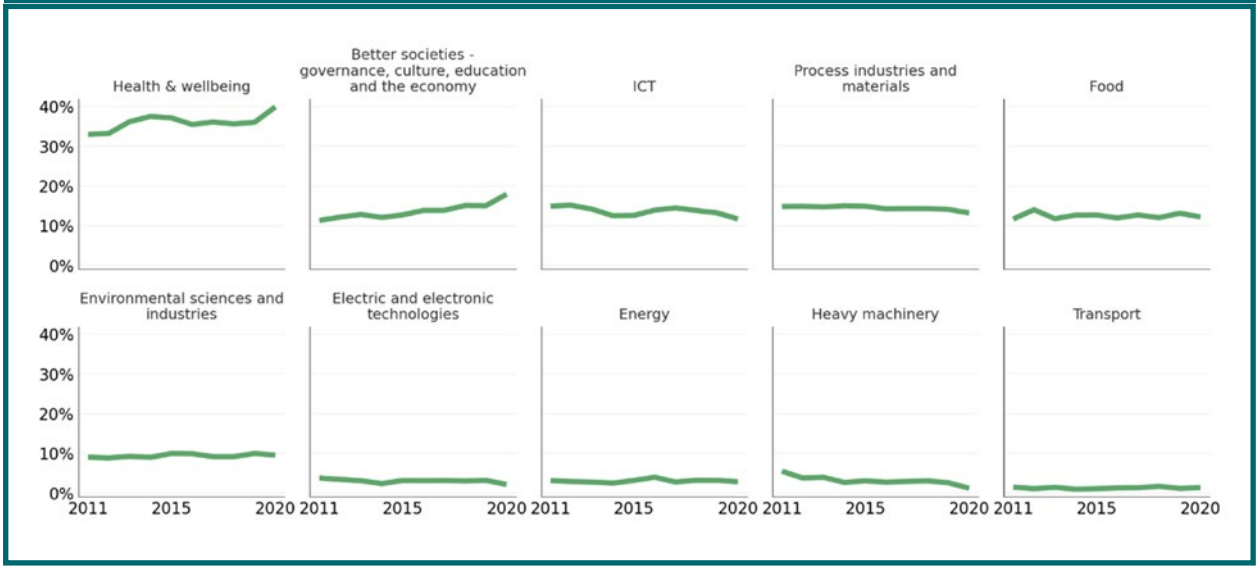
The temporal evolution of the preliminary specialisation domains for Serbia (see Figure 78) is characterised by small variations in the yearly output in all ten domains. Health & Wellbeing and Better Societies appear to be slowly growing over time, while all the remaining domains seem to be stable over time. These suggest that Serbia, in contrast to the other Western Balkan economies, has a solid research base in all ten domains and it is actually increasing its output in (mainly) social sciences--something that seems to be the trend in the entire region.

We finally discuss the analysis we carried out in the case of Serbia to detect the main local actors and international collaborators for each domain. As usual, the analysis for local institutions is performed across all data sources, while for collaborations we specifically look at scientific publications and R&D projects funded by European competitive schemes.

Table 28. Serbia - The semantic content of each of the specialisation domains

Domain	Keywords
Better societies - governance, culture, education and the economy	economic, market, management, social, process, company, policy, public, business, service, strategy, quality, system, financial, teacher, sustainable, environmental, resource, economy, society
Electric and electronic technologies	signal, frequency, voltage, power, sensor, philtre, circuit, system, electrode, noise, antenna, device, electrical, source, simulation, pulse, band, detection, electric, ghz
Energy	energy, heat, power, system, air, plant, temperature, waste, thermal, gas, consumption, water, fuel, source, combustion, electric, ash, coal, flow, heating
Environmental sciences and industries	specie, water, concentration, population, soil, metal, river, plant, data, environmental, natural, copper, sediment, pollution, mineral, source, habitat, chemical, forest, organic
Food	plant, extract, acid, oil, food, product, fruit, antioxidant, seed, strain, compound, leaf, cultivar, quality, concentration, milk, protein, phenolic, wheat, treatment
Health & wellbeing	patient, cell, treatment, disease, age, child, clinical, health, control, data, therapy, blood, woman, population, tumour, diagnosis, cancer, male, tissue, medical
Heavy machinery	device, water, surface, valve, pipe, body, machine, material, piston, herewith, cylinder, assembly, pressure, system, air, construction, housing, metal, wheel, connexion
ICT	system, data, process, network, algorithm, tool, control, software, quality, management, device, service, simulation, environment, computer, neural, engineering, web, prediction, fuzzy
Process industries and materials	temperature, surface, material, process, reaction, acid, particle, concentration, compound, ion, electron, chemical, spectroscopy, energy, powder, water, interaction, microscopy, film, ray
Transport	vehicle, traffic, urban, transport, road, city, temperature, climate, noise, safety, data, accident, railway, car, weather, passenger, system, transportation, speed, pedestrian
No domain	system, space, graph, energy, numerical, nonlinear, optical, beam, mass, quantum, wave, electron, frequency, operator, society, vertex, magnetic, interaction, motion, data

Figure 78. Serbia - Temporal evolution of the preliminary specialisation domains



The analysis of local actors is shown in Figure 79, where we report, for all domains, the top-10 most prolific institutions across the data sources we analysed. We found the most active Serbian institution to be the University of Belgrade, whose specialisation within the Serbian research system is in the domains Process industries and materials, Environmental industries and materials, and Transport. The second most active local actor is the University of Novi Sad, which is specialised in the Food, Better society and ICT domains. The third ranked institution is the University of Niš, specialised in ICT, Electric and electronic technologies and Energy.

We then examined the embeddedness of Serbia into international R&D collaboration networks. We first examined collaborations within the WB extended neighbourhood for the case of scientific publications and EU-funded competitive R&D projects (Figure 80). In this geographical context, we found Serbia to especially collaborate in scientific publications with Croatia, Slovenia and Greece. Notable collaborations with Croatia are detected in the domains Environmental sciences and industries, Heavy machinery and Transport. Significant collaborations with Slovenia are observed in the domains Process Industries and Materials, Environmental sciences and industries and Energy, while with Greece in Health & wellbeing. For what concerns partnerships in European R&D projects, strong ties are observed with Greece, Slovenia, Hungary and Romania, with collaborations mainly in the domains Better societies, ICT and Health & Wellbeing.

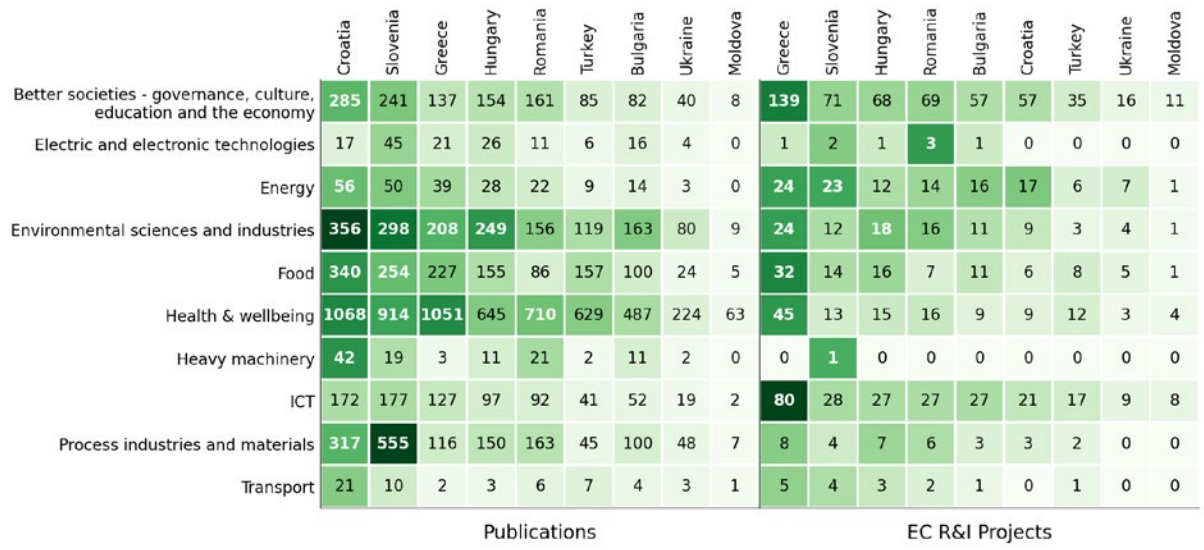
When widening the analysis to the whole world, according to the data sources we used in our study, the main Serbian partner country in publications is the United States: particularly strong ties with the US are found in the domain Health & wellbeing and ICT. The second most frequent collaborator with Serbia in publications appears to be Germany, with whom the most significant domains of partnerships are found to be Environmental sciences and industries, Health & well-

Figure 79. Top actors across domains for the case of Serbia by number of records (all sources)

	Health & wellbeing	Process industries and materials	Food	ICT	Better societies - governance, culture, education and the economy	Environmental sciences and industries	Electric and electronic technologies	Energy	Heavy machinery	Transport
University of Belgrade	11051	5670	4012	3674	3839	3762	987	949	520	523
University of Novi Sad	3493	1941	2455	2590	2305	1435	384	444	257	165
University of Niš	2844	966	942	1517	702	692	347	298	146	65
University of Kragujevac	2435	959	682	494	669	276	106	151	172	44
Institut za Nuklearne Nauke Vinca	992	2062	283	141	86	294	276	169	17	9
Belgrade University School of Medicine	3535	58	152	95	121	37	7	3	7	4
Klinicki Centar Srbije	3267	21	94	48	43	18	2	1	1	4
University of Belgrade, Faculty of Chemistry	659	531	634	26	62	252	157	55	1	2
Institute for Chemistry, Technology and Metallurgy	356	773	321	105	46	224	205	76	3	1
Vojnomedicinska Akademija	1381	98	107	66	110	31	5	13	5	15

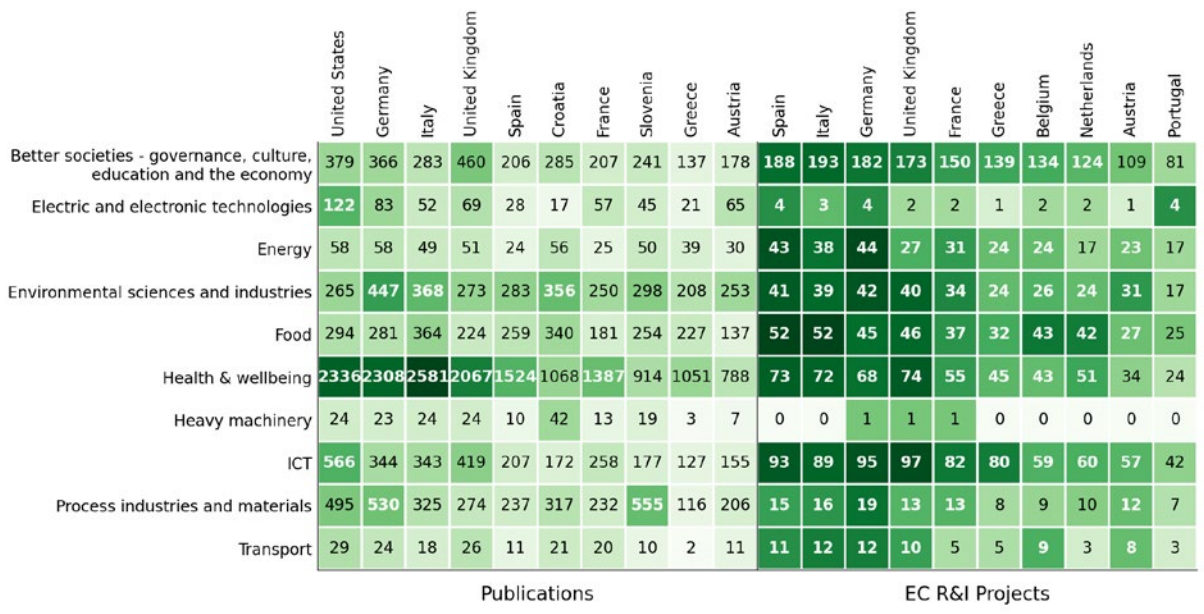
Colour indicates relative contribution, computed column-wise.

Figure 80. Serbian international collaborators per domain, presented as number of records (all sources), within the WB extended geographic neighbourhood



Colour indicates collaboration intensity, computed row-wise.

Figure 81. Serbian international collaborators per domain, presented as number of records (all sources), worldwide



Colour indicates collaboration intensity, computed row-wise.

being, and Process industries and materials. The third main Serbian partner in publications is Italy, with which significant ties are found in the domains Environmental sciences and industries and Health & wellbeing.

Finally, when looking at collaborations in R&D projects funded by European competitive schemes, we found the main Serbian partners to be Spain, Italy, Germany and the United Kingdom. Collaborations with all of them happen especially in the domains Better society, ICT and Health & wellbeing.

CHAPTER

5. Conclusions

The Western Balkans region is striving to enhance its economic development and foster innovation. Historically, the region has faced significant economic and social challenges - including high unemployment, low levels of innovation, and limited access to advanced technologies - however, in recent years, there has been a concerted effort to transition towards a knowledge-based economy and improve the region's overall economic performance.

In this transition the region is attempting a shift from traditional industries towards knowledge-intensive sectors. This shift is driven by the recognition that a knowledge-based economy can lead to higher levels of productivity, innovation, and competitiveness. Furthermore, the emphasis on knowledge-based economic activities has the potential to attract foreign direct investment and promote sustainable growth pathways.

Each economy in the region is currently working on advancing its innovation ecosystem through the adoption of smart specialisation processes.

Smart specialisation offers a strategic approach to address these challenges and unlock the innovation potential in the Western Balkans. By identifying and focusing on key sectors where countries have a comparative advantage, smart specialisation can help in aligning innovation strategies with regional strengths. This approach encourages collaboration among stakeholders including government, academia, businesses, and civil society, fostering a more coordinated and effective innovation ecosystem.

Based on the experience in the last decade at European level, Smart Specialisation processes (both design and implementation) are called upon to play a crucial role in driving the knowledge-based economic transformation of the Western Balkans, mainly through:

- Identification of Strategic Priorities: By identifying and prioritizing specific areas for innovation and research, Smart Specialisation processes help focus resources and investment on sectors that have the greatest potential for growth. This strategic approach ensures that limited resources are used effectively to drive economic transformation in the region.
- Building Innovation Ecosystems: Smart Specialisation processes aim to build vibrant innovation ecosystems by fostering collaboration between research institutions, businesses, and government agencies. This collaborative approach facilitates knowledge exchange, technology transfer, and the exploitation of research findings, essential for speeding up economic transformation.
- Enhancing Competitiveness: Smart Specialisation processes help enhance the competitiveness of the Western Balkans by promoting the development of specialized skills and capabilities in high-value sectors. By focusing on areas where the region has a competitive advantage, Smart Specialisation processes enable the Western Balkans to position itself as a hub for innovation and entrepreneurship.
- Enhancing regional collaboration: Smart Specialisation processes contribute to a conducive environment for investment by showcasing the region's strengths in specific industries. Regional collaboration opportunities in knowledge-intensive sectors can further stimulate economic transformation and contribute to job creation and economic growth.

Smart Specialisation also bears significant political importance, being a part of the EU accession assessment process. As most of the economies from the EU enlargement and neighbourhood region aspire to the EU membership, Smart Specialisation represents a crucial instrument for the process of European integration in the domain of research and innovation. Within the screening process the adoption of the Smart Specialisation model is part of the assessment of the cluster 5 (Competitiveness and inclusive growth) of candi-

date countries in the EU accession process, related namely to chapter 25 – Science and research and chapter 20 – Enterprise and industrial policy (and, to a certain extent, chapter 22 - Regional policy and coordination of structural instruments).

Smart Specialisation enables these countries to shape the mechanism for absorbing and using relevant EU programmes and funds for sustainable growth as they are closing on the path to become fully-fledged EU member states. It is helping to align innovation and industrial policies closer to the EU standards, with overarching priorities for investments identified in an evidence-based manner.

At the same time, the economies are often joining forces and working together in overcoming some of the common challenges through regional networking activities propelled by the Smart Specialisation exercise. This collaboration also includes various EU member states who are sharing their own experiences from the process. In that regard, due to its transformational nature, Smart Specialisation has the ability to increase countries' potential for tackling societal challenge, such as poverty, inclusion, sustainability, circular economy and similar. This is especially important for the economies from the Western Balkans who are experiencing specific difficulties in tackling these challenges while putting efforts into aligning their legislations and capacities with the European Union system.

The Smart Specialisation process has proven to be strengthening the region's economy. The Smart Specialisation is enhancing national capacities for governance of innovation policy implementation and building-up relevant stakeholder networks. The process - starting from mapping potential to development of course of actions - is continuously enlarging, bringing new stakeholders establishing new and stronger links between the stakeholders and strengthening existing and initialising new cooperation activities.

One of the key aspects of smart specialisation is promoting cross-border collaboration to maximize the benefits of regional innovation ecosystems. The Western Balkans economies can explore opportunities for collaboration by sharing resources, knowledge, and best practices as to create a more integrated and competitive regional innovation landscape. Despite the potential benefits, there are still challenges that need to be addressed to facilitate effective collaboration in the region. These challenges include bureaucratic barriers, divergent regulatory frameworks, and the need for enhanced connectivity and infrastructure.

Smart specialisation offers a strategic framework for facilitating a knowledge-based economic transformation and aligning innovation efforts for cross-border collaboration, anyway there are still weaknesses to tackle in order to improve the adoption of smart specialisation processes in the region.

The European Union has been a strong advocate of smart specialisation in the region providing funding and technical assistance, to support its design and implementation processes. The work done so far in the region has proven significant achievements, smart specialisation is at the core of the political agendas for the Western Balkans economies, and the place-based dimension in the smart specialisation processes represent the main ingredient for upcoming opportunities and challenges ahead.

The mapping exercises in the initial stages of the S3 design process have proven to be critical due to the lack and the heterogeneity of data. A timely access to detailed and up to date statistics is key to all quantitative mapping studies and it is crucial to receive adequate support from local stakeholders. It is crucial to collect long enough time series data to allow the analysis of robust trends over time.

For each WB economy, industries with a current and emerging strengths have been analysed and for all the six Western Balkan economies combined, 58 industries have current strengths, 31 industries have emerging strengths, and 8 industries have both current and emerging strengths. At regional level common patterns of economic specialisation (both current and emerging) are

relatively rare, and the WB economies appear to have their own unique pattern of specialisation. Industries that at country level present both current and emerging economic strengths are "Manufacture of parts and accessories for motor vehicles", "Steam and air conditioning supply", "Other specific construction works", "Wholesale of food, beverages and tobacco", "Support activities for transportation", "Restaurants and mobile food service activities", "Wired telecommunications activities", "Other telecommunications activities".

With regards to scientific and technological potential, specialisations have been calculated on Scientific Publications, Patents, Trademarks, European competitive R&I and cultural projects and Clusters and Science Parks. Data sources on science and technology present several differences in terms of classifications and the topic modelling approach has been adopted in order to overcome mismatching. 10 S&T domains of relevance for the WB R&D ecosystem were found that can be grouped into science-oriented (i.e. relatively publication-intense) domains, balanced domains and technology-oriented (i.e. relatively patent-intense) domains, that is, ordered by number of total records: 1. Health and wellbeing is a science-oriented domain, with a large volume of associated records and a slowly growing trend. 2. ICT is a balanced domain, with a large volume of associated records and a rather stable trend. 3. Process industries and materials is a technology-oriented domain, with a large volume of associated records and a stable trend. 4. Better societies - governance, culture, education and the economy is a science-oriented domain, with a medium-sized volume of associated records and growing trend. 5. Food is a technology-oriented domain, with a medium-sized volume of associated records and a stable trend. 6. Environmental sciences and industries is a balanced domain, with a medium-sized volume of associated records and a stable trend. 7. Heavy machinery is a balanced domain, with a low volume of associated records and a slightly declining trend. 8. Energy is a balanced domain, with a low volume of associated records and a stable trend. 9. Electric and electronic technologies is a science-oriented domain, with a low volume of associated records and a stable trend. Finally, 10. Transport is a balanced domain, with a low volume of associated records and a stable trend.

The mismatch between economic and scientific and technological potential is not a surprise, and although common patterns of economic specialisation are relatively rare, WB economies express a certain potential for science & technology collaborations. One of the goal of smart specialisation strategies in the region is to bridge the gap between Industry and Science, as well as enhance the development potential unlocking opportunities and exploiting technological strengths.

Beyond actual collaboration, the taxonomic and semantic analysis of WB economies' S&T specialisation shows, overall, a notable thematic alignment or overlap. The 10 identified preliminary S&T domains are present in all the economies, and although the rank of each domain in each economy may change, the relative distribution of domains is largely similar. This means that whatever the selected S3 domains and niches in each economy are, there will be some peers with overlapping priorities and thus potential for collaboration. A subset of the 10 domains where also identified[27] in 2017 as Priority areas for R&D and innovation spending Expenditure, that is Energy, Environmental sciences and industries, Food, Health and ICT. These seem to be consistent areas of potential regional cooperation and collaboration in science, technology and innovation policy.

For future mapping studies iterative and integrated approach between the quantitative and qualitative mapping by using in several stages the results of one mapping to feed into the other seems to be the proper way to identify potential and inform stakeholders in relevant decision making processes.

It is thus fundamental to complement the analy-

(27) Radosevic, S., Aralica, Z., Raos, J., Assessing Research and Policy Support Needs for Innovation in South East Europe, SmartEIZ Report, 2017.

sis with corresponding work based on local data sources and expert insight. Particularly further analysis should be devoted to specific sectors and disciplines characterised by lower-technological levels, traditional industries, non-technological innovation, creative and design-based industries and locally oriented disciplines. Also, this work could be complemented with analysis on other sources of innovative growth, such as education and training, managerial and organisational improvement, foreign direct investment and private sector modernisation through acquisition of external technology.

Smart specialisation processes are called upon take into account the Common Regional Market perspective and the outward looking potential, firstly considering the opportunities given by the strengthening of the regional value chains, secondly encompassing the alignment of the EU standards and requirements of the European Single Market.

REFERENCES

Cohan, A., Feldman, S., Beltagy, I., Downey, D., & Weld, D. S. *Specter: Document-level representation learning using citation-informed transformers*. 2020

Devlin, J., Chang, M-W., Lee, K., Toutanova, K., *BERT: Pre-training of Deep Bidirectional Transformers for Language Understanding*. NAACL-HLT (1) 2019: 4171-4186

Edwards, J, and Marinelli, E (eds) (2018) *Higher Education for Smart Specialisation: A Handbook* (Version 1.0) Seville: European Commission

Foray, D., *Smart Specialisation: Opportunities and Challenges for Regional Innovation Policy*, Routledge, London, 2015.

Foray, D., David, P.A. and Hall, B., Smart specialisation: From academic idea to political instrument, the surprising career of a concept and the difficulties involved in its implementation. Management of Technology and Entrepreneurship Institute. Working Paper 2011-001, Lausanne, 2011.

Foray, D. and Goenaga Beldarrain, X., *The goals of smart specialisatio*n, S3 Policy Brief Series No 01/2013, EUR 26005 EN, Publications Office of the European Union, Luxembourg, 2013, JRC82213.

Foray, D. and Rainoldi, A., *Smart specialisation programmes and implementation*, JRC Working Papers JRC82224, Joint Research Centre, 2013.

Foray, D., David, P. A., and Hall, B., *Knowledge for Growth: Prospects for science, technology and innovation*, Report EUR 24047, European Union, 2009.

Gianelle, G., Kyriakou, D., McCann, P. and Morgan, K. Smart Specialisation on the move: reflections on six years of implementation and prospects for the future, *Regional Studies*, 2020, 54:10, 1323-1327.

Gianelle, C., Kyriakou, D., Cohen, C. and Przeor, M. (eds), *Implementing Smart Specialisation: A Handbook*, Brussels: European Commission, 2016, EUR 28053 EN, doi:10.2791/53569.

Griffiths, T. L., and Steyvers, M., *Finding scientific topics*, Proc. Natl. Acad. USA, 101,5228-5235 (2004)

Kyriakou, D., Palazuelos Martinez, M., Perianez-Forte, I., and Rainoldi, A. (eds.), *Governing Smart Specialisation (1st ed.)*, Routledge, London, 2016.

Maaten, L., Hinton, G., Visualizing Data using T-SNE. Journal of Machine Learning Research 9 (2008) 2579-2605

Macqueen, J., Some methods for classification and analysis of multivariate observations. Proceedings of the Fifth Berkeley Symposium on Mathematical Statistics and Probability. Volume 1: Statistics Vol. 5.1 • 1. 1967

Marinelli, E., and Perianez Forte, I., *Smart Specialisation at work: The entrepreneurial discovery as a continuous process*, S3 Working Paper Series No. 12/2017, EUR 28838 EN, Publications Office of the European Union, Luxembourg, 2017, ISBN 978-92-79-74377-1, doi:10.2760/514714, JRC108571.

Matusiak, M. and Kleibrink, A., (eds), *Supporting an Innovation Agenda for the Western Balkans - Tools and Methodologies*, EUR 29179 EN, Publications Office of the European Union, Luxembourg, 2018, ISBN 978-92-79-81870-7, doi:10.2760/48162, JRC111430.

Matusiak, M., Radovanovic, N., Nauwelaers, C., Kaczkowska, K. and Kramer, J., *Smart Specialisation implementation framework for the EU Enlargement and Neighbourhood Region*, EUR 31018 EN, Publications Office of the European Union, Luxembourg, 2022, ISBN 978-92-76-49360-0, doi:10.2760/056593, JRC128028.

Perianez Forte, I. and Wilson, J., *Assessing Smart Specialisation: The Entrepreneurial Discovery Process*, EUR 30709 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-37823-5, doi:10.2760/559139, JRC124405.

Radosevic, S., Aralica, Z., Raos, J., Assessing Research and Policy Support Needs for Innovation in South East Europe, Smart EIZ Report, 2017.

Radovanovic, N. and Bole, D., *Guidelines for the stakeholder dialogue in the process of designing and implementing Smart Specialisation strategies in the EU Enlargement and Neighbourhood Region*, Publications Office of the European Union, Luxembourg, 2023 (upcoming).

Radovanovic, N. and Gerussi E., *Challenges in Governance of Smart Specialisation in South East Europe*, Smart Specialisation JRC Policy Insights, JRC120642, May 2020.

Radovanovic, N. and Benner, M., *Smart Specialisation and the Wider Innovation Policy Context in the Western Balkans*, EUR 29918 EN, Publications Office of the European Union, Luxembourg, 2019, ISBN 978-92-76-12550-1, doi:10.2760/380898, JRC118199.

Schubert, A., Braun, T., Relative indicators and relational charts for comparative assessment of publication output and citation impact, Scientometrics, 9, 281–291 (1986).

LIST OF ABBREVIATIONS AND DEFINITIONS

AL	Albania
ASJC	All Science Journal Classification
B2B	Business-to-business
B2C	Business-to-consumer
BIH	Bosnia and Herzegovina
CAGR	compound annual growth rate
CM	critical mass
E&I	Economic and innovation
E&IA	Enlargement & Integration Action
EC	European Commission
EDP	entrepreneurial discovery process
E&N	Enlargement and Neighbourhood
EPO	European Patent Office
EU	European Union
FP7	Framework Programme 7
GDP	Gross Domestic Product
GVC	Global Value Chain
H2020	Horizon2020
ICT	Information and communication technology
ICT	Information and communications technologies
ILO	International Labour Organisation
INDSTAT	Industrial statistics database
IPA	Instruments for Pre accession Assistance
IPC	international patent classification
IPR	intellectual property rights
IT	Information technology
JRC	Joint Research Centre
LDA	Latent Dirichlet Allocation algorithm
LQ	Location quotient

MK	North Macedonia
MN	Montenegro
NABS	Classification of socio-economic objectives
NACE	Nomenclature Générale des Activités Économiques dans les Communautés Européennes
NCI	Normalised citation impact
NDICI	Neighbourhood, Development and International Cooperation Instrument
NICE	International classification of good and services
RIS3	Research and Innovation Strategies for Smart Specialisation
R&D	Research and Development
R&D&I	Research, Development and Innovation
R&I	Research and Innovation
S&T	Scientific and Technological
S3	Smart Specialisation Strategies
SI	Specialisation Index
SITC	Standard International Trade Classification
SMEs	Small Medium Enterprises
SR	Serbia
STI	Science, Technology, Innovation
SWOT	Strengths, Weaknesses, Opportunities and Threats
USPTO	United States Patent and Trademark Office
WB	Western Balkans
WB6	Six economies of the Western Balkans (Albania, Bosnia and Herzegovina, Kosovo, Montenegro, North Macedonia, Serbia)
WEF	World Economic Forum
WIPO	World Intellectual Property Organisation
XK	Kosovo

LIST OF BOXES

LIST OF FIGURES

LIST OF TABLES

Annex 1. Smart Specialisation framework for EU Enlargement and Neighbourhood region

Phase	No.	Stage of the process	Explanation	Role of national/regional administration	Research input (local and international experts)
INSTITUTIONAL CAPACITY BUILDING	**1**	**Decision to start smart specialisation process**			
	1.1	**Formal request**	A country or a region has to formally express interest in developing Smart Specialisation strategy. The support is given on the basis of readiness assessment	Prepare and send the request	Not needed
	1.2	**Analysis of context – country specific conditions**	The context analysis should provide basic information concerning the administrative and political issues and the level of development of a country/region	Providing information	
	1.3	**Discussion with public administration**	Discussion with public administration is a technical step that allows to determine mode of cooperation and a preliminary roadmap	Identifying appropriate representatives	Not needed
	1.4	**Awareness event**	Awareness event can be targeted to internal or external stakeholders (depending on needs) and helps explaining the smart specialisation approach and its benefits	Organization of logistics and inviting participants	Can support the event
	1.5	**Establishment of national/ regional S3 team(s)**	National/regional team should include: • the representatives of all ministries/departments whose mandate is regional policy, scientific and innovation policy, economic development, education and skills development • representatives of national statistical offices • representatives of national patent/IP offices • external stakeholders (representatives of business and research sector, business intermediaries, NGOs)	Appointment of the team	Can be participants
	1.6	**Participation in S3 training**	The training is organized by the JRC in collaboration with other relevant EC institutions where possible, according to needs and prepares the national and regional S3 teams to manage and organize the strategy development process	Sending appropriate representation	Not needed
	1.7.	**Agreement with the JRC**	Agreement with JRC includes a roadmap, mutual obligations and criteria for common work and assessment of final document	Co-designing and formalising the agreement	
INSTITUTIONAL CAPACITY BUILDING	**2**	**Analysis of strategic mandates**			
	2.1	**Overview of existing policies and priorities relevant for S3**	The purpose of this stage is to identify the existing economic, scientific or innovation priorities and domains present in strategies and policies together with instruments for their implementation	Providing the overview of the strategies, policies and instruments	Not needed
	2.2	**Decision of place of S3 in the strategic framework**	The national/regional S3 team should decide how smart specialisation strategy will be adopted and how it will be coordinated with other relevant policies	Adopting a decision	
	2.3	**Decision on the national/ regional dimension of S3**	Depending on the size of the country and existing subnational administrative structure, a decision should be taken on the territorial dimension of S3 – it is always recommended to have a regional approach, if possible.	Adopting a decision	

Phase	No.	Stage of the process	Explanation	Role of national/regional administration	Research input (local and international experts)
DIAGNOSIS (MAPPING EXERCISE)	**3**	**Analysis of existing economic, scientific and innovation potential (quantitative)**			
	3.1	**Provision of statistical data**	For quantitative mapping following data is needed: • industrial subsectors (NACE rev. 2, 3 or 4 digit, 5-10 year period): - Employment - Value added - Number of companies by size - Wages - Share of innovative companies (CIS indicators) • product groups or subsectors: - Exports - areas of science - Scientific publications - Patents • education and skills (if available): - Employment by occupation and industrial subsectors - (ISCO-08, 3 or 4 digit; NACE rev. 2, 3 or 4 digit, 5-10 year period) - Employment by the highest education level achieved and industrial subsectors (ISCED; NACE rev. 2, 3 or 4 digit, 5-10 year period) - Number of students/graduates by education levels and field of study - STEM graduates The data should be provided by national statistical office, national patent/IPR office and other relevant institutions	Arranging the data provision	Quantitative mapping on the basis of: • Statistical data • Literature • International databases • Representative surveys (combination of sources to be agreed)
	3.2	**Mapping of economic, innovation and scientific potential**	Mapping is a statistical analysis of main strengths and specialisations in terms of economic, innovation and scientific potential, encompassing also other related drivers, such as e.g. human capital capacities. Its objective is to indicate preliminary areas of smart specialisation based on the expert assessment of matches between the three types of potential. JRC provides relevant methodology for this exercise.	Supporting data collection, providing additional sources and consulting the process	Performing the analysis
	3.3	**Creation of the local expert team**	Local expert team cooperates with the international expert in order to understand the methodology and help adjust it to the country profile and needs. It is made of scientists with relevant expertise in economics, economic geography, scientometrics and patent analyses.	Identifying and mobilising local experts	Cooperation between local and international experts
	3.4	**Additional analyses**	Additional analyses can provide better understanding of the priority domains. They can include international benchmarking, analysis of value chains, revealed comparative advantage, sector skills studies on future needs, relevant education indicators and other relevant issues	Identifying existing analyses that can be useful or commissioning new ones	Performing the analyses
	3.5	**Consultation with stakeholders**	The results of the mapping exercise must be consulted with internal and external stakeholders. Internal stakeholders include all the ministries and departments that have competences concerning the analysed potentials. External stakeholders are representatives of business, education and training institutions, academia and NGOs relevant from the point of view of the preliminary smart specialisation domains.	Organization of the consultations and invitation of appropriate stakeholders	Should be participants
	3.6	**Publication of the report**	The smart specialisation process has to be transparent. The mapping report should be made available to the public minimum in electronic version and made available (in English) on the S3 Platform portal. If necessary, it should also be translated to the local language.	On-line publication of the report and providing an electronic version for S3 Platform	Not needed
	4	**In-depth analysis of priority domains (qualitative)**			
	4.1	**Expert interpretation of the results of mapping exercise**	The qualitative interpretation of the results is necessary to overcome the constraints of existing industry and scientific classifications and uncover real sectors and value chains they represent. Specific value chains for priority domains have to be identified together with challenges and trends. It can be done on the basis of in-depth interviews, focus groups or case studies with experts representing the key and most innovative companies, sectorial experts and researchers cooperating with business. If interviews are considered, minimum 10-15 interviews with key organisations should be conducted per preliminary priority domain. The result of this analysis is the better definition of preliminary priority domains for the purposes of entrepreneurial discovery process.	Organization of the qualitative analysis	Performing the analysis
	4.2	**Publication of the report**	The smart specialisation process has to be transparent. The qualitative report should be made available to the public minimum in electronic version and made available (in English) on the S3 Platform portal. If necessary it should also be translated to the local language. Mapping report and qualitative report can be published together.	On-line publication of the report and providing an electronic version for S3 Platform	Not needed
	4.3	**Decision on priority domains for EDP**	After the quantitative a qualitative analysis, a common panel should be organized involving national smart specialisation team, experts and JRC representatives in order to establish the priority domains for the entrepreneurial discovery process.	Organization of the panel and inviting experts	Should be participants

Phase	No.	Stage of the process	Explanation	Role of national/regional administration	Research input (local and international experts)
STAKEHOLDER DIALOGUE	**5**	**Entrepreneurial discovery process (EDP)**			
	5.1	**EDP training**	Training of EDP coordinators and facilitators is organized by JRC and designed to prepare the teams of national coordinators and facilitators (moderators) of the EDP workshops. The coordinators represent National Smart Specialisation Teams and facilitators are experienced moderators with business experience.	Appointing and mobilising coordinators and moderators	Not needed
	5.2	**Identification of stakeholders for each priority domain**	For each priority domain, relevant stakeholders need to be identified. They include key players in value chains, innovative companies, cluster members, chambers of commerce and other business associations, education providers, researchers and organizations from related fields. They can be identified by desk research and interviews or a more objective network analysis of scientific and innovation cooperation.	Coordination of the identification exercise	Can assist with the analysis
	5.3	**EDP plan and working rules**	Before the EDP is formally launched, clear rules should be defined for participation and decision-making process. They need to be communicated to the members of working groups together with the invitation or at the first meeting. As the EDP is a series of workshops, often organized in different regions, a plan has to be developed and communicated to the participants.	Definition and communication of the working rules and plan	Not needed
	5.4	**Definition of EDP working groups**	The working groups should well represent the value chains identified in qualitative mapping for each priority domain and include quadruple helix stakeholders, i.e. representatives of business, academic, governmental and civil sectors relevant to the priority domains. Representatives of companies should constitute minimum 50% of participants of each working group.	Inviting and mobilising the working groups members	Not needed
	5.4	**EDP workshops**	A series of workshops should be organized for each priority domain. The deliverables of the EDP workshops are: • EDP kick-off conference presenting all priority domains • SWOT analysis • Vision for the future and final name of priority domain • Policy mix (objectives and actions with indicators)	Organization of the workshops	Should be participants
	5.5	**EDP input for S3**	The results of the EDP process should be the main input for the smart specialisation strategy. The coordinators and facilitators should cooperate to provide written conclusions from each workshop and consult them with the participants.	Coordination of the delivery of written input	Not needed
INSTITUTIONAL CAPACITY FOR IMPLEMENTATION	**6**	**Design of monitoring, implementation and financing system**			
	6.1	**Monitoring guidance**	Monitoring guidance is given during a meeting of National Smart Specialisation Team with JRC. It concerns the rules for the design of indicators and reporting.	Arranging a guidance meeting	Can support the process
	6.2	**Design of monitoring system**	The National Smart Specialisation Team prepares the indicators and designs the monitoring system according to received guidance.	Design of the monitoring system for S3	Can support the process
	6.3	**Implementation and financing guidance**	Implementation and financing guidance is given during a meeting of National Smart Specialisation Team with JRC. It concerns the organizational and financing rules for effective implementation.	Arranging a guidance meeting	Not needed
	6.4	**Design of implementation system**	The National Smart Specialisation Team prepares the organizational and financing scheme for S3 according to received guidance.	Design of the implementation system for S3	Not needed
FINAL STRATEGY	**7**	**Preparation of S3 strategy document**			
	7.1	**Preparation of draft S3 strategy**	The National Smart Specialisation Team prepares the draft of S3 strategy including: the results of mapping exercise, description and justification of priority domains, SWOT analysis, vision for the future, strategic goals, operational objectives and action plans, monitoring and evaluation system and implementation system including financing sources.	Preparation of draft S3 strategy	Can support the process
	7.2	**Consultation with stakeholders**	The final draft has to be consulted with the EDP working groups and wider group of stakeholders of regional or national innovation systems. It can be done during a final conference.	Organization of consultation process	Can support the process
	7.3	**Formal and EC approval**	The relevant authorities formally approve the S3 strategy. The National Smart Specialisation Team requests EC approval of the S3 strategy. Implementation should start shortly after that.	Launching the S3 strategy approval process	Not needed

Annex 2. Steps taken to build the WB6 NACE 3-digit database and results on industries with current and emerging strengths

Cross comparative analyses among all WB6 economies requires strong data programmes to process data as efficient as possible, due to the increasing availability of data and demand to cluster groups of economies according to their economic and geographical proximity. The manual within this annex provides a short how-to-guide to calculate the economic potential of industries in WB economies.

STATA has been used for both the 2018 and 2020 studies, but the how-to-guide is generalized in such a way that it can be applied to other economies as well. The diagram below shows the basic imputations necessary for measuring current specialisation and rate of change in specialisation described in the report. Estimated values are calculated according to the methodology explained under the Descriptive Statistics section in the report. Total employment and turnover by economy by year have then been calculated, which allows for measuring individual WB economy performance.

STEP 1

- Convert numeric indicators stored as strings to numbers
- Create an indicator related to year, which is needed for turning the Excel format of the columns into time-serie columns
- Run a code book to check whether the code has executed the assignment of labels and indicator creation correctly
- Store this file seperately, as it will serve as a basic file to return to when imputations further down the steps are performed incorrectly

STEP 2

- Sort indicators according to their NACE Code. Values without a NACE code are dropped from the data set
- Turn the Excel format of the collumns into time-serie collumns and store it under a new file name
- Calculate the unestimated size and frequency of missing and nonmissing values by employment and turnover, which allow for an overview on the number of non-estimated values in the dataset
- Estimate values of employment and turnover data and store it under a new file name as well (see *Descriptive Statistics section*)
- Calculate the estimated size and frequency of missing and nonmissing values by employment and turnover, which allow for an overview on the number of estimated values and a comparison against the non-estimated values

STEP 3

- Create a code that calculates WB6 economy total by year
- Create a benchmark economy which outperforms other economies on employment and/or turnover over all the analysed years. Within this report, the aggregate of the WB6 economies has been set as the benchmark for both employment and turnover over 2012-2019

Below the full results from the WB6 NACE 3-digit database are summarized.

Overview Industries Current Strength								
			AL	BA	KV	ME	MK	RS
		58	8	12	10	11	8	9
11	Growing of non-perennial crops	1	0	0	0	0	0	1
21	Silviculture and other forestry activities	1	0	1	0	0	0	0
31	Fishing	1	1	0	0	0	0	0
52	Mining of lignite	1	0	1	0	0	0	0
61	Extraction of crude petroleum	1	1	0	0	0	0	0
72	Mining of non-ferrous metal ores	1	0	0	1	0	0	0
89	Mining and quarrying n.e.c.	1	1	0	0	0	0	0
103	Processing and preserving of fruit and vegetables	1	0	0	0	0	0	1
141	Manufacture of wearing apparel, except fur apparel	1	0	0	0	0	1	0
161	Sawmilling and planing of wood	1	0	1	0	0	0	0
162	Manufacture of products of wood, cork, straw and plaiting materials	1	0	1	0	0	0	0
221	Manufacture of rubber products	1	0	0	0	0	0	1
235	Manufacture of cement, lime and plaster	1	0	0	1	0	0	0
236	Manufacture of articles of concrete, cement and plaster	1	0	0	1	0	0	0
241	Manufacture of basic iron and steel and of ferro-alloys	1	0	1	0	0	0	0
251	Manufacture of structural metal products	1	0	1	0	0	0	0
293	Manufacture of parts and accessories for motor vehicles	1	0	0	0	0	1	0
351	Electric power generation, transmission and distribution	1	0	0	1	0	0	0
353	Steam and air conditioning supply	2	0	0	1	0	0	1
433	Building completion and finishing	1	0	0	0	0	1	0
439	Other specialised construction activities	1	1	0	0	0	0	0
452	Maintenance and repair of motor vehicles	1	0	0	0	1	0	0
461	Wholesale on a fee or contract basis	3	0	1	1	1	0	0
463	Wholesale of food, beverages and tobacco	1	0	0	1	0	0	0

Overview Industries Current Strength								
			AL	BA	KV	ME	MK	RS
465	Wholesale of information and communication equipment	1	1	0	0	0	0	0
466	Wholesale of other machinery, equipment and supplies	1	0	0	0	0	0	1
467	Other specialised wholesale	1	0	1	0	0	0	0
469	Non-specialised wholesale trade	2	1	0	0	1	0	0
472	Retail sale of food, beverages and tobacco in specialised stores	1	0	1	0	0	0	0
475	Retail sale of other household equipment in specialised stores	2	0	0	0	1	1	0
477	Retail sale of other goods in specialised stores	2	0	0	0	1	1	0
494	Freight transport by road and removal services	1	0	0	0	0	1	0
511	Passenger air transport	1	0	0	0	1	0	0
522	Support activities for transportation	1	0	0	0	0	0	1
551	Hotels and similar accommodation	1	0	0	0	1	0	0
561	Restaurants and mobile food service activities	2	0	0	0	1	1	0
611	Wired telecommunications activities	2	0	0	1	0	0	1
619	Other telecommunications activities	2	0	1	0	1	0	0
620	Computer programming, consultancy and related activities	1	0	0	0	0	0	1
641	Monetary intermediation	1	1	0	0	0	0	0
642	Activities of holding companies	1	0	0	1	0	0	0
649	Other financial service activities, except insurance and pension funding	2	0	0	1	1	0	0
683	Real estate activities on a fee or contract basis	1	1	0	0	0	0	0
702	Management consultancy activities	1	0	0	0	0	0	1
791	Travel agency and tour operator activities	1	0	0	0	1	0	0
861	Hospital activities	1	0	1	0	0	0	0
862	Medical and dental practice activities	2	0	1	0	0	1	0

Overview Industries Emerging Strength								
			AL	BA	KV	ME	MK	RS
		31	3	6	5	5	6	6
101	Processing and preserving of meat and production of meat products	1	0	1	0	0	0	0
108	Manufacture of other food products	2	0	1	0	0	1	0
222	Manufacture of plastic products	1	0	1	0	0	0	0
251	Manufacture of structural metal products	1	0	0	0	0	0	1
259	Manufacture of other fabricated metal products	2	0	1	0	0	1	0
293	Manufacture of parts and accessories for motor vehicles	1	0	0	0	0	1	0
351	Electric power generation, transmission and distribution	1	0	0	0	1	0	0
353	Steam and air conditioning supply	1	0	0	1	0	0	0
412	Construction of residential and non-residential buildings	2	0	0	0	1	0	1
421	Construction of roads and railways	1	0	0	0	1	0	0
432	Electrical, plumbing and other construction installation activities	1	0	0	0	1	0	0
439	Other specialised construction activities	1	1	0	0	0	0	0
463	Wholesale of food, beverages and tobacco	1	0	0	1	0	0	0
464	Wholesale of household goods	1	1	0	0	0	0	0
467	Other specialised wholesale	2	0	0	0	1	1	0
472	Retail sale of food, beverages and tobacco in specialised stores	1	0	0	1	0	0	0
475	Retail sale of other household equipment in specialised stores	1	0	0	0	0	0	1
477	Retail sale of other goods in specialised stores	1	0	0	0	0	0	1
494	Freight transport by road and removal services	1	0	0	0	0	0	1
522	Support activities for transportation	1	0	0	0	0	0	1
561	Restaurants and mobile food service activities	1	0	0	0	0	1	0
611	Wired telecommunications activities	1	0	0	1	0	0	0
619	Other telecommunications activities	1	0	1	0	0	0	0
641	Monetary intermediation	2	0	1	1	0	0	0

Overview Industries Emerging Strength								
			AL	BA	KV	ME	MK	RS
711	Architectural and engineering activities and related technical consultancy	1	1	0	0	0	0	0
920	Gambling and betting activities	1	0	0	0	0	1	0

Annex 3. Mapping science and technology potential. Methodological process

It must be highlighted that, for the WB regions and for each economy, preliminary specialisation domains or preliminary mapping of scientific potentials towards economic potentials are lacking. Therefore, the approach entailed a necessary initial effort devoted to the identification of potential domains of interest and to the classification of all research and innovations outputs within those domains.

Given the above considerations, the approach followed 4 sequential steps to analyse the data, exploring, characterising and classifying R&D&I activities of the WB economies; both according to taxonomies chosen qualitatively ad-hoc and to topics emerging from the data itself, independently from the NACE sector codes. Finally, all results were qualitatively mapped towards NACE sectors, so that all the S&T potentials identified could be readily translated into economic potentials as expressed by traditional economic statistics.

The four sequential steps of the methodology are:

- **First step:** Initial specialisation analysis with the data sources' original taxonomies.
- **Second step:** Independently from the preliminary economic domains identified in the documentation, the second step identified emergent specialisation topics from the titles and text abstracts or descriptions of the records (publications, projects, patents, etc.). After a natural language pre-process step, Topic modelling, a machine learning technique, was implemented through the Latent Dirichlet Allocation algorithm, returning a collection of topics that emerged from the textual content of the analysed documents. The topics are, in practice, a collection of keywords that tend to appear together in different documents and that represent coherent domains.
- **Third step:** A qualitative manual alignment was performed between the statistics obtained at the first step, the topics obtained at the second step and the current & emerging strengths identified in the report Mapping of the economic potential in Western Balkan countries, prepared by UNU-MERIT for the JRC. This enabled the definition of ad-hoc S3 preliminary priority domains that were used throughout the analysis.
- **Fourth step:** a second, independent and complementary topic modelling process has been performed on all the S&T documents, providing a finer, second level thematic classification system of the preliminary domains, better expressing their semantic content
- **Fifth step:** To allow further exploitation of the findings uncovered and to enable connection with economic activities, the research and innovation domains defined at the third step were manually mapped onto NACE sectors in qualitative fashion.

FIRST STEP: INITIAL SPECIALISATION ANALYSIS WITH THE DATA SOURCES' ORIGINAL TAXONOMIES

The integrated datasets are all categorised in accordance with some native taxonomy, such as, e.g., the International Patent Classification scheme for patents, or Bibliometric Subject Areas and Fields for publications. To have a first grasp of the research and innovation areas of specialisation of each country, for every dataset, statistics and temporal trends of outputs in agreement with their respective original taxonomy have been calculated.

This initial effort allows one to identify both consolidated areas of strength (i.e. those taxonomic categories where record statistics are large) and emerging fields of interest (i.e. those taxonomic categories where temporal pattern feature increasing trends)

After having drawn a first overview of the areas featuring the most intensive research and innovation activities by computing the respective statis-

tics, a specialisation analysis has been performed for each WB economy against the EU-27. Particularly, for each economy, the Location Quotients[28] have been computed in terms of the data original taxonomies. The location quotients measure, for a certain entity of interest (e.g. a university, a region or a country) the degree of specialisation in a given category against a given baseline (e.g. the EU, or the world). The LQ is equal to the ratio of two proportions: the proportion of the output produced by the entity in the category with respect to the entity's total, divided by the proportion of the output produced by the baseline in the category with respect to the baseline total. Therefore, a LQ greater than 1 implies the entity of interest is specialised in the category at hand with respect to baseline, whereas a LQ below 1 means the opposite. In the present case, the entities will be single WB economies or the entire WB region, while the baseline will be EU-27, a choice that makes our results compatible with previous studies. Moreover, to maintain consistency with previous studies, we have selected LQ=1.5 as the specialisation threshold. This means 50% stronger concentration with respect to the baseline.

SECOND STEP: TOPIC MODELLING FOR THE EXTRACTION OF EMERGENT DOMAINS OF INTEREST FROM TEXTS IN THE DATA SOURCES

In the second step, specialisation topics were automatically extracted from the text fields of the records describing science and innovation activities and results, with no recourse to any preliminary specialisation domain. "Topic Modelling", a machine learning text mining technique, was implemented in this work through the Latent Dirichlet Allocation (LDA) algorithm. Topics were extracted from the titles, abstracts, project objectives, keywords, etc. Each of them consists of an ordered list of words, each related with a specific R&D&I theme. Since this method links each publication, project and patent with a certain weight[29] to any given topic, in a continuous space, the result of this effort does not consist in a categorical classification: a publication can strongly belong to several topics, and weakly to others. In turn, all words in the text corpus may belong to several topics, with different strengths (from a negligible to strong relationship).

A graphical representation of the results produced by Topic Modelling via Latent Dirichlet Allocation is reported in the Figure B.

In agreement with Griffiths and Steyvers (2004)[30], the number of topics was chosen by maximising the Log-likelihood of each topic model, a standard approach in statistics for optimal model selection.

THIRD STEP: TRANSLATING ALL AVAILABLE INFORMATION INTO A SET OF DOMAINS

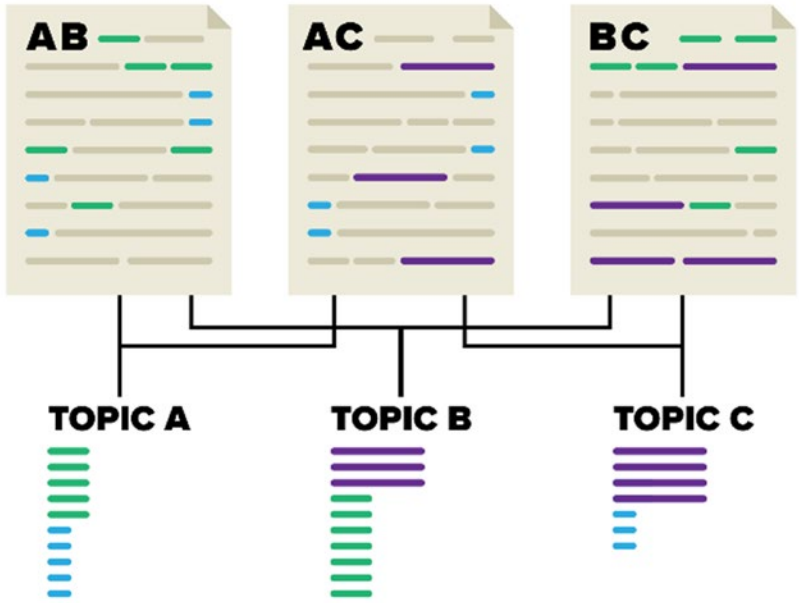
From the results obtained at step 1 and step 2, a series of preliminary specialisation domains have been built to facilitate use for stakeholders in a participatory co-design of R&D&I policies, particularly Entrepreneurial Discovery process in the context of smart specialisation. For the identified domains simple synthetic labels have been selected in qualitative fashion, by picking names that could fit both WB-transversal and economy-specific scientific and technological themes that emerged from the analysed texts. These labels are inspired by i. the results of the report "Mapping of the economic potential in Western Balkan countries", prepared by UNU-MERIT for the JRC and ii. the conclusions of the reports documenting the S3 strategy design processes undertaken by some of the WB economies. As explained, the

(28) See Schubert and Braun (1986).

(29) The weight is computed by numerically maximising a mathematical model, based on the Dirichlet probability distribution. In a nutshell, the model assumes that every document in the corpus is associated with a weight ranging from 0 to 1 to each of the topics. Weights close to zero denote a weak linkage between a given document and a certain topic, while weights close to one indicate a strong connection between a document and a topic. Working with topics and weights requires technical analyses that are beyond the scope of the present work, therefore topics and weights are not discussed in this document.

(30) See Griffiths and Steyvers (2004)

Figure B. Representation of the results produced by Topic Modelling via Latent Dirichlet Allocation



Documents are connected to several topics, while topics are composed of words appearing in the various texts. The same words can appear in multiple topics, while the topics connected to some specific documents may feature some words which are not actually contained in some of the texts, but that are semantically related.

topic modelling exercise yields a series of topics consisting of groups of relevant words: in practical terms, to define the different domains, topics whose semantic was largely overlapping were grouped together.

FOURTH STEP: CHARACTERISING THE SEMANTIC CONTENT OF THE PRELIMINARY DOMAINS WITH A FINER AUTOMATIC CLASSIFICATION SYSTEM

To achieve a greater understanding of research and innovation domains in the WB, we have applied a second level automatic thematic classification derived from a deep learning topic modelling framework to the same data set of S&T documents. To do so, we have used a novel Deep Learning framework: the BERT[31] algorithm as implemented by the Allen Institute of AI, which is trained on a massive dataset of scholarly publications - SPECTER[32]. This model translates entire short texts (such as titles and abstracts) into vectors that may be treated by a machine.

Semantically similar texts will have closer positions in the vector space. Using the K-Means[33] clustering algorithm, documents are clustered into 60 groups, which can be interpreted as semantic topics, thus a list of thematises representing the whole corpus of texts. At the end of the process, each document is clustered into one topic. These topics have been manually labelled by the authors, guided by an extraction, for each topic, of the most relevant and informative words, using several complementary natural language processing techniques.

FIFTH STEP: MAPPING RESULTS ONTO ECONOMIC ACTIVITIES

The domains defined in this report are finally mapped onto qualitatively matching economic activities encoded into NACE, Rev. 2 (2008). The mapping, which is performed at the two-digits

(31) See Devlin, et. al. (2019)

(32) See Cohan, et. al. (2020)

(33) See Macqueen (1967)

level, is carried out manually, in a purely qualitative fashion, and it does not absolutely aim at rigorousness. The mapping process is implemented by exploiting the eye@RIS3 tool of the S3 platform of the JRC. Among other information, the tool provides, for different European and extra-European territories, a description of the current and/or prospective S3 priorities and their corresponding NACE categories. The information is gathered from the Smart Specialisation Strategy documents for European regions and government strategy documents for extra-European territories, respectively.

Each identified domain has been manually looked for and matched to the S3 priorities listed in the tool. All connected NACE codes were then collected, and, for each domain, we retained the most frequent ones. This strategy allowed to associate to each domain a list of pertinent NACE codes that frequently appear connected to analogous S3 priorities in the eye@RIS3 tool.

LIMITATIONS AND FINAL METHODOLOGICAL CONSIDERATIONS

Following the qualitative and quantitative exploratory analysis presented above, we must highlight some relevant limitations and considerations that can fundamentally affect the specialisation and policy conclusions of the current exercise:

- Bias against lower-technology sectors, traditional sectors, non-technological innovation: Most records compiled in the international data sources listed above belong to the natural sciences and to technological innovation, partly due the nature of the sources of information used, partly due to the specialisation of the WB science and innovation ecosystem and the region's science and innovation policies. The relative absence of non-technological research and innovation activities (i.e. design or experience-based industries), which can have an important role in specialisation strategies, and the lower propensity to publish, protect intellectual property or participate in EU projects of lower-technology and traditional sectors has to be taken into account.
- The relative absence of non-technological research and innovation activities (such as design-based industries or tourism) shouldn't be taken as fact, and a more holistic view of WB's capacities and opportunities for innovation must be measured with other indicators and explored in the EDP Process. Furthermore, creative and experience-based industries, and more generally, the value of non-technological innovation in all sectors, could have an important role in WB specialisation strategies.
- Uneven number of records across the analysed data sources which over-represents scientific outputs: relative number or production of records in the different data sources (projects, patents, and publications) is very different, with a much larger number of publications than the other two. To avoid manipulation of the raw numbers, no normalisation has been performed to control for this disparity. Nevertheless, this must be considered when interpreting the results and conclusion of the analysis, particularly when there is a specific interest in technological innovation and the role of companies and other non-academic actors.
- Low number of records hindering a deeper characterisation of some preliminary specialisation domains: The low number of records in some domains and/or economies may prevent a richer/finer characterisation of preliminary priority domains and could provide unreliable indicators at the second level of analysis.
- Uneven representation of institutional typologies, overrepresentation of academic actors and underrepresentation of companies, NGOs, governments, etc., developing innovation or applying technology: as a consequence of the limitations above, it can be expected that companies, NGOs, governments, etc., are under-represented in the data sources and thus in the results of the analysis. Additional care must be taken when analysing results and interpreting conclusions related to priority-setting and the market or society-oriented innovation and application capacity of the

preliminary priority domains.

- Large number of individual patent applicants jeopardising a representative characterisation of patenting activity of WB organisations. The six Western Balkan economies present a very large number of individual persons as applicants in the patent data source, amounting to 84%. That is, only 16% of WB patents can be directly connected to academic institutions, companies or some other organisation. Certainly, there can be a number of individual inventors and patent agents, but there are also cases where university staff, for instance, applies to patents as individuals. WB legislation as well as the internal regulations and organisation of academic institutions and R&D grants could facilitate and incentivise institutional patent applications, always guaranteeing the intellectual and economic rights of the inventors.
- Relative weight of Serbia in trans-WB analyses: From each data source, the number of records available for Serbia outnumbers those for the rest of the WB economies combined. This means that statistics and record figures for the whole WB region are almost congruent with those of Serbia; as a consequence, the analyses carried out at the entire WB regional level are inevitably skewed towards the Serbian profile.
- Presence of Kosovo in the data sources: For trademarks, patents and publications, it is not possible to search for Kosovo as a country from the data sources, preventing an allround characterisation of Kosovar outputs in research and innovation. The issue was mitigated as much as possible for trademarks and publications by searching records by city, state and postcode of the applicant or the affiliation, respectively. Nevertheless, some records lack this information and not all documents effectively produced by Kosovar actors are granted to have been retrieved.

As expressed in the bullet points, the current analysis regarding the scientific and technological activities and potentialities rely only on international data sources which suffer relevant biases that can, to some degree, mis-represent the reality of the WB science and innovation activities, particularly in less internationalised and knowledge-intensive sectors.

This study presents an analysis that allows one to appreciate the scientific and technological potential of the WB economies as automatically extracted from the textual content of the abstracts of publications, research projects and patents. As such, the scope of the domains and the respective trends and figures are largely shaped by the volume and focus of the different data sources. In particular, the focus and trends of nine out of ten domains is primarily shaped by the content of publications, while those of the domain Heavy Machinery by the content of patents.

As shown in Section 4.2, in the time period considered in the present study (2011-2020), the number of scientific publications has been increasing, while the number of patents followed a U shape, reaching its bottom between 2015 and 2017, with a direct effect on the trends of each domain specifically. This may leave the reader with the impression that, e.g., Heavy machinery is a domain with a decreasing output volume, while it may not necessarily prove to be the case once additional information is considered. For instance, the sudden drop in the number of patents from 2012 to 2017 seems to suggest a systemic change happened, not captured by the sources analysed in this study.

Another aspect to be considered is that, because of their design, calls for projects funded by the EC framework programmes tend to promote research activities in the domains Better Societies and ICT, and, to a lesser degree, environmental issues.

Mentioning the relevance of local stakeholders, further observations about the current work must necessarily be devoted to the nature of the actors identified in this study. Because of the relative weight of publications and competitive R&D projects, this study highlights the major role of

universities within the WB research and development ecosystem. While this finding may be a partial misrepresentation of the local reality due to the nature of the data sources analysed, this information should nevertheless prove extremely useful. Indeed, since the transformation of the WB economies goes hand in hand with the transformation of the higher education sector, given the specificities of the regional entrepreneurial ecosystem, it would be desirable that local universities and the public sector in general contribute strongly to pushing forward some of the identified priorities, notably in collaboration with non-academic partners. This is especially true for those priorities that have a societal vocation, such as Energy, Health and Environmental sciences and industries. Nevertheless, in smart specialisation processes, business and civic society are in the driving seat, while the public and academic sectors should try their best to complement, answer to the needs and support opportunities in the private sector.

ORIGINAL TAXONOMIES OF THE DATA SOURCES

Subject Areas (SCOPUS)

AGRI Agricultural and Biological Sciences

ARTS Arts and Humanities

BIOC Biochemistry, Genetics and Molecular Biology

BUSI Business, Management and Accounting

CENG Chemical Engineering

CHEM Chemistry

COMP Computer Science

DECI Decision Sciences

DENT Dentistry

EART Earth and Planetary Sciences

ECON Economics, Econometrics and Finance

ENER Energy ENGI Engineering

ENVI Environmental Science

HEAL Health Professions

IMMU Immunology and Microbiology

MATE Materials Science

MATH Mathematics

MEDI Medicine

MULT Multidisciplinary

NEUR Neuroscience

NURS Nursing

PHAR Pharmacology, Toxicology and Pharmaceutics

PHYS Physics and Astronomy

PSYC Psychology

SOCI Social Sciences

VETE Veterinary

Second-Level International Patent Classification (IPC) codes

A

A01 Agriculture; Forestry; Animal husbandry; Hunting; Trapping; Fishing

A21 Baking; Equipment for making or processing doughs; Doughs for baking

A23 Foods or foodstuffs; Their treatment, not covered by other classes

A24 Tobacco; Cigars; Cigarettes; Smokers' requisites

A41 Wearing apparel

A43 Footwear

A47 Furniture; Domestic articles or appliances; Coffee mills; Spice mills; Suction cleaners in general

A61 Medical or veterinary science; Hygiene

A62 Life-saving; Fire-fighting

A63 Sports; Games; Amusements

B01 Physical or chemical processes or apparatus in general

B

B03 Separation of solid materials using liquids or using pneumatic tables or jigs; Magnetic or electrostatic separation of solid materials from solid materials or fluids; Separation by high-voltage electric fields

B04 Centrifugal apparatus or machines for carrying-out physical or chemical processes

B05 Spraying or atomising in general; Applying liquids or other fluent materials to surfaces, in general

B06 Generating or transmitting mechanical vibrations in general

B07 Separating solids from solids; Sorting

B08 Cleaning

B09 Disposal of solid waste; Reclamation of contaminated soil

B21 Mechanical metal-working without essentially removing material; Punching metal

B22 Casting; Powder metallurgy

B23 Machine tools; Metal-working not otherwise provided for

B24 Grinding; Polishing

B25 Hand tools; Portable power-driven tools; Handles for hand implements; Workshop equipment; Manipulators

B26 Hand cutting tools; Cutting; Severing

B27 Working or preserving wood or similar material; Nailing or stapling machines in general

B28 Working cement, clay, or stone

B29 Working of plastics; Working of substances in a plastic state in general

B30 Presses

B31 Making paper articles; Working paper

B32 Layered products

B41 Printing; Lining machines; Typewriters; Stamps

B60 Vehicles in general

B61 Railways

B62 Land vehicles for travelling otherwise than on rails

B63 Ships or other waterborne vessels; Related equipment

B64 Aircraft; Aviation; Cosmonautics

B65 Conveying; Packing; Storing; Handling thin or filamentary material

B66 Hoisting; Lifting; Hauling

B67 Opening or closing bottles, jars or similar containers; Liquid handling

B68 Saddlery; Upholstery

B81 Micro-structural technology

B82 Nano-technology

C

C01 Inorganic chemistry

C02 Treatment of water, waste water, sewage, or sludge

C03 Glass; Mineral or slag wool

C04 Cements; Concrete; Artificial stone; Ceramics; Refractories

C05 Fertilisers; Manufacture thereof

C06 Explosives; Matches

C08 Organic macromolecular compounds; Their preparation or chemical working-up; Compositions based thereon

C09 Dyes; Paints; Polishes; Natural resins; Adhesives; Compositions not otherwise provided for; Applications of materials not otherwise provided for

C10 Petroleum, gas or coke industries; Technical gases containing carbon monoxide; Fuels; Lubricants; Peat

C11 Animal or vegetable oils, fats, fatty substances or waxes; Fatty acids therefrom; Detergents; Candles

C12 Biochemistry; Beer; Spirits; Wine; Vinegar; Microbiology; Enzymology; Mutation or genetic engineering

C13 Sugar industry

C14 Skins; Hides; Pelts; Leather

C21 Metallurgy of iron

C22 Metallurgy; Ferrous or non-ferrous alloys; Treatment of alloys or non-ferrous metals

C23 Coating metallic material; Coating material with metallic material; Chemical surface treatment; Diffusion treatment of metallic material; Coating by vacuum evaporation, by sputtering, by ion implantation or by chemical vapour deposition, in general; Inhibiting corrosion of metallic material or incrustation in general

C25 Electrolytic or electrophoretic processes; Apparatus therefor

C30 Crystal growth

D

D01 Natural or artificial threads or fibres; Spinning

D02 Yarns; Mechanical finishing of yarns or ropes; Warping or beaming

D03 Weaving

D04 Braiding; Lace-making; Knitting; Trimmings; Non-woven fabrics

D05 Sewing; Embroidering; Tufting

D06 Treatment of textiles or the like; Laundering; Flexible materials not otherwise provided for

D07 Ropes; Cables other than electric

D21 Paper-making; Production of cellulose

E

E01 Construction of roads, railways, or bridges

E02 Hydraulic engineering; Foundations; Soil-shifting

E03 Water supply; Sewerage

E04 Building

E05 Locks; Keys; Window or door fittings; Safes

E06 Doors, windows, shutters, or roller blinds, in general; Ladders

E21 Earth or rock drilling; Mining

F

F01 Machines or engines in general; Engine plants in general; Steam engines

F02 Combustion engines; Hot-gas or combustion-product engine plants

F03 Machines or engines for liquids; Wind, spring, or weight motors; Producing mechanical power or a reactive propulsive thrust, not otherwise provided for

F04 Positive-displacement machines for liquids; Pumps for liquids or elastic fluids

F15 Fluid-pressure actuators; Hydraulics or pneumatics in general

F16 Engineering elements or units; General measures for producing and maintaining effective functioning of machines or installations; Thermal insulation in general

F17 Storing or distributing gases or liquids

F21 Lighting

F22 Steam generation

F23 Combustion apparatus; Combustion processes

F24 Heating; Ranges; Ventilating

F25 Refrigeration or cooling; Combined heating and refrigeration systems; Heat pump systems; Manufacture or storage of ice; Liquefaction or solidification of gases

F26 Drying

F27 Furnaces; Kilns; Ovens; Retorts

F28 Heat exchange in general

F41 Weapons

F42 Ammunition; Blasting

G

G01 Measuring; Testing

G02 Optics

G03 Photography; Cinematography; Analogous techniques using waves other than optical waves; Electrography; Holography

G04 Horology

G05 Controlling; Regulating

G06 Computing; Calculating; Counting

G07 Checking-devices

G08 Signalling

G09 Educating; Cryptography; Display; Advertising; Seals

G10 Musical instruments; Acoustics

G11 Information storage

G12 Instrument details

G21 Nuclear physics; Nuclear engineering

H

H01 Basic electric elements

H02 Generation, conversion, or distribution of electric power

H03 Basic electronic circuitry

H04 Electric communication technique

H05 Electric techniques not otherwise provided for

NICE CLASSIFICATION (TRADEMARKS)

1. Chemical products for use in industry; unprocessed artificial and synthetic resins; adhesive emulsions, not included in other classes; all aforesaid goods not in the field of passive fire protection and high temperature insulation.

2. Paints, varnishes and lacquers; colourants; mordants; raw natural resins; Metals in foil and powder form for painters, decorators, printers and artists; acrylic, water-colour, water and oil paints; primers, gesso; metal-effect and pearl-effect paints; finger paints and paints for windows.

3. Bleaching preparations and other substances for laundry use; Cleaning-, polishing, scouring- and abrasive preparations; soaps; perfumery.

4. Industrial oils and greases; lubricants; dust absorbing, wetting and binding compositions.

5. Pharmaceutical preparations.

6. Metal building materials; fastenings of common metal, in particular for terraces; screws of metal.

7. Cutting, drilling, grinding and engraving machines for home and business use and universal computerized numerical controllers sold as an integral part thereof; power operated computerized machine cutters, drillers and grinders; engraving machines; laser engraving machines; three dimensional modelling machines; replacement parts for the above-mentioned goods; all aforesaid goods not being or for use with or as parts or consumables for industrial gravure printing, letterpress printing or offset printing machines.

8. Hand tools and implements (hand operated); cutlery; side arms; razors; hair clippers for animals, electric and non-electric; interchangeable blades for brushes, combs, razors and hair clippers for animals; nail clippers, electric or non-electric; Electric and non-electric depilatory appliances; hair removing tweezers; pedicure sets; nail buffers, electric or non-electric; nail and hoof files, rasps (hand tools), farriers' knives, pliers and pincers; apparatus for tattooing; tool belts.

9. Apparatus controlled by computers, namely, displays, printers and x-y plotters; plotter printers; cutting plotters for use as sign makers; combination ink jet printer and cutter; combination thermal printer and cutter; computer printers; x-y plotters; three dimensional scanners; computer programs for controlling cutting, drilling, grinding and engraving machines, power operated computerized machine cutters, drillers and grinders, engraving machines, laser engraving machines, three dimensional modeling machines, plotter printers, cutting plotters for use as sign makers, printing and cutting machines, computer printers, x-y plotters and three dimensional scanners; replacement parts for the above-mentioned goods; all aforesaid goods not being or for use with or as parts or consumables for industrial gravure printing, letterpress printing or offset printing machines.

10. Hearing aids and accessories, namely hearing aid couplings and receivers.

11. Apparatus for lighting, heating, steam generating, drying, ventilating, water supply and sanitary purposes for hairdressing and beauty salons; hair dryers; hairdressing lamps.

12. Vehicles; apparatus for locomotion by land, air or water.

13. Explosives; fireworks, pyrotechnic products; firecrackers, signal rockets.

14. Watches; horological and chronometric instruments, parts and fittings for watches.

15. Musical instruments.

16. Packaging containers of cardboard and of paper; pamphlets, leaflets, personal information sheets, instruction sheets, all relating to medication management.

17. Insulating, stopping and packing tape.

18. Leather and imitations of leather, umbrellas, parasols and walking sticks; wallets; handbags; rucksacks, backpacks; wheeled shopping bags; bags for climbers; bags for campers; travelling bags; beach bags; schoolbags; luggage, bags for sports, briefcases, pocket wallets of cloth.

19. Grout; asphalt, pitch and bitumen, concrete, cement, grouting and mortar including fluid concrete, masonry mortar, floor grout, mortar for repair purposes; binding agents, aggregate materials and adjuvant preparations, included in this class, for the preparation of grout; filling materials and binding agents for construction purposes, included in this class; binding agents for road maintenance; all aforesaid goods not in the field of passive fire protection and high temperature insulation.

20. Containers, packs and packaging.

21. Household or kitchen utensils and containers; combs and brushes (except paintbrushes); brush-making materials; currycombs, large-toothed combs for the hair and scrubbing brushes for animals; toilet sponges and abrasive sponges for scrubbing animals; hand operated cleaning instruments; toilet utensils and toilet cases; feeding troughs for animals; litter boxes (trays) for pets; birdcages and bird baths.

22. Real hair; natural locks of hair.

23. Yarns and threads, for textile use.

24. Fabrics for textile use; bath linen, bed linen, household linen, table linen, not of paper.

25. Footwear.

26. Lace and embroidery, ribbons and braid; hair bands, barrettes and hair-slides, hair pins, hair curling pins; hairnets; hair ornaments; tresses of hair; false hair; wigs.

27. Mats, in particular ground protection and erosion protection mats, of plant fibres without seeds, vegetation and growing mats, mulch material of plastic for use in agriculture and horticulture, vegetation fascines (not of natural material), all the aforesaid goods other than for domestic animals.

28. Games; protective paddings (parts of sports suits), bags for sporting articles.

29. Delicatessen articles, namely olives with herbs and pickled in brine, sheep's cheese in brine and in herbal oil, cream cheese being filling for fruit, fruit filled with cream cheese, goats' milk cheese; pickled vegetables with various fillings and fruits; pulp concentrates; piccalilli; pickles; soups; vegetable pies; mince meat in pastry and in flat bread, included in class 29; edible oils and fats.

30. Bread, flat bread, pastries; vinegar, relishes; chutneys (condiments); spices; dips; ketchup, mustard; pastes (condiments).

31. Agricultural, horticultural and forestry products; fresh fruits and vegetables.

32. Non alcoholic drinks; essences for making beverages; non-alcoholic fruit extracts; non-alcoholic fruit drinks; non-alcoholic fruit nectars; non-alcoholic fruit juices; beverage preparations; liqueur preparations; lemonades; syrups for lemonade; fruit nectars; syrups for beverages; sorbets.

33. Low-alcohol wines; aperitifs, digestifs and cocktails with a spirit and wine base; cider; brandy; mead (hydromel); sake; piquette; gin; brandy; wines.

34. Tobacco, whether manufactured or unmanufactured; cigarettes; cigars; tobacco products; tobacco substitutes, none being for medicinal or curative purposes; matches and smokers' articles.

35. Business mediation in the purchase and sale, import and export of chemicals used in industry, artificial resins and synthetic resins, unprocessed, adhesive emulsions, grout, asphalt, pitch and bitumen, concrete, cement, grouting and mortar including fluid concrete, masonry mortar, floor grout, mortar for repair purposes, binding agents, aggregate materials and adjuvant preparations for the preparation of grout, filling materials and binding agents for construction purposes, binding agents for road maintenance; sales promotion; consultancy on the aforesaid services; the aforesaid services also offered via electronic networks, including the Internet; all aforesaid services not in the field of passive fire protection and high temperature insulation.

36. Insurance; financial affairs; monetary affairs; real estate affairs.

37. Maintenance and repair of horological and chronometric instruments.

38. Telecommunications services; broadcasting of radio and television programmes; transmission, whether or not digitally, of sound and images (broadcasting), including via radio, television, satellite, cable, free-to-air and by electronic means; providing of electronic telecommunication connections; providing of access to telecommunication networks; Internet access provider services; communications by computer terminals; interactive communication services via the Internet, cable television networks or other forms of data transfer; cable television broadcasting; rental of (tele)communication apparatus; services of telecommunication networks, including with regard to cable TV information services; information and consultancy relating to the aforesaid services; all the aforesaid services, whether or not provided via electronic channels, including radio, television, teletext and the Internet.

39. Transport; packaging and storage of goods; travel arrangement.

40. Processing, recycling and finishing of paper, cardboard, cellulose, glass, metals, natural or synthetic fibres and solid and liquid waste.

41. Educational services, namely, conducting speeches and programs in the field of designing and manufacturing environmentally friendly and sustainable materials, products and buildings.

42. Architectural and engineering consulting services in the field of sustainable building design.

43. Services for providing of food and drink; temporary accommodation offered on night trains.

44. Veterinary services; pet grooming; hygiene and beauty treatments for animals; animal grooming; identification tattooing and inserting of identity chips under the skin of an animal.

45. Legal services; security services for the protection of property and individuals; personal and social services rendered by others to meet individual needs.

GETTING IN TOUCH WITH THE EU

IN PERSON

All over the European Union there are hundreds of Europe Direct centres. You can find the address of the centre nearest you online (*european-union.europa.eu/contact-eu/meet-us_en*).

ON THE PHONE OR IN WRITING

Europe Direct is a service that answers your questions about the European Union. You can contact this service:

— by freephone: 00 800 6 7 8 9 10 11 (certain operators may charge for these calls),

— at the following standard number: +32 22999696,

— via the following form: *european-union.europa.eu/contact-eu/write-us_en*.

FINDING INFORMATION ABOUT THE EU

Online

Information about the European Union in all the official languages of the EU is available on the Europa website (*european-union.europa.eu*).

EU publications

You can view or order EU publications at op.europa.eu/en/publications. Multiple copies of free publications can be obtained by contacting Europe Direct or your local documentation centre (*european-union.europa.eu/contact-eu/meet-us_en*).

EU law and related documents

For access to legal information from the EU, including all EU law since 1951 in all the official language versions, go to EUR-Lex (*eur-lex.europa.eu*).

Open data from the EU

The portal data.europa.eu provides access to open datasets from the EU institutions, bodies and agencies. These can be downloaded and reused for free, for both commercial and non-commercial purposes. The portal also provides access to a wealth of datasets from European countries.

Science for policy

The Joint Research Centre (JRC) provides independent, evidence-based knowledge and science, supporting EU policies to positively impact society

EU Science Hub
joint-research-centre.ec.europa.eu

Publications Office
of the European Union