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Contact information

Alexander Tübke
Address: Edificio Expo. C. Inca Garcilaso 3. E-41092 Seville (Spain)
E-mail: JRC-B3-SECRETARIAT@ec.europa.eu
Tel.: +34 9544-88250

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Abstract

This study offers a novel analytical approach to inform the regional search for new industrial opportunities, as promoted by Smart Specialisation within the EU Cohesion policy context. The analysis departs from the challenges of practicing Smart Specialisation and its entrepreneurial discovery process in a dynamic perspective. It argues that the adoption of a dynamic approach to identify new opportunities implies mapping regional business and innovation assets as well as, assessing their position within the global technological and industrial landscape. The report brings a case study of the Lombardy region business environment, spurring from the S3 Lab initiative (in collaboration with Baden-Württemberg, Catalonia and Lapland), together with a comparative analysis focusing on technological development. The empirical study combines patent data from OECD REGPAT and territorial proprietary micro-data from Lombardy region on firm creation in emerging industries (EI) – new industrial sectors or existing sectors evolving into new industries (European Cluster Observatory). These industries represent a priority area for Lombardy's innovation-led development strategy. The initial observations confirm the importance of such industries in the region; they represent more than one-third of employment, almost a half of the regional value-added and feature together the majority of innovative start-ups, suggesting the relevance of the regional strategic development choices. Also, in terms of productive advantages, Lombardy ranks high in some key EI. The mapping of technological competences through patent indicators measuring specialisation, diversification and the ability to specialise in fast-growing and niche fields gives relevant insights on the technological potential of the region, providing further guidance for better targeted interventions.

Keywords: smart specialisation, emerging industries, regional search, technological specialisation

Classification-JEL: O25, O33, O38, R58

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1. Thinking about Smart Specialisation

1.1 Smart Specialisation in a nutshell

The Smart Specialisation framework has introduced new ways of thinking about local development and structural change, contributing to the redefinition of the EU regional policy. In particular, the concept of Smart Specialisation was defined to address the issue of specialisation in R&D and innovation and provides a basis to design effective strategies for the medium-long term development of territories (Foray et al., 2009). Smart Specialisation is therefore an innovation policy framework designed to support regions (and countries) in the identification of the most promising and desirable areas of specialisation, and to encourage investment in programs which may complement the local productive and knowledge assets to create future comparative advantages.

The adoption of Research and Innovation Smart Specialisation Strategies (RIS3) has been highlighted by the Europe 2020's Innovation Union flagship initiative and the EU Cohesion policy as part of the strategy to deliver smart, sustainable and inclusive growth (European Commission, 2010a). Within the Cohesion policy frame, the EU regions were required to design their RIS3 as a preliminary condition to access the European structural and investments funds provided under the operational programmes ("ex-ante conditionality").¹ From a policy perspective, Smart Specialisation has been put forward as a strategic response to the limits of the "one-size-fit-all" technological and industrial model and with the aim to limit the fragmentation and duplication of granting schemes of public R&I investments across EU.

Smart Specialisation entails a logic of prioritization "*in a vertical logic (to favour some technologies, fields, population of firms)*", Foray and Goenaga (2013). In this logic, it is acknowledged that regions, even the most innovative, cannot stand out in more than a handful of domains and should be able to identify few priority areas where dynamic competitive advantages can be established or strengthened. Such priority areas should build upon the assets and resources available to territories and upon their specific socio-economic challenges.

1.2 A cookbook of Smart Specialisation

The adoption of RIS3 intends to facilitate the development of sustainable comparative advantages by focusing on few industrial and technological activities. Yet, as shown by the design and first implementation experiences, the development and monitoring of RIS3 are none of trivial businesses. Precisely because of its requirements and distinctive features – the

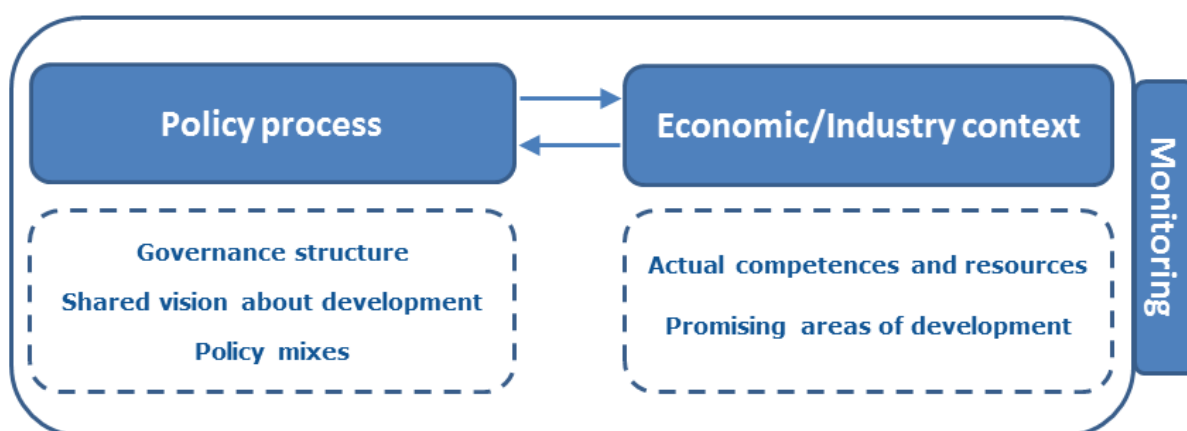
¹ "Operational Programme: document setting out a Member State or region's strategy for contribution to the Europe 2020 strategy through the ERDF, the ESF and / or the Cohesion Fund, consistent with both the Regulations and the Member State's Partnership Agreement (Articles 27 and 96 CPR)." European Commission (2015), European Structural and Investment Funds 2014-2020: Official Texts and Commentaries http://ec.europa.eu/regional_policy/sources/docgener/guides/blue_book/blueguide_en.pdf

emphasis on a vertical and innovation-led approach, the inclusive consultative process and the central role of the entrepreneurial discovery process (EDP) – the adoption and adaptation of a Smart Specialisation strategy raise many challenges especially when it comes to turn it into practice (see for instance McCann and Ortega 2015; Capello and Kroll, 2016).

In order to design and put in practice a Smart Specialisation logic, six broad and non-necessarily successive steps have been identified (Foray et al., 2012), starting with the analysis of the current regional research and industrial capabilities and assets, and the economic specialisation. A particular attention should be granted to the dynamics of entrepreneurial activities and emerging sectors in this analytical phase.

Indeed, the six steps proposed by Foray et al. (ibid.)² can be grouped in two main areas; those pertaining to the policy area and those pertaining to the economic/industry area. A similar conceptual distinction has been used by Kleibrink et al. (2016), where the basic elements of the operational solution (their third phase: definition of responses and formulation of solutions) to achieve regional strategic objective are grouped into "Priorities" and "Policy Mix". Figure 1, illustrates how the six steps foreseen by Foray et al. (2012) can come together under two (plus one) main areas.

Figure 1: An operational (over)view of Smart Specialisation



Source: own elaborations.

The vision and the decision process (Policy process) should allow regions to identify a small set of priority areas and domains beyond the current state of the art (Economic/Industry context). The focus of Smart Specialisation on the desirable transformations within the economy calls for a great attention to the areas of relevant entrepreneurial knowledge. Indeed, in the

² The six steps are: 1. Analysis of the regional context and potential for innovation; 2. Set up of a sound and inclusive governance structure; 3. Production of a shared vision about the future of the region; 4. Selection of a limited number of priorities for regional development; 5. Establishment of suitable policy mixes; 6. Integration of monitoring and evaluation mechanisms.

Smart Specialisation heuristics, the entrepreneurial discovery processes (EDPs) are seen as the privileged source to communicate about what could be best produced and to reveal the most promising areas of specialisation in terms of R&D and innovation. Besides the critical information from the EDPs, the discrimination among activities relies on several criteria related, among others, to the novelty, the existence of assets and capabilities, the funding needs, the economies of scope and scale from the agglomeration of the related R&D and innovation investments. Particular attention should be given to their potentialities in transforming the established regional industrial structures. The recent focus on global value chains would suggest that regions should develop their RIS3 strategies without limiting to the traditional sectors (classification), but aiming at positioning themselves within specific stages of broader value chains. Moreover, the (de)selection of priorities is a dynamic and gradual process enabling regular revisions and updates.

In a nutshell, regions should think local – *value and rely on their current R&I assets and potential* –, dynamic – *identify the technological and market opportunities* and, at the same time, adopt a forward- and outward-looking stance, relying on regular benchmarking, ex-post evaluation tools and foresight exercises.

1.3 The industrial side of Smart Specialisation

The key role of Smart Specialisation to achieve a smart, inclusive and sustainable growth in Europe has been underlined in the communication *For an European Industrial Renaissance* (European Commission 2014).³ The design and implementation of strategies for Smart Specialisation intend to support the efforts of the EU to foster its post-crisis recovery, competitiveness and resilience, through a stronger and modernized industrial base. The modernization of the EU industry implies more and more targeted investments in research and innovation as means to shift away from an industrial competitiveness based on low-value-added and low-quality. In the framework of the EU growth strategy, the emphasis of Smart Specialisation on a more efficient organisation of research and innovation for the purpose of economic and industrial transformation is thus seen as an important dimension to support the modernization of the EU industrial base.

The need to modernize the EU industry entails, for instance, supporting the adoption of new technologies (e.g. digital technologies), but also competing for new or emerging domains. In this perspective, what Smart Specialisation mainly puts forward is the need for countries and regions to identify unique opportunities for structural change (Foray and Goenaga 2013). This can take four different patterns: *i)* transition, when new domains emerge from existing industrial commons; *ii)* diversification based on potential synergies between established activities and new activities; *iii)* radical foundation of entirely new innovation-driven business

³ European Commission (2014), For a European Industrial Renaissance, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions /* COM/2014/014 final*/ Available at <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52014DC0014>

activities; *iv*) modernization through the adoption or co-development of specific technologies to improve efficiency. In many cases, implementing RIS3 would often rely on both the adoption of new technologies throughout the industries and on the development into specific niches (activities, fields or technologies). Obviously, this can hardly be done without suitable and continuous monitoring and analytical efforts. Indeed, the availability of reliable and actual information on the market, industrial features and dynamics is critical for territories both for regional profiling and effective decision-making or targeting purposes (Correa and Guceri 2016).

At the EU level, early funds were made available under the H2020 targeting the industrial leadership pillar, improved market access and the establishment of public-private partnerships. In order to support concrete investment projects under the Smart Specialisation framework, ESIF explicitly include innovation financing in line with the industrial policy priorities. Early related strategic areas have been identified and include advanced manufacturing, key enabling technologies, clean vehicles and transport, bio-based products, construction and raw materials and smart grids.

Furthermore, Thematic Smart Specialisation Platforms⁴ (TSSPs or S3P) have been set up in order to facilitate the identification of regional investment projects connected to specific thematic areas as well as to trigger relevant investment partnerships between EU regions. In this framework, in addition to the S3P Energy platform (2015), two additional platforms on Industrial modernization (IM) and Agri-food have been launched in 2016 in order to support the uptake of the structural investments funds and stimulate interregional cooperation based on matching priorities respectively in the energy sector, in key enabling technologies, in service innovation or resource efficiency, etc. and to agriculture and food. Such TSSPs are expected to be dynamic spaces in order to enable adjustments/refinements, experimentation and to support the continued creation of roadmaps for joint demonstration and co-investments.

In addition of the EU funding instruments and platforms, some regions have developed specific tools and frameworks to implement their RIS3 in practice. Launched by the Lombardy region the S3Lab initiative offers among others, evaluation and promotion tools and mutual learning spaces, in order to bring together EU regions with similar challenges and contexts. This lab is part of the region's efforts to support the growth and evolution of the local industry with a focus on Emerging Industries that feature among Lombardy's target areas for innovation-led development.⁵ Key to this initiative is thus the design of the "right" framework for continuous EDP focusing on EI in order to discover and promote new market opportunities and potential future products and or technologies materializing the emergence or development of such industries.

⁴ See at <http://s3platform.jrc.ec.europa.eu/s3-thematic-platforms>

⁵ See at <http://www.s3.regione.lombardia.it/>

1.4 Thinking about the dynamic of Smart Specialisation

The foresight of emerging technologies and the identification of emerging industries pose great challenges and opportunities for both scholars and policy makers. The EDP, even at a small regional scale, can quickly become hardly sustainable in terms of monitoring and management (Foray et al. 2012, Piirainen et al. 2017). In this respect, appropriate data and monitoring tools to inform policy-making are crucial.

The present study focuses on these aspects and aims at illustrating the opportunity to combine regions' proprietary data with information and expertise available at the EU level. Indeed, regions have access to micro data of interest, which are not always accessible to authorities at the EU level, while the European Commission can provide valuable support and analyses through the various platforms and the expertise of the EU institutions in different scientometric tools.

Smart Specialisation belongs to the new “industrial policy approaches”, which aim to unveil the future economic value of different industrial paths for regional structural change and to build up more effective policies by means of a vertical “logic”, concentrating the resources. In this perspective, S3 offers relevant levers to explore and discover new technological and market opportunities and open thereby new domains for constructing regional competitive advantages.

Partially due to the lack of relevant information and weak monitoring and governance structures, the entrepreneurial discovery process may often result in an excessive focus on the existing sectoral strengths in a geographic area and on projects focusing on short term returns. However, in a fast changing technology landscape, adopting a dynamic approach to the identification of priority areas and investments cannot be done without pre-empting or anticipating longer term industrial and technological trends. The identification of unique comparative advantages for a sustainable regional development thus demands longer term strategies and investment horizons as well as broader monitoring and benchmarking settings.

In this report, we adopt two different approaches to tackle this issue. On the one hand, we will discuss an insightful option that regions may follow in the EDP related to emerging opportunities. This will be illustrated through a case study performed in the Lombardy region (Italy), which led to the setup of the S3 Lab initiative in collaboration with the regions of Baden-Württemberg (Germany), Catalonia (Spain) and Lapland (Finland). On the other hand, we will put forward an EU level analytical perspective to identify strengths and opportunities within the global technological developments.

2 The identification of new regional opportunities

2.1 The European Cluster Observatory and the Emerging industries

The European Cluster Observatory set up by DG-GROW aims at strengthening the role of cluster policies to support the EU industry. The observatory performs monitoring works related to the concept of emerging industries. Although a consensus on the definition of emerging industries is still to be achieved (and the same holds true for the concept of emerging technologies), the European Cluster Observatory adopted the definition proposed by Heffernan and Phaal. In this context, "emerging industries" are linked to the creation of new industrial value chains, or the radical reconfiguration of existing ones. In the latter case, new configurations will be often driven by a disruptive idea (or convergence of ideas), leading to the development of new products/services with higher added value.⁶

Defined in such way, emerging industries can be identified either as new industrial sectors or as (parts of) existing industrial sectors that are evolving or converging into new industries. New industrial activities may subsequently lead to the emergence of novel industries. As defined, the concept relates much to the idea of structural change that is central in the Smart Specialisation approach. This is often driven by human necessities, key enabling technologies, new business models and the societal challenges triggering or pushing the industrial transformation. Yet, the identification of emerging industries remains challenging because of the intrinsically changing characteristics of this group of industries.

The European Cluster Panorama (Ketels and Protsiv 2014, 2016) defines 10 emerging industries through a data-driven approach. The first step consists in the identification of a broad group of similar industries with systematic relations across EU regions. A second step focuses on a narrower set of industries based on strong linkages in specific locations. This analytical approach is based on the concept of related variety put forward by Frenken, Van Oort, and Verburg (2007). In their framework, structural change is understood as a process of related diversification (i.e. in generic terms, it corresponds to a diversification in fields/activities relatively close to the existing activities or relying on similar assets). In this perspective, emerging industries would primarily be searched where novel cross-sectoral linkages are most likely to materialise and a reasonable assumption is that future linkages might occur where signals of their existence can already be observed.

The identification of emerging clusters of related industries relies on the work of Delgado *et al.* (2016) on data from America, preliminary adjusted to fit the NACE 2.0 industrial classification and European specificities. This approach has the advantage to provide a list of NACE codes related to the pre-defined emerging clusters thus allowing for identification at various European scales. The definition of industry employed here differs from the traditional ones based on industrial sectors (e.g. economics activities at the more granular levels can be

⁶ This definition developed by Heffernan & Phaal (2009) was used in the policy roadmap of the European Forum for Clusters in Emerging Industries. More details can be found at <http://www.clusterobservatory.eu/index.html>

clustered not following to the NACE hierarchical structure). Industry refers here to a set of economic activities involving in the transformation and production of manufactured goods and of services; such approach is closer to the conceptual definition of value chains.

In table 1 we report the 10 emerging industries identified by the Cluster Panorama, together with some information about their relevance in terms of employment creation at the EU level. The average wages paid in these sectors compared to the overall economy are also provided.

2.2 The Lombardy exercise

The approach put forward by the European Cluster Observatory could be a relevant starting point for the regions to identify and explore areas of emerging opportunities where to look at and foster the EDPs. In particular, by focusing on the emerging industries the spectrum of possible actors/technologies to be monitored is largely reduced thus facilitating the identification and the setting up of tailored support - e.g. by integrating into the mechanism - of the relevant RIS3 regional stakeholders.

As a case study we describe the approach designed by Finlombarda SpA⁷ and followed by the Lombardy region as an inspirational illustration for other regions. Indeed, understanding the positioning of the EI in the territory is key to leverage 'weak signals' of new high growth potentials.

The model of the abovementioned practice consists in two complementary phases. The first phase relies on a top-down approach and the second one aims to involve territorial actors (business, academia, research bodies, professional and trade associations, clusters etc.) in a more bottom-up fashion. The two phases play different roles in the EDP depending on the target of the analysis. When the focus is made on supporting established industries shorter and mid-term visions of the regional path may be reasonably pictured as key regional actors are more likely to be aware of existing competitive advantages and critical success factors. In this case, the bottom-up approach may be more relevant than the top-down one. Indeed, the policy maker can recognize technological priorities through continuous consultation and sharing processes with its traditional stakeholders.

However, when the focus is put on the identification of emerging industries, a wider and longer term vision of the market evolution and the regional innovation system appears to be even more necessary. In this case, different and more complex processes of regional search or exploratory exercises will often be needed. A dual approach remains the most relevant one considering that the top down perspective can allow highlighting weak signals of emerging activities in order to orient better bottom up activities as well as the definition of regional support programs.

⁷ Finlombarda SpA is the financial company fully-owned by the Lombardy Region which mission is the promotion of the regional socio-economic development.

Table 1: Profiling emerging industries

	Industry Definition	Share of employment 2014 [b]	Average relative wage 2014 [b]
Biopharmaceuticals	Is an expansion of the Biopharmaceutical cluster with upstream (chemical) and downstream (wholesale and packaging) industries, and other core activities (research and development). It mainly produces medical drugs by biotechnology methods (involving live organisms or bioprocessing).	0.92%	148.06%
Digital Industries	Cover some of the core sectors in the information age, combining services related to information technologies with the hardware they use. It is related to an increasingly cross-cutting technology has become an element of most parts of economic activity.	3.97%	140.01%
Creative Industries	Defined as “industries which use culture as an input and have a cultural dimension, although their outputs are mainly functional. They include architecture and design, which integrate creative elements into wider processes, as well as subsectors such as graphic design, fashion design or advertising.[b]	5.63%	139.44%
Medical Devices	It is an industrial sector, manufacturing products which are generally based on biomedical engineering, and which are developed through mechanical, electrical and/or materials engineering, leading to products that permanently or temporarily replace or support a function of the body.	1.92%	135.58%
Environmental Industries	The ‘green economy’ is defined as encompassing all economic activities that lead to reducing environmental pressures of human activity. The latter is expected to result from the more efficient use of natural resources and from reducing harmful emissions across the lifecycle. Green economy includes a range of products, services, technologies and processes serving many different economic sectors.	3.47%	119.82%
Mobility Technologies	They stem from the Automotive cluster as a core and expand it with related technologies from the Production Technology and Aerospace cluster as well as few related upstream activities like Metalworking and Plastics. Topics dealt with by technological innovation in the field of mobility include road vehicle engineering, internal combustion engines, batteries and motors, electric and hybrid power-trains, urban and high speed rail transportation, aircraft types and aerodynamics, radar, navigation, GPS, GIS, etc.	4.30%	119.15%
Advanced Packaging	It includes the Paper and Packaging cluster, complemented with packaging-related industries from Plastics, Automotive, Metalworking and other clusters that are often significantly larger in overall employment	1.93%	111.64%
Experience Industries	They combine creation and consumption of cultural products and services, comprising "companies whose activities supply innovative products and services to provide customers with 'experiences' that stimulate emotions and senses, move, entertain and surprise, thrill, enthuse and involve". These are defined “as the combination of six sub-sectors: Accommodation and tours, Food and drink, Gambling, Museums and parks, Sports and leisure, and Arts”.	6.06%	110.03%
Blue Growth Industries	They include all sectors and industries related to a maritime environment as well as sectors producing, making use of, and treating fresh-water sources.	5.15%	100.68%
Logistical Services	It is an industry based on Transportation and Logistics cluster with the addition of several supporting industries. Logistics is the management of the flow of goods or people and the actual process of transport between a starting point and a specific destination land-, air-based or space-based. On one hand, this includes the logistics operation provision (terrestrial or via satellite), on the other hand, the development and provision of IT-systems for the logistics planning, organisation, and management.	3.03%	82.20%

Source: Adapted from the European Cluster Panorama (Ketels and Protsiv, 2016).

Note: [a] European Commission (2010b) Green paper – Unlocking the potential of cultural and creative industries, Communication COM (2010) 183. [b] With respect to the whole EU industries.

In particular, it is relevant to anticipate as soon as possible the development of the markets within mega-trends in areas such as bio-economy, circular economy and so on, looking for the future economic and social value of new technological and innovation opportunities. In doing so, it would be possible to anticipate strategic investments in line with regional competitive factors in terms of human capital, skills mixes, research infrastructures, education and other enabling conditions. The expected outcome is that in the medium or longer term, when emerging industries would become established, the EI-operating enterprises will compete better; that is, with greater competitive advantages than their competitors.

The present study, framed within the EU's Smart Specialisation initiative, can be complementary to other frameworks developed, for instance, by the Vanguard Initiative or in the context of S3 Thematic Platforms. In addition, it may spur novel political ideas and raise awareness about the new challenges in a long term horizon while strengthening or enabling better-calibrated shorter term actions.

During the first phase of the exercise, the region has exploited proprietary territorial micro data and applied a data-driven approach on the ten EIs identified in the European Cluster Panorama. In the case of Lombardy, the collaboration with Unioncamere Lombardia⁸ enabled a direct access to information on enterprise creation at the regional and country levels for 2013/2014.⁹ The data driven approach systematically applied at regional level can allow shedding lights on weak signals of different or other emerging industries.

Figure 2 reports some descriptive statistics of the EI in the Lombardy region. About one fourth of firms in the region operate in an EI; however, these firms generate a rather high share of turnover (39%) and employ about 37% of the total Lombardy workforce. Even more interesting is that the firms that operate in the EI account for a relatively important share of Lombardy's overall value added (44%); firms operating in the EI are able to generate higher value added than the regional average. Importantly, 93% of the innovative start-ups¹⁰ operate in an EI and about half of high-growth start-ups and SMEs belong to EI. These figures confirm the strong dynamism and potential of this sub-group of industries, key to the regional transformation agenda.

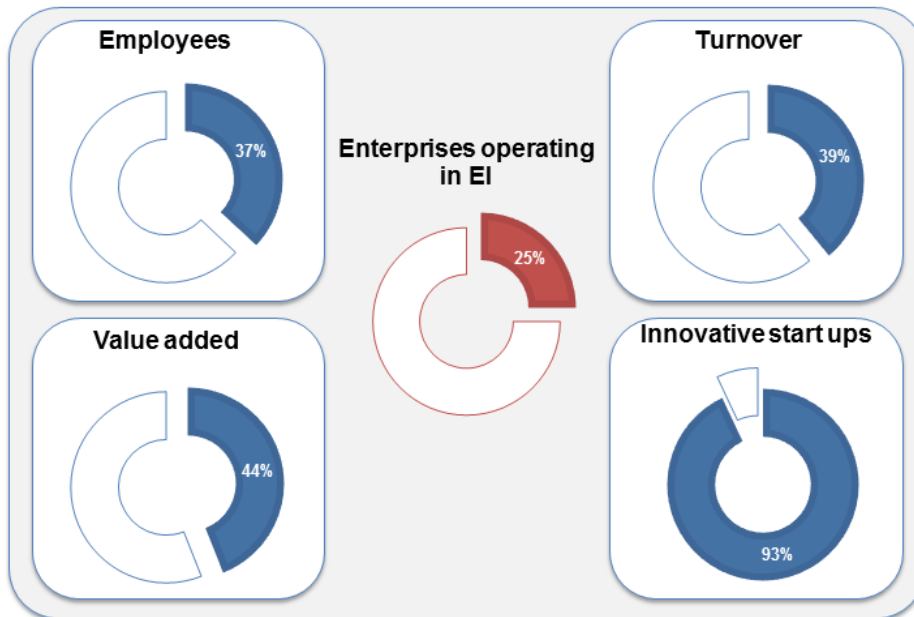
⁸ The regional association for Lombardy's chambers of commerce (www.lom.camcom.it)

⁹ The access to microdata is extremely useful; indeed it allows monitoring the industrial dynamics at a micro scale, especially to better describe start-ups or gazelles activities and to understand peculiarities associated to different age and size (e.g. SMEs and young and gazelles) as well as growth rates categories.

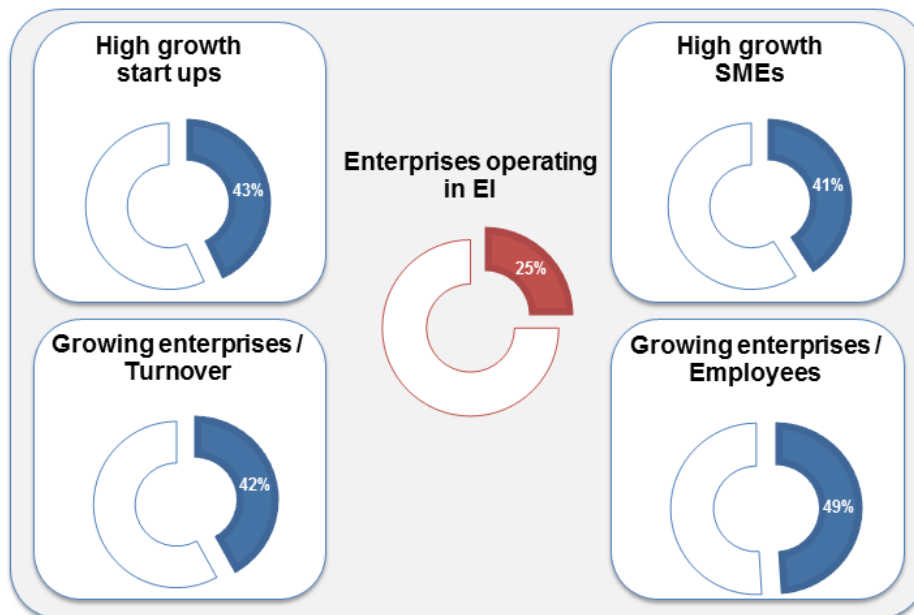
¹⁰ An innovative start-up is a firm founded within the last 5 years and with a turnover of less than 5 million and which business lines focus on innovative product and/or services with a high technological content. http://startup.registroimprese.it/index_en.html

Figure 2: Emerging Industries in the Lombardy economy

The size of EI in the economy



EI as a dynamic part of the economy



Source: own elaborations.

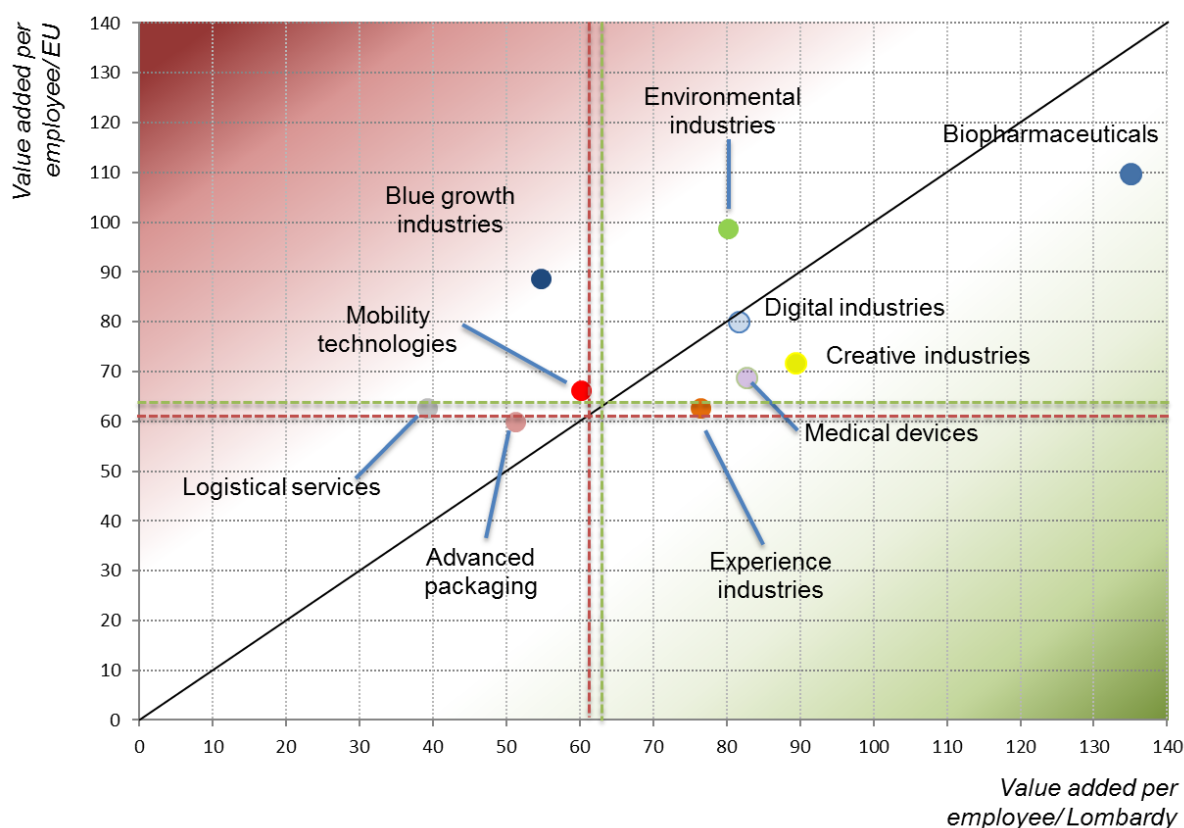
As it could be seen in Table 1, EI represent a rather heterogeneous group of industries. Capturing these specificities is essential in order to design better tailored policy support schemes. This is relevant for instance if policy aims at supporting their growth and expansion in the markets (regional, national and international).

Moreover, regions will often have different competitive advantages across specific industries. The concept of competitive advantage is central in the Smart Specialisation narrative; thus a better understanding of the regional industrial specialisations appears fundamental for a well-

informed decision making (SWOT analyses are recommended in RIS3 steps). For this case study, the competitive advantages are defined based on two indicators: the value added per employee and the average income. This choice relates to the need to create a competitive economy and better jobs, consistently with the public authorities' priorities and with the Juncker priority of boosting jobs, growth and investment.¹¹

Figure 3 depicts the relative position of EI in Lombardy with respect to the rest of the EU. On the horizontal axis, the value added per employee in Lombardy is reported, while in the vertical one the EU average is shown. The average value added for Lombardy and EU are plotted using green and red dashed lines respectively. The 45 degree line splits the figure in two areas: above the line are the EI for which the productivity is higher in the rest of the EU (i.e. lower in Lombardy), while below the line feature the EI where Lombardy region reports a superior productivity.

Figure 3: Comparing average value added of EI in Lombardy and the rest of EU



Source: elaborations from data provided by Unioncamere Lombardia and available data on European Cluster Panorama and European Cluster Observatory.

Note: green lines indicate Lombardy average, red one the EU average.

Biopharmaceutical industries show the highest value added among the EI, and Lombardy shows a productivity advantage with respect to the EU average. Also in Creative Industries,

¹¹ https://ec.europa.eu/commission/publications/president-junckers-political-guidelines_en

Lombardy performs quite well, both in absolute and relative terms. Lombardy's Digital industries present a value-added per employee higher than the region's average but similar to the EU average value. In contrast, Environmental technologies in Lombardy report higher productivity levels than the overall industry average of the region (intra-regional industrial advantage), whilst no comparative advantage is observed with respect to the EU's Environmental industries (inter-regional industrial advantage). Industries like Advanced packaging and Logistical services exhibit productivity values similar to the EU-average value and slightly lower than the whole region's average per employee VA.

These basic statistics give an insightful profiling and benchmarking of Lombardy performances in the EI. Moreover, they can be complemented with a range of information such as the firm size, growth patterns, innovation processes and sources, and market needs to strengthen the evidence base in view of better fitted policy interventions. Indeed, often at the crossroads of industries, emerging industries may have a range of needs (entirely) different from mature industries, where modernization is usually targeted. Thus, and even more for EI, which often bring together distinct technological and business contexts, it is very critical to avoid a one-size-fits-all industry policy (Fuchs, 2014).

Figure 4 reports a growth/share matrix, which provides some examples of opportunities for EI at different stages following a qualitative and practice-based approach. Industries are located in the quadrants according to two dimensions at least: growth and comparative advantage with respect to the EU.

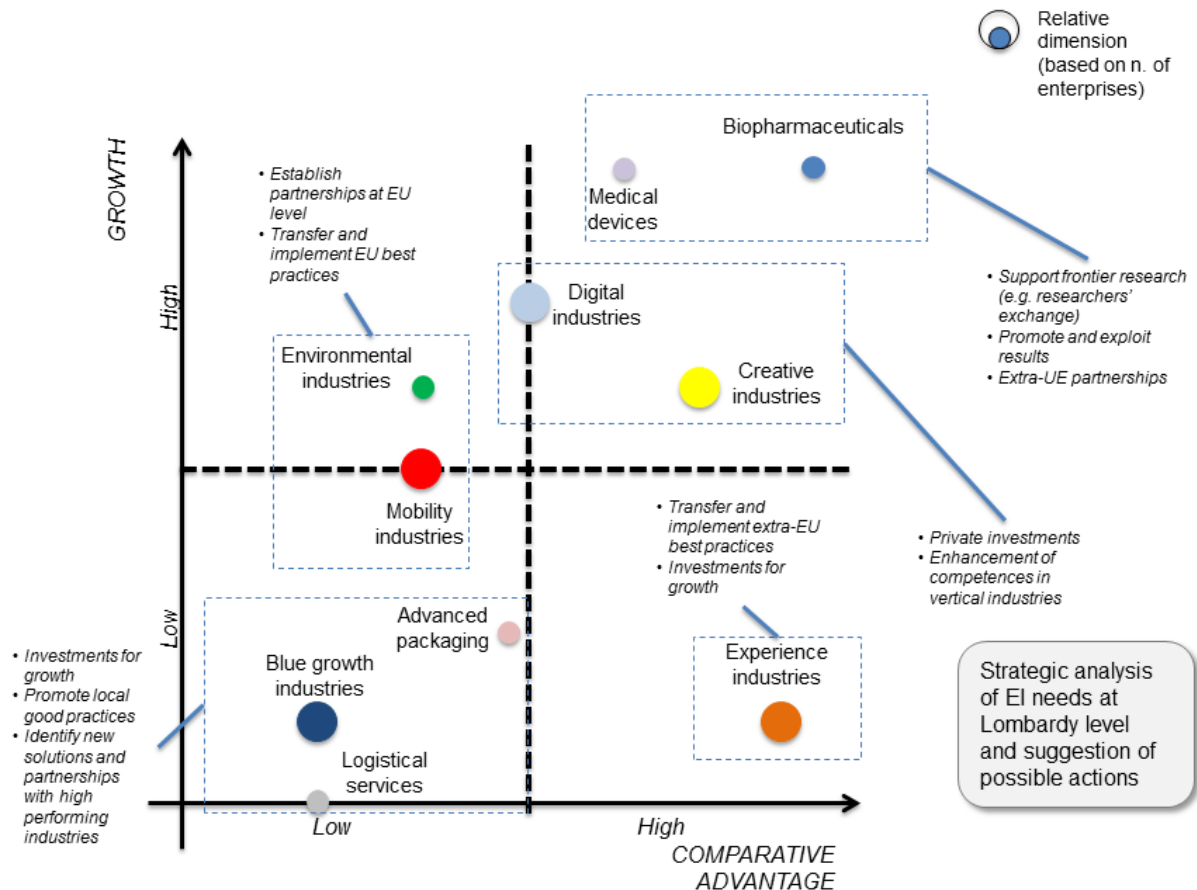
The first dimension (vertical axis) refers to industry growth rates in terms of turnover and employees and EI are ordered accordingly. The industries reported above the horizontal line feature annual growth rates of 5% or above, over the three years preceding 2013. Biopharmaceuticals and Digital industries, respectively record the highest growth rates both in terms of turnover and employees, while lowest rates can be observed in Blue growth industries and Experience industries. These two industries actually exhibit similar growth rates, but they split apart when the second dimension is accounted for.

The horizontal axis attempts to represent the comparative advantages of Lombardy's EI, when the EU is taken as the baseline. Similarly to the vertical axis, this dimension is twofold, combining information from value-added per employee and average wage. Again, Lombardy-based Biopharmaceuticals companies appears to be in the upper reaches; in other words, in this EI, the region would benefit both from a growing market and relatively strong competitive advantage, supporting frontier-research targeting as well as providing relevant grounds for international partnerships. Other industries where the region has stronger comparative advantages include Experience Industries and Creative Industries. What graphically differentiates these two industries is that the latter one records much higher growth rates (vertical axis).

In a nutshell, the top right panel features Lombardy's EI with high growth rates and strong comparative advantages (e.g. Biopharmaceuticals, Medical Devices); the top left panel shows EI with relatively lower comparative advantages (e.g. Environmental industries); the bottom right

panel reports industries with relatively high comparative advantage but experiencing low growth rates (e.g. Experience industries); finally, the bottom left panel points to Lombardy's EI featuring low growth rates and relatively lower advantages compared to the EU (e.g. Blue growth industries, Logistical services).

Figure 4: Opportunities and needs of EI: An example from Lombardy



Source: Growth/share matrix elaborated from data provided by Unioncamere Lombardia and data available on European Cluster Panorama and European Cluster Observatory.

New intervention approaches can be conceptualized according to the industry location in the matrix. In each region, the industrial dynamics would be different depending, among other, on the specific industrial structure and recent (global) trends; this holds particularly true when emerging industries are considered.

Descriptive analyses are relevant to draw a first overview, but remained limited for the purpose of identifying and characterizing EI. Besides the top-down approach implemented by Lombardy, the analytical phase should also integrate the bottom-up perspective. This second phase of the exercise is considered essential in order to precise further specific EI-supporting mechanisms in a place-based perspective and in view of capturing the emergence of new industries on the grounds. In this view, a method to identify cases of interest for subsequent structured interviews has been employed. This intends to deepen and bring into light novel

business models and/or emerging industrial (supply) systems, competitiveness factors, the positioning within global value chains, emerging needs as well as addressing the scalability of the business models.

The selected targets are the Lombardy-based innovative start-ups and SMEs registered in the Chambers of Commerce. The decision to select these targets mainly relies on the possibility of having further elaborations and up-to-date data with high frequency. It also relates to the nature of the subjects included in the registers, which by definition are of a great interest in the analysis of potential EIs.

During the second half of the year 2015 and the beginning of the year 2016, the period during which the bottom-up approach was implemented, more than 1000 innovative start-ups and a dozen of innovative SMEs were registered in Lombardy. The perimeter of analysis was further reduced to less than 40 candidate companies according to the following criteria:¹²

1. to be active in the NACE codes of EI identified by the European Commission;
2. for start-ups, to reach a turnover of at least € 500,000 or a number of employees equal to at least 10;
3. to meet high growth start-up definition requirements (€ 1,000,000 turnover and 10 employees) or gazelle (€ 2,000,000 turnover and 10 employees in less than 5 years from birth or, alternatively, companies up to 5 years old and featuring per year employees growth rate of at least 10% during three consecutive years);
4. to be the applicant of at least of one patent;
5. to record external equity investments (in particular by venture capital) in share capital;
6. to be active in the NACE codes falling within more than one EI identified by the European Commission.

Based on these criteria a pilot was launched. In the frame of this exercise, a first group of 14 selected companies was involved in one-to-one interviews for the purposes of the bottom-up phase. Most of the interviewed companies operate or compete in the Digital Industries, Creative Industries and Environmental industries.

The abovementioned methodology (top down and bottom up approaches) is the conceptual basis of the Observatory dedicated to the identification of the Lombardy's EI and the definition and design of tailored policy mixes. What is next? The scalability of the model will permanently involve Unioncamere Lombardia for the data analysis and the Lombardy's clusters for the bottom up phase. In this context, the clusters could play a key role for the next generation of Research and Innovation Smart Specialisation Strategies (RIS3).

In terms of policy mix, three dimensions will be accounted for when designing regional instruments to support the emergence and/or development of EI. The dimensions approved within the Regional Resolution¹³ are:

¹² Criteria 1 and 2 have been applied to the entire perimeter of Lombardy; moreover, the selected firms had to respond to at least one of the criteria 3, 4, 5 or 6

¹³ Lombardy Regional Resolution, n. X/6814, 30th of June 2017, Determinations regarding the smart specialisation strategy of Lombardy Region: emerging industries - Definition and methods of identification

1. **Innovativeness** : this also includes the adoption of new technologies and the ability to create new areas or transform existing ones;
2. **Growth capacity/rate of growth**: this refers, among other, to the signals of industries featuring high growth rates; the ability to generate wealth and quality employment are also analysed;
3. **Capacity to respond to the needs**, even potential, of the market, which requires to assess of the ability to respond to emerging needs (adaptability) and the potential of the targeted industry(ies).

2.3 Profiling regional technological advantages

The mapping of the technological competences at the regional level can facilitate more comprehensive benchmarking exercises as well as complement the analytical efforts of regions in their search for cooperation and investment partnerships. This mapping allows describing the knowledge creation processes and innovation activities that act as drivers of territorial competitiveness and employment.

Depending on the level of disaggregation of the data it is possible to analyse the main patterns and trends at the world, national and regional levels. In this respect, patent-based analysis can serve to inform regions in their prioritization exercises. In addition, such mapping of regional technological knowledge may be instrumental in reviewing the RIS3 thematic priorities as it brings, among other, more details about specific potential technological areas of interest and investment.

Patents are the main output of technology-oriented R&D activities, they contain a wealth of useful information about the invention, such as the technical fields to which the patent pertains to and the addresses of the different actors in the innovation process (applicant and inventors) (Acs, 1989). Patent documents are classified into technical fields based on a hierarchical classification system, the International Patent Classification system (IPC), with about 70 000 entries (IPC classes). Schmoch (WIPO, 2013) developed a hierarchical classification scheme which groups IPC classes into 35 technological fields belonging to five main technological areas, namely: Electrical Engineering, Mechanical Engineering, Instruments, Chemistry, and Other Fields.

In what follows, the technological profiling of four EU regions (Lombardy, Baden-Württemberg, Catalonia and Lapland) will be analysed using patent filings at EPO during the period 2011-2013. These filings were retrieved from REGPAT, a PATSTAT version developed by the OECD where patents are linked to regions (NUTS2) according to the addresses of the applicants and inventors. In the present study, we exploit the location data for inventors to examine the technological capabilities of the four European regions. The underlying assumption is that the inventors' location is a relevant and systematic approach to proxy the geographical area(s) where technological and knowledge creation activities are carried out. We fractionally count the number of patent filings across regional inventors' locations for each of the 35 WIPO technological fields.

Table 2 summarises the relative technological performances of the four regions involved in the S3Lab on Emerging Industries. In the first column, 'overall growth of patents' refers to the change in EU patenting activities between 2001/03 and 2011/13 per WIPO technological field. For each region considered in the report, we compute the relative growth rates in patenting activities over the same period. The blue cells correspond to fields where the regional growth of patenting is higher than the EU average and grey cells denote growth rates that are lower than the EU average; white cells denote fields with less than three patents per year in the 2001/03 period (given the low initial patenting activity, comparisons based on growth rates may be misleading).

The growth of patenting activities varies greatly across technological fields and point to regional differences in the technological development paths. The top 10 fast-growing technologies (FGTFs) over the period considered are: 1) 'Thermal processes and apparatus'; 2) 'Electrical machinery, apparatus, energy'; 3) 'Other consumer goods'; 4) 'Micro-structural and nano-technology'; 5) 'Medical technology'; 6) 'Furniture, Games'; 7) 'Civil Engineering'; 8) 'Environmental Technology'; 9) 'Engines, pumps, turbines'; 10) 'Material, metallurgy'. All these fields show growth rates over 30%, whereas 'Telecommunications' and 'Basic communication processes' record an important drop in the patenting activity (superior to 40% decrease).

Baden-Württemberg, Catalonia, Lapland and Lombardy present quite distinct patterns of technological development over the decade. Catalonia exhibits particular good performances in the broadest set of technological fields; that is in 14 over the 35 fields. In contrast, Lombardy presents a relatively more stable pattern of technological development. For this latter region, above-EU average growth rates are found in 'Analysis of biological material', 'IT methods for management', 'Digital communication' and 'Basic materials chemistry'. With the exception of Lombardy, the regions show growth rates higher than the EU average in 'Medical technologies' and 'Audio-visual technologies' (an overall declining patenting field in the EU).

Table 2: Patent growth rates by WIPO technological field (2001-2003 to 2011-2013) and relative regional performances.

Technological field	Overall growth of patents	Baden-Wutternberg	Catalunia	Lapland	Lombardy
Thermal processes and apparatus	64.8%				
Electrical machinery, apparatus, energy	59.9%				
Other consumer goods	51.2%				
Micro-structural and nano-technology	47.7%				
Medical technology	41.7%				
Furniture, games	39.2%				
Civil engineering	36.6%				
Environmental technology	36.1%				
Engines, pumps, turbines	34.2%				
Materials, metallurgy	30.9%				
Measurement	30.2%				
Other special machines	27.8%				
Mechanical elements	22.4%				
Surface technology, coating	22.4%				
Analysis of biological materials	19.8%				
Digital communication	17.2%				
Machine tools	16.9%				
Transport	15.7%				
Handling	14.1%				
IT methods for management	13.7%				
Food chemistry	12.6%				
Chemical engineering	9.4%				
Macromolecular chemistry, polymers	8.9%				
Control	7.6%				
Semiconductors	5.7%				
Basic materials chemistry	4.8%				
Computer technology	3.3%				
Biotechnology	-7.7%				
Organic fine chemistry	-22.5%				
Pharmaceuticals	-28.4%				
Audio-visual technology	-28.8%				
Optics	-30.2%				
Textile and paper machines	-33.0%				
Basic communication processes	-41.4%				
Telecommunications	-42.5%				

Note: Technological fields are ranked by the growth rates between the two periods. Blue cells correspond to fields where the regional growth of patenting is higher than the EU average, where grey cells denote growth rates or rates lower than the EU average.

In the next step we calculate the RTA values for the 35 WIPO categories of the four regions of interest. The relative technological advantage (RTA) is a common indicator of technological specialisation, which can be used to proxy and map the technological competences of regions. The RTA of a region i a technological field j is defined as it follows:

$$RTA_{ij} = \frac{p_{ij}/\sum_j p_{ij}}{\sum_i p_{ij}/\sum_i \sum_j p_{ij}} \quad (1)$$

In equation 1, p_{ij} is the number of patents related to technological field j filed by inventors in region i . RTA values above 1 mean that the share of region i 's patents in the technology field j is higher than the EU's share of patents in this field. In this case, the region is said to have a relative advantage in the given technology. Symmetrically, RTA values lower than 1 correspond

to fields where the region is said to be relatively less specialised.

Figure 5 pictures, for each region, the relative technological advantages in the two periods considered (2001/03; dotted lines; 2011/13; plain lines) in order to explore the changes in the technological specialisations over the last decade.

Within the top 10 fast growing technological fields (FGTFs), Lombardy is the region with the greatest number of specialisation areas. Indeed, it presents relative technological advantages in seven out of the ten fast growing fields. In terms of relative changes, the region has lost its relative advantages in 'Micro-structural and nano-technology' while it has gained comparative advantages in the development of 'Medical technologies' over the period considered. Among the FGTFs, the region records relatively stronger advantages in 'Furniture, games' and 'Other consumer goods'.

Baden-Württemberg is specialised in five out of the 10 fast growing fields, performing particularly well in fields such as 'Engines, pumps, turbines', 'Thermal processes, and apparatus', 'Electrical machinery, apparatus, energy' and 'Environmental technology'. During the last ten years, the region has built up comparative advantages in the development of fast-growing technologies related to 'Furniture, games' and 'Other consumer goods', whilst losing its relative specialisation in 'Micro-structural and nano-technology'. These changes brought Baden-Württemberg and Lombardy's technological profiles closer to each other than ten years ago.

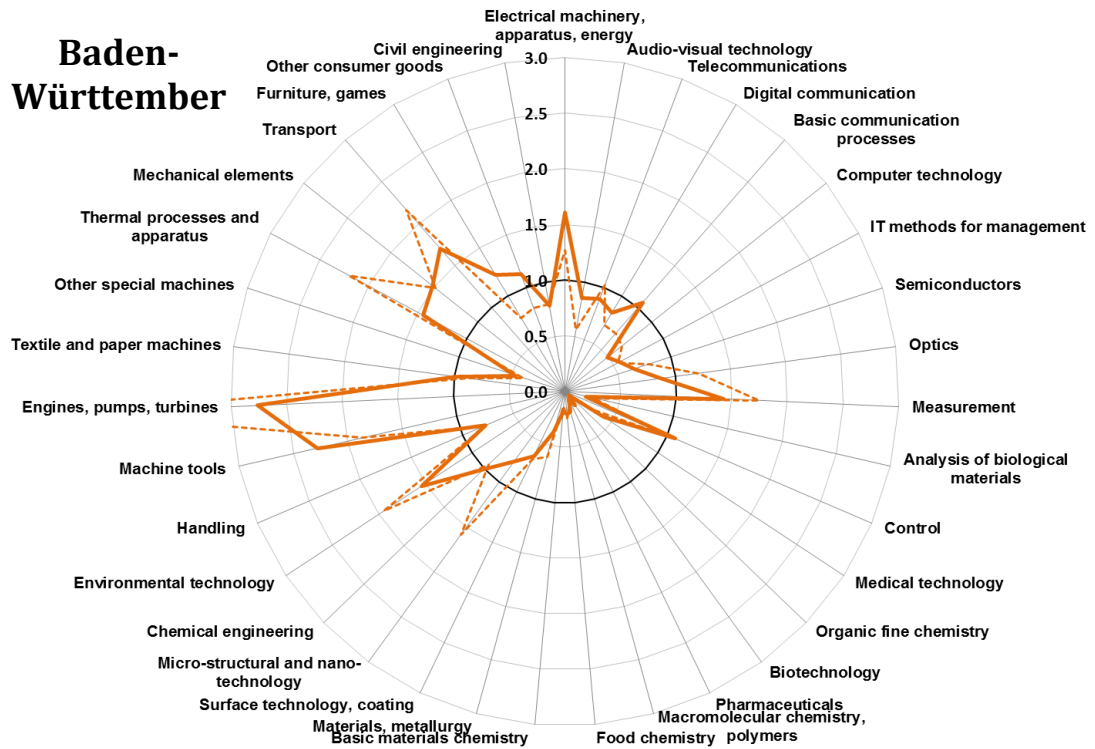
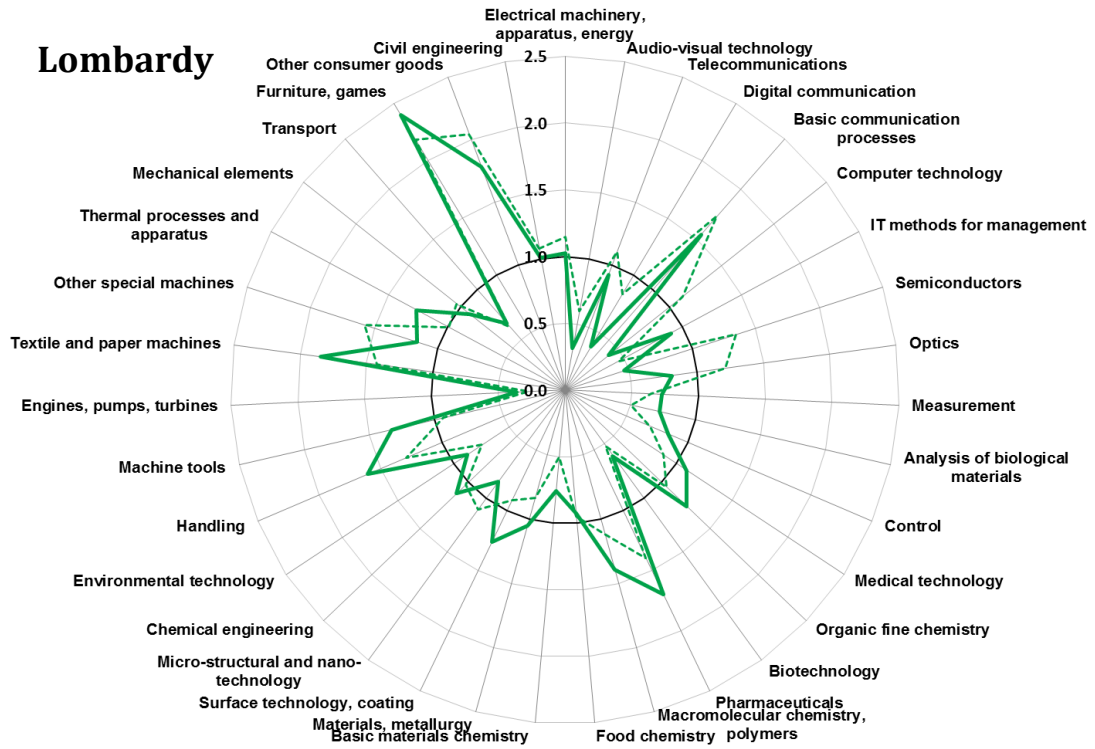
As compared to Lombardy and Baden-Württemberg, Catalonia presents a much narrower specialisation within the FGTFs. Indeed, Catalonia appears to be specialised in 'Medical technology', 'Engines, pumps, turbines' and 'Furniture, games'. The first two technological fields represent new areas of relative specialisation for the regional environment developed during the period considered. In the same period, Catalonia gained relative technological advantages in the 'Analysis of biological materials', and 'Biotechnology'. These new comparative advantages add to prior specialisations in 'Pharmaceuticals', 'Organic fine chemistry' and 'Food Chemistry' and form all together a set of strong regional competences around medical and biochemical technologies (the region lost its comparative advantage in 'Chemical engineering').

Lapland, by far the smallest region considered, shows among the FGTFs relative technological advantages in 'Thermal processes and apparatus' and 'Environmental technology'. The Lapland region experienced an important drop in the RTA value in 'Chemical engineering' and 'Basic communication processes', while it increased its specialisation in 'Digital communication', suggesting some substitution among the two technologies.¹⁴

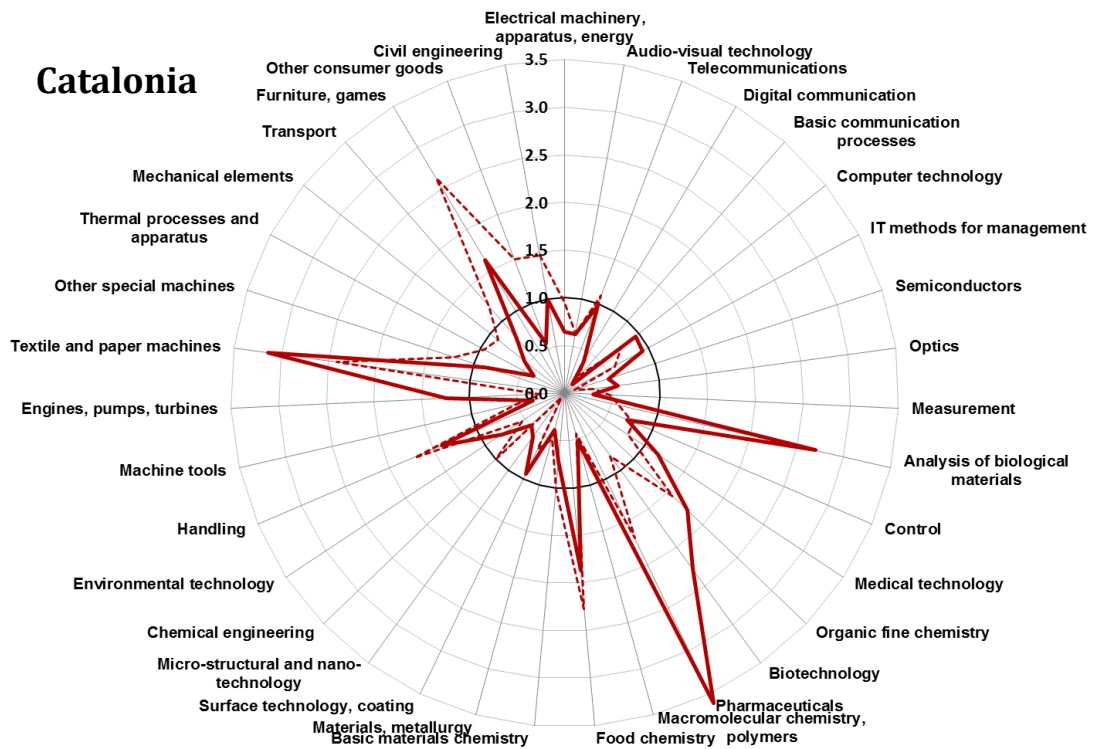
Overall, the extent to which regions shift from non-specialisation to specialisation in their technological activities - and vice-versa - does not seem too extensive. This is consistent with the stability of specialisation profiles observed at more aggregate levels in the short and medium term (path dependency). Moreover, it suggests that further insights can be gained from the analysis on the dynamics of RTAs beyond the specialisation/no specialisation dichotomy.

¹⁴ For the sake of readability, RTAs values are cut at 3 in the chart. The RTAs of Lapland in 'Digital communication' almost doubled during the period considered reached a value of 8.4.

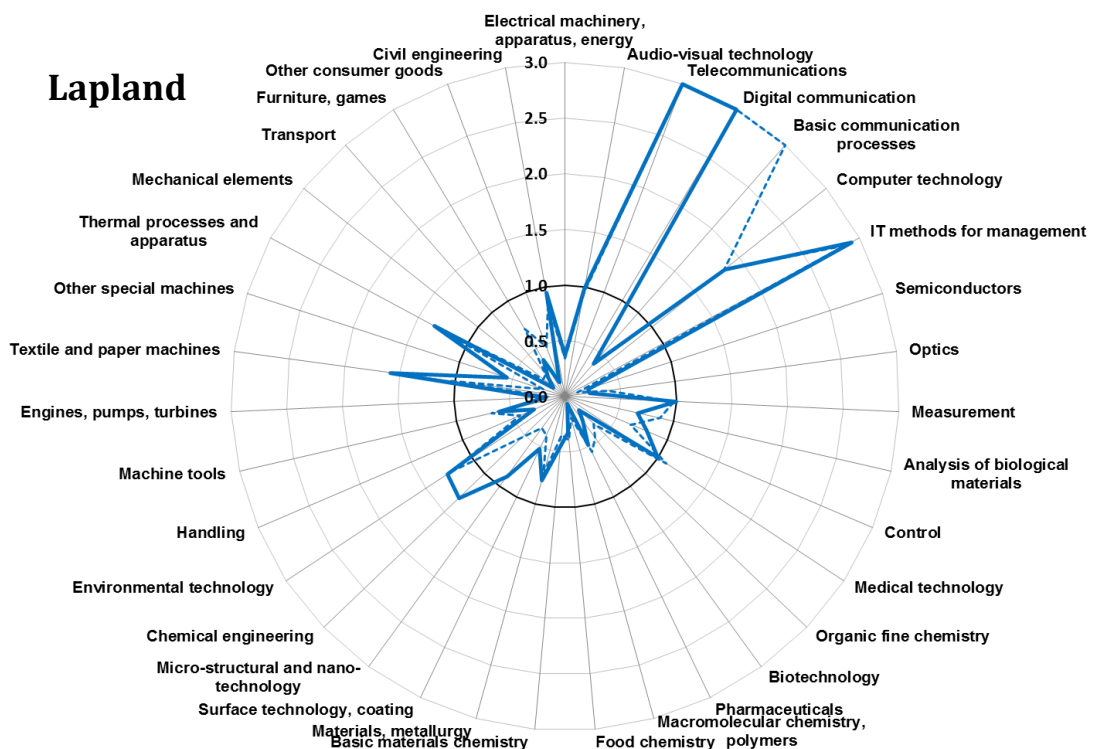
Figure 5: Relative technological advantages by region (2011/13 versus 2001/03)



Catalonia



Lapland



Note: RTAs in 2001/03 are represented with dotted lines and plain lines denote RTAs in 2011/13.

Looking at the latest years (2011-2013), we may explore different patterns of the regional technological specialisations. For each region we count the number of different technological fields with RTA values over 1 (specialisation). This is an indication of the diversity of technological competences. In addition, we count the technological fields where the number of patents in each of the four regions exceeds the EU average number of patents in that specific field. The results are summarised in Table 3.

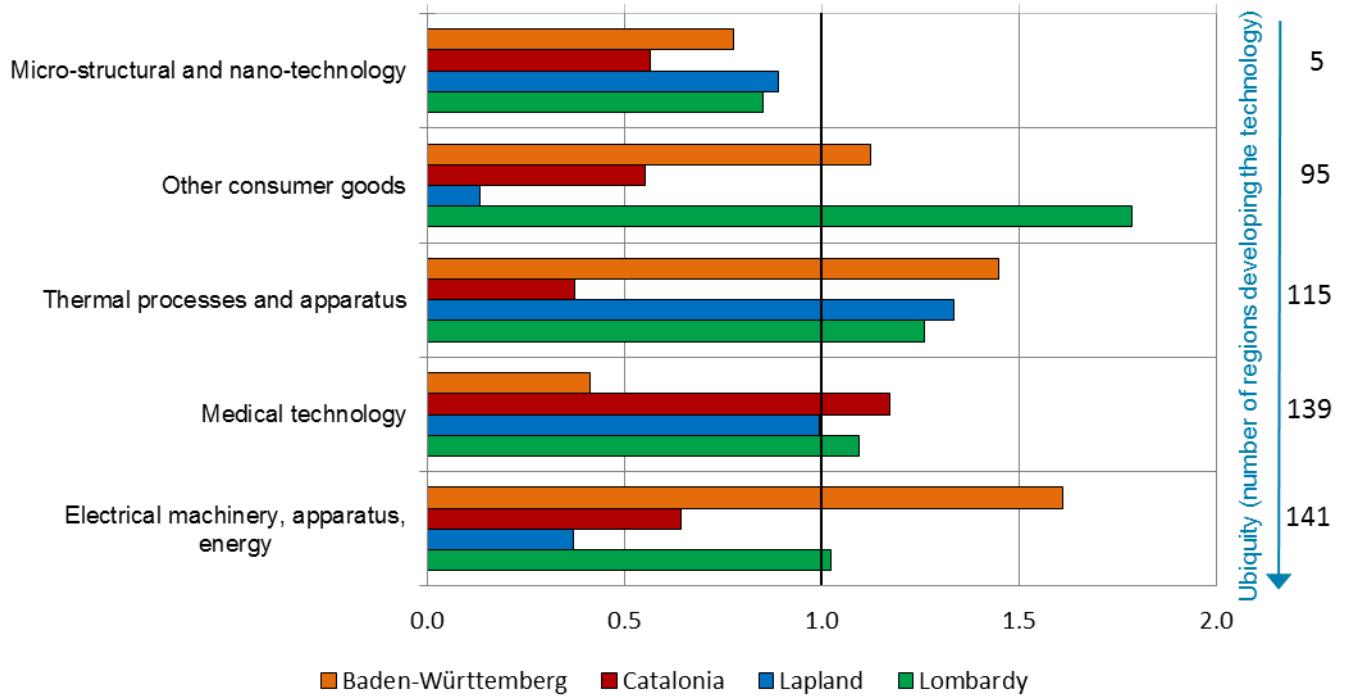
Table 3: Number of technological fields where regions specialise and where they patent more than the average

Region	RTA>1	Patents>avg	RTA>1 and patents>avg
Lombardy	17	25	17
Catalonia	14	8	8
Lapland	8	3	3
Baden-Württemberg	13	28	13

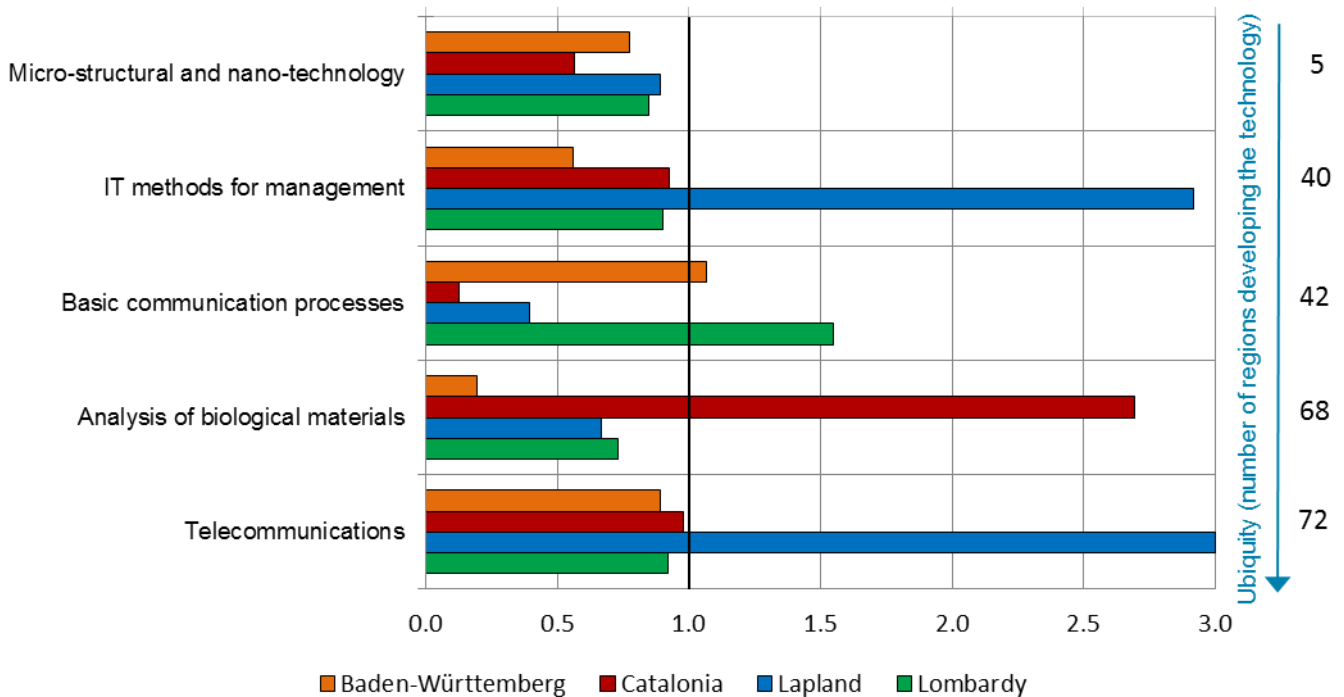
Technological diversification is the highest in Lombardy having above-one RTAs in 17 out of the 35 WIPO technological fields; at the same time the patent filings by Lombardy-based inventors exceed the average number of filings by EU regions in 25 out of the 35 WIPO fields. In other words, Lombardy region seems to have a rather high critical mass in the technologies where it is specialised. To a lesser extent, Baden-Württemberg and Catalonia are also highly diversified with 14 and 13 WIPO technological fields presenting RTA values over 1. However, Baden-Württemberg shows a high critical mass in a broader set of technologies than Catalonia, probably due to the larger size of the region and its higher patenting activity. Lapland, a region with less than 200,000 inhabitants, shows specialisation in 8 technological fields and a high critical mass in three of them, all communication related technologies. Expectedly, the extent of technological diversification is somehow related to the size of the territory considered.

Finally, Figure 6 reports the specialisation of the four regions respectively in the top five fast-growing (top) and least five ubiquitous (bottom) technological fields. Ubiquitous technological fields (or technologies) are those where the highest number of regions are active in terms of patenting, therefore the least ubiquitous identify "niche" technologies. As suggested by Hausmann, Hidalgo et al. (2007) complex technologies – those requiring many pieces of knowledge – tend to be less ubiquitous.

Figure 6: Regions specialisation in fast growing and least ubiquitous technological fields.



Fast growing technological fields



Least ubiquitous fields

Note: Only regions with more than 3 patents per year were considered in this analysis. An above-one index of specialisation in a ubiquitous field intends to proxy for the ability of a region to specialise in a "niche" field (where a few regions are able to develop new technologies).

Given the current conceptual shift from sectoral dynamics to global value chains, it is relevant, especially for smaller (less diversified) regions to identify niche areas with high transformative potential. In order to identify those regions which specialise to a greater extent in these technological fields, we count the number of EU regions with at least one patent in a specific technological field in the period under study. Then, the specialisation of regions in ubiquitous fields is computed as previously (RTAs, see pp. 22-23). In Figure 6, we show only the five least ubiquitous fields among the EU regions.

Looking at the top fast-growing technological fields, 'Thermal processes and apparatus' and 'Medical Technologies' are the technologies where three out of four of the regions display comparative advantages. Lombardy and Baden-Württemberg are also specialised in 'Other consumer good' and 'Electrical machinery, apparatus, and energy'. None of the four regions specialise in the least ubiquitous and fast growing field of 'Micro-structural and nano-technology'.

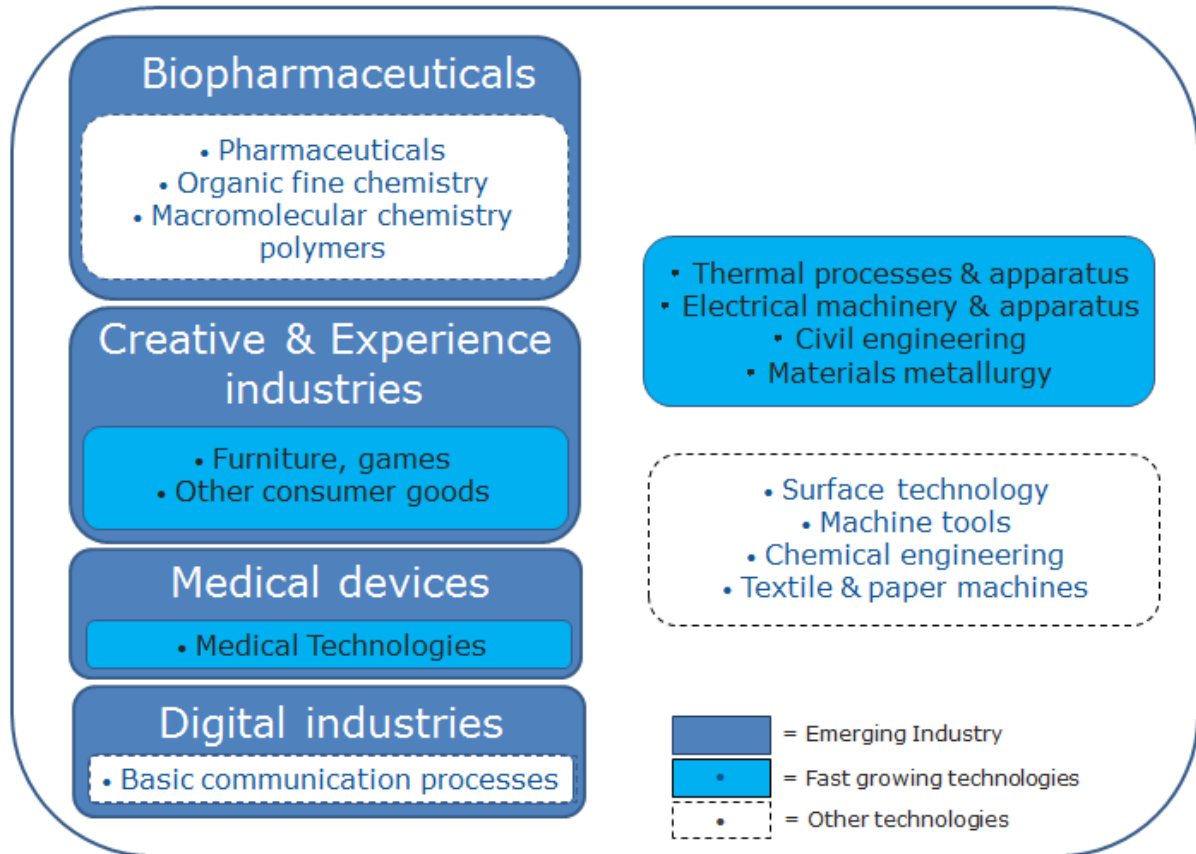
Considering the least ubiquitous fields, different patterns of specialisations emerge. Indeed, while Lombardy and Baden-Württemberg have relative technological advantages in 'Basic communication processes' (developed in 42 EU regions), Catalonia appears to be the sole region relatively specialised in 'Analysis of biological materials', consistently with its cluster of technological competences mentioned above. Differently from the other regions, Lapland is specialised in two out of the five least ubiquitous fields, namely in 'IT methods for management' and 'Telecommunications', that are communication-related technologies.

2.4 Putting the two approaches together

In Figure 7, we bring together the comparative advantages derived from the Lombardy regional exercise on emerging industries (Figure 4) and the technological specialisations of Lombardy, as profiled in the broader EU context (Figure 5). Although such comparative exercise should be undertaken with care, a few initial observations can be made.

Biopharmaceuticals features as a key driving EI in Lombardy as illustrated by the per employee value-added and average wage ratios above the EU average. This industry includes firms operating in the upstream (chemical) and downstream industries (wholesale & packaging) as well as R&D-performing companies dedicated to the production of medical drugs by biotech methods. These relative economic performances may be traced back to the significant presence of the pharmaceuticals industry in Lombardy. Moreover, the EU-benchmarked technological strengths suggest that the region also relies on persistent technological advantages in related fields such 'Pharmaceuticals', 'Organic fine chemistry' and 'Macromolecular chemistry, polymers'.

Figure 7: Top emerging industries & technological advantages in Lombardy



Similarly, Lombardy's 'Medical devices' industry is performing relatively better than the EU average both in terms of value added and employees. This EI is related to the manufacturing of products based on biomedical engineering and developed through mechanical, electrical and/or materials engineering. The region has also become relatively specialised in the development of 'Medical technology' over the last decade. Considering that 'Medical technology' is a fast-growing technology, the region seems to be relatively well-endowed to position itself building upon consistent technological development capabilities.

Other EI of importance in the region include 'Creative industries' and 'Experience industries', respectively reflecting business operations in activities related to culture, architecture & design, graphic & fashion design, advertising, for the former, and to accommodation & tours, food & drink, gambling, museums, sports & leisure & arts, for the latter. The technological profiling of the region shows, that such EI-related advantages can be associated with two long-term areas of regional technological specialisation, namely 'Furniture, games' and 'Other consumer goods'. These fields feature also among the top 10 fast-growing technological fields in Europe over the period 2001/03-2011/13.

Also 'Digital industries' in Lombardy appear as a growing EI but the region departs from a less strong comparative advantage as benchmarked with the EU and in comparison to other EI (Figure 4). The region's production of IT-related services and hardware support may be connected with relatively stable technological strengths in 'Basic communication processes'.

However, especially with respect to these industries the use of patent analysis may be limited by the rules governing the European Patent Convention (EPC). Indeed, under the EPC a computer program claimed "as such" is not patentable and program listings as such are protected by copyright.¹⁵ Therefore, at least with respect to the soft part of the "digital industries" in Europe, an approach based on firm level data, eventually complemented by the analysis of investments in intangible assets other than R&D, may be preferable.

Finally, the region appears to be specialised in promising technological fields that seems to be related to industries/activities other than the specific EI identified by the European Cluster Observatory. Obviously, this does not mean that these technologies are unrelated to the targeted EI, which can be users of a broader range of technologies and products and technologies. On the contrary, the technological approach might reveal signals about potential complementary or alternative technological areas of interest for the region that are not (yet) directly ascribable to EI.

Overall this comparison suggests that combining "bottom-up" regional methodologies with benchmarking analyses at the EU/global level puts forward insightful analytical consistencies and provides information that complements each other. Informed by comprehensive analyses, local pilots and experimentations, RIS3 strategies might uncover pathways to high-potential activities and bring regions to the development of medium- long-term competitive assets.

3. Conclusions

The concept of Smart Specialisation emphasizes the principle of prioritisation to foster economic development by targeting some specific technologies or industrial fields. This concept has been sometimes translated in a 'static imperative': "look at what are you good at and built upon it". However, an important dimension of a successful Smart Specialisation strategy is the continuous search for new opportunities for structural change within regions. In this work, we restate the importance of the dynamic aspect of Smart Specialisation. Then, we discuss why this is underexplored and provide some relevant examples as a base to develop evidence-based mechanisms for regional search. In particular, we link the concept of Smart Specialisation with the notion of Emerging Industries. In doing so, we also limit the scope of research to new opportunity fields in the industrial landscape.

Targeting emerging industries is likely to require novel or updated policy instruments to support the related entrepreneurial activities and the development of new industrial segments as the foundations for the regional industrial transformation. Further analysis is needed, but these instruments are expected to depend upon the maturity of the sector, the capital intensity, growth potential and competitiveness factors. In this respect, awareness about the specific

¹⁵ For a patent to be granted for a computer-implemented invention, a technical problem has to be solved in a novel and non-obvious manner (<https://www.epo.org/news-issues/issues/software.html>).

needs of start-up companies and direct interactions with "non-usual suspects" can only further enrich our understanding of the actual industrial dynamics and strengthen the evidence base for Smart Specialisation processes. Moreover, our report puts forward key challenges in terms of data analysis and collection capabilities in relation, for instance, to the monitoring and benchmarking tools available to and within regions. Such tools are crucial in order for regions to better design of strategies for the development of future regional competitive advantages.

Combining evidence from technological trends at the macro level with regional analytics offers relevant avenues to inform regions in their process of selecting specific technologies and industries in a Smart Specialisation fashion. Moreover, such exercises may be instrumental to provide insights on the similarities across EU regions in view of targeting further collaborative and mutual learning initiatives. In this latter perspective, common definitions or grids as the ones promoted by the European Cluster Observatory are undoubtedly necessary, if not essential, in a still fragmented EU industrial and technological landscape.

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