Regional Innovation Monitor Plus 2016

Regional Innovation Report
Emilia-Romagna (Industry 4.0 and smart systems)

To the European Commission
Internal Market, Industry, Entrepreneurship and SMEs Directorate-General
Directorate F – Innovation and Advanced Manufacturing
Regional Innovation Monitor Plus 2016

Regional Innovation Report
Emilia-Romagna (Industry 4.0 and smart systems)

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**PREFACE**

In the context of the growth and investment package set out in the Investment Plan of the European Commission, the Regional Innovation Monitor Plus (RIM Plus) provides a unique platform for sharing knowledge and know-how on major innovation and industrial policy trends in in some 200 regions across EU20 Member States.

Launched in 2010, the Regional Innovation Monitor aimed at supporting sharing of intelligence on innovation policies across EU regions. Building upon the experience gained and results obtained during the period 2010-2012, the RIM Plus 2013-2014 provided practical guidance to regions on how to use the collected information, via a network of regional experts. Since 2014, the RIM Plus has introduced a thematic focus on advanced manufacturing.

The RIM Plus 2015-2016 evolved from a general monitoring of innovation policies towards establishing a more thematic focus in selected areas in order to contribute to improving the competitiveness of European regions.

Particularly, the RIM Plus aims through its activities and in close cooperation with the regional stakeholders and other relevant initiatives to achieve the following:

- Contribute to the development of new and open spaces of collaboration and exchange on advanced manufacturing, each with a clearly defined thematic focus.
- Play an enabling role in providing evidence-based information on specific themes and bring in outside perspective from other regions.
- Map out regional practices in support of advanced manufacturing and relevant pilot/demo projects and work towards involving the relevant stakeholders.
- Provide an easy access and comparative overview of regional innovation policies and relevant actions in the field of advanced manufacturing.
- Share the lessons learned with the European Commission services to feed into the preparation of future programmes.

The main aim of 30 regional reports is to provide a description and analysis of developments in the area advanced manufacturing with a clearly defined thematic focus and regional innovation policy, taking into account the specific context of the region as well as general trends. All regional innovation reports are produced in a standardised way using a common methodological and conceptual framework, in order to allow for horizontal analysis, with a view to preparing the Final EU Regional Innovation Monitor Plus report.

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*Further information:*

Executive Summary

1. Advanced Manufacturing: Industry 4.0 and Smart systems

Emilia-Romagna can be considered a strong manufacturing region. In statistical terms, strictly manufacturing employment and value added account only for about 25%, but many other sectors are directly connected with manufacturing performance: logistics, trade, ICT, several parts of services and also part of the primary sectors and of building sector. The effective relevance of manufacturing can indeed be valued at around 65% of GDP.

In the manufacturing sector, the mechanical engineering is the most important, covering, with all its various sectors, more than 50% of employment and more than 60% of exports. Despite the relevance of the agro-food cluster and the construction cluster, mechanical engineering and automotive represent the most relevant cluster of the region.

In recent years, the regional government has invested strongly in R&D and innovation, promoting research-industry collaboration and creating a Regional High-Tech Network in which one of the platforms of laboratories is dedicated to advanced mechanics and materials. The Smart Specialisation strategy assumed, as well, the field of mechatronics and automotive as one of the main priorities for R&D investment. Most of items linked to Industry 4.0 are already treated even if not with adequate systematisation.

Industry 4.0 and smart manufacturing can have a transversal impact both on consolidated and emerging clusters (even if mainly in mechanical engineering), and also creating opportunities of reciprocal contamination. Digital manufacturing, at the same time, generated opportunities for new informal start-ups and bottom-up initiatives all over the regions, the so called 'Fablabs', that are diffusing the new culture and the new approach to manufacturing to the younger generation.

- **Challenge 1. Increasing awareness about the potential of broadband infrastructure:** First challenge is that of making companies aware of the potentialities and risks of broadband. Most of them imagine that it will simply facilitate trade through e-commerce but not that it is possible to reorganise entire value chains and that the nature of work will change. The region has achieved a remarkable presence of broadband access all over the major and minor population centres; companies individually or by consortia can easily access broadband connections and services, but they need to understand the real advantages they can obtain, the risks linked to missing these opportunities, and what changes will occur in their business model and in the organisation of the value chain.

- **Challenge 2. Better connecting research to industrial innovation:** A second challenge is that of further improving the connection and positive interaction between the spheres of research and of companies. After several years of work, and despite some significant improvements, there is still a significant separation between the two spheres. The future efforts of the region will consist in determining a wider autonomy in the industrial research laboratories, increasing their attention to the market. It will be essential to develop finalised projects involving firms and combining competencies of mechanical, materials and digital competencies, largely available in the research and university system. Still, several technological results remain unexploited for lack of adequate motivation context and opportunities for researchers, or for lack of information for companies; it remains a crucial
challenge for further increasing the competitiveness of the region, considering the dynamism and the ability for quick reaction of its social and entrepreneurial environment.

- **Challenge 3. Absorbing creative resources into firms:** For traditional or even for some type of innovative firms it is not normal to introduce some types of protagonists typical of the creative economy. Creative people are normally difficult to manage and include in an organisational scheme, because they need freedom of thinking and of initiatives. But it is a fact that the world of creative people has been very quick to adopt the concept of digital making or manufacturing, in many cases much weaker than consolidated firms. It is necessary to find new managerial schemes to valorise this new propensity and to transform it in real value. From a concrete business point of view, Industry 4.0, especially in the dimension of Internet of Things, requires first of all a reinforcement of the creative and technical design function within firms, in order to keep control of the value chain. The experience of Fablabs, especially in that original aspect of matching traditional handicraft production with digital design and 3D printing can be a great source of strategic human resources for the industrial system.

- **Challenge 4. Redesign business and network models and managerial approaches:** It is evident that several organisational changes will take place within firms and they will change the business and the network models of firms. The capacity of firms to successfully compete will depend on the capacity to mobilise adequate creative and innovative resources according to teamwork and methods of organisation in a context of open innovation. This is a very complicated cultural change for the great majority of firms. The part of the system most exposed to such changes consists of providers and subcontractors, normally the weaker components of the value chains. It is true that not everything will be made by 3D printing or the Internet of Things, but several of these firms risk being excluded by their traditional collaboration networks or reducing their contractual power and added value. There is the need for a careful policy action for extending the participation of the majority of protagonists to this phase of change in manufacturing, and it is possible to involve the leading firms themselves in programmes of reorganisation at the cluster level.

- **Challenge 5. Reinforcing ICT and service innovation:** Two of the main weaknesses of Emilia-Romagna productive system can be jointly individuated in the ICT sector and in the service sector in general. The ICT sector, excluding some cases of excellence, is not enough developed and is represented by very small software developers with little management and innovation capacity. They are less attractive for young ICT engineers. The best ICT competences are embodied in manufacturing companies, meaning that innovation is basically led by manufacturing and not by ICT. The same it happens with other services, especially knowledge-intensive services. The level of productivity is quite low, since most of the time they are individual or micro firms, or sometimes, individual professionals. It is necessary to stimulate the transforming power linked to service innovation by a structural reinforcement of this sector, which could have a relevant impact also in other fields, not only manufacturing, but also tourism, retail and social. But it is absolutely crucial that Industry 4.0 be accompanied by service innovation in order to establish completely new relationships at the market level.

- **Challenge 6. Exploring new applications for business related to Industry 4.0:** It is not yet clear if Industry 4.0 will mean an increase or reduction of employment in consolidated sectors. But it is almost certain that it will create new product possibilities, new markets, and new sectors and
business opportunities. In the world of arts, handicrafts, architectural recovery, or even reconstruction of lost artworks, or in the health and wellness sector, for building artificial bones or prosthesis. In a few words, it is possible to generate new industries, and humanistic competencies and creativity can give an important contribute to this challenge.

2. Regional Innovation Performance Trends, Governance and Instruments

In 2013 the Emilia-Romagna Business R&D expenditure accounted to €356 per inhabitant, while the Italian average is €190.6. It is the second region in Italy in this indicator, behind Piedmont, which is a region with the presence of large private research units of big companies. In this sense, it must be observed that it is one of the top performing regions in the country. At the same time public research is less than half of this value. It means that the economic environment is able to greatly mobilise and maximise knowledge resources.

In the 2000s, Emilia-Romagna’s regional expenditure in R&D grew very quickly and passed from less than 1% of GDP to 1.66%. The growth was driven by private R&D growth, which already represents more than two thirds of the total expenditure. Of course it is still far away from European objectives established in Lisbon and from the trends in Northern Europe, but it must be considered that in recent years the Italian government spent very little money to support research and development.

Employment in R&D is around 29,500 units out of a total workforce of 2.1 million people. More than 18,500 are employed in firms, with more or less the same ratio in R&D expenses. An important figure in the Italian panorama that presents a relevant gap with Northern Europe is the share of S&T graduates among people between 20 and 29 years; they are 18.7%, well above the 13.2% seen at the Italian level.

Three elements of output can be considered as a consequence of these indicators in the Italian context:

- First, the high level of exports. Emilia-Romagna is one of the regions with the highest share of exports in its GDP, and the highest if considering the value of exports per capita, which implies that exports are strongly based on quality and innovation value.
- Secondly, the good number of industrial patents registered, which traditionally sees the region at the top in Italy in relation to population.
- Finally, the relevant number of innovative start-ups, both in high-tech and digital applications, and the growth of the community of start-ups around universities and technopoles, business incubators, hubs and Fablabs.

In this positive context, and with limited public resources, the possible future orientations can be the following:

- **Maximising opportunities of relationships, ‘contamination’ and collaboration between the different types of actors of change.**

Normally, different categories of innovators have a strong identity and are not so easily available to collaborate with different groups. Considering the three typologies, scientists and engineers, informatics and creative workers, it is clear that spontaneous communication and integration it is not often simple. One future orientation of policy measures could be that of requiring a multiplicity of relationships in order to valorise the multidimensional aspects of innovation. Initial actions in this sense have already been attempted, both with support schemes and through governance and coordination activities. One of the calls that will be implemented in the next months is that of supporting projects of innovation and diversification of products and services, in which a set of possible services can be required of various natures (technology
consultancy, tests, measurement and computing, design, software and multimedia consultancy, prototyping). It is possible to give priority to projects that combine different types of support. Another possible action, already attempted, but probably to promote even more, is the match between existing consolidated firms and start-ups, especially digital start-ups. Small start-ups producing games and apps, sometimes apparently insignificant, can have a disruptive effect on business models and competitiveness if used in the right context.

In the future, also in the implementation of the Smart Specialisation Strategy and in particular, in the perspective of promoting the culture of smart manufacturing, events that will match the various protagonists can be increased. For instance, It is necessary to ‘contaminate’ researchers working in technopoles with creative and digital figures working in Fablabs and co-working spaces, and of course with entrepreneurs and managers of final products and services, designers and consultants. It can appear a sort of theory of chaos, but it will produce networking effects.

- **Promoting new management approaches and culture.**

  For approaching the markets in this new perspective of involving, internally and externally to the company, different kind of competencies, there is the need for new management models and new capabilities. On one side, it is necessary to let creative resources express themselves in the best conditions of freedom. On the other side, it is necessary to orient this energy towards specific business models, specific products to industrialise, and specific approaches to clients and stakeholders with adequate communication techniques. It is necessary to emphasise teamwork and networking methodologies, to stimulate creative solutions and collaborations between individuals and firms. Only in this way everybody will understand the complexity of the processes and understand the relevance of reciprocal contributions. In a few words, smart manufacturing needs to embody high levels of culture and knowledge, even of differentiated nature.

  It is to be verified how much schools of management are adopting this new vision or are still following the vertical scheme of single business functions for big organisations. It appears possible that the problem will be solved by another bottom-up phenomenon emerging in the region: that of business academies. Successful firms are recognising the value of the cluster they belong to, but also of the social context in which they work, and they are dedicating some of their resources to these “academies”, that are formal and informal training organisations for the real innovation challenges of the future, connected with the business of the company, but not only this.

- **Developing strategic research projects for making available advanced and innovative demonstrators.**

  It is necessary that the most relevant research infrastructure organisations be strongly involved in large strategic projects to be financed under Horizon 2020 or national funds, in order to develop leading competencies and advanced demonstrators able to stimulate further innovative solutions by firms. For instance, it is possible to develop large strategic projects in fields like Big Data applications, or virtualisation of production, and so on.

  In this field, in which the level of specialisation of companies is already very relevant, the research system shouldn’t concentrate so much on technology transfer (sometimes not necessary), but mainly in anticipating market and technology evolution. With the support of regional commitment, such a possibility in Emilia-Romagna is absolutely realistic, thanks to the presence of the research organisations mentioned above.
• Developing innovative policy schemes for R&I based on the mobilisation of non-public resources.

Considering the situation of public funds, the Region must develop policy initiatives and innovative financial instruments such as revolving funds or venture capital, in order to promote more innovative and market oriented schemes to stimulate the dynamism of the ecosystem. In this sense, it is necessary to mobilise banks and other financial organisations to make private resources available for research and innovation, possibly with the support of adequate guarantees of EIF and other credit guarantee funds.
1. Advanced Manufacturing: Industry 4.0 and smart systems

1.1 Overview of performance and trends

Emilia-Romagna is a southern European leading region in terms of entrepreneurship, innovativeness and economic dynamism, and one of the most dynamic economic systems in the whole European Union. Regional GDP per capita is one of the highest in Italy and well above the EU average (about €32,500 vs. €26,500 in Italy and €27,500 in the EU in 2014). The high level of GDP has been achieved thanks to a very high export propensity and the international competitiveness of the manufacturing sector. In 2015 regional exports were €55.2bn, more than 36% of the regional GDP. This means that the level of exports per capita is around €11,600, the highest level in Italy and one of the highest in the EU.

The region can be considered a strong manufacturing region. In statistical terms, strictly manufacturing employment and value added account only for about 25% of the total employment, but many other sectors are directly connected with manufacturing performance: logistics, trade, ICT, several categories of services, as well as part of the primary sectors and of the building sector. Taking this into account, the overall relevance of manufacturing can be valued at around 65% of total GDP.

In the manufacturing sector, mechanical engineering and its sub-sectors are the most important, covering more than 50% of employment and more than 60% of exports. Even accounting for the importance of the agro-food cluster and of the construction cluster, mechanical engineering and automotive remains the most relevant and representative cluster of the region.

The regional GDP increased by 1.2% in 2015, despite the low growth profile of Italy as a whole (+0.8%). It must be considered that the national system has been exerting a depressing effect on the general growth of the region, especially in the Euro era; this can be attributed to macroeconomic constraints, inefficiencies in the public sector, and a high level of taxation.

The region was strongly affected by the economic crisis of 2008 and of the following years, being a strongly export-oriented region; the sharp decline in global demand provoked a reduction in exports of 25%, and, as a consequence, a reduction in GDP of 5.5%. Export levels were quickly recovered already in 2011, thanks to innovation and product diversification; GDP levels were recovered only in 2014.

In 2008, Emilia-Romagna was in a condition very close to full employment, with an unemployment rate of 2.8%. The unemployment rate gradually increased and reached 8.4% in 2013. In practical terms, more than 100,000 workers became unemployed. In 2015 the unemployment rate has reduced to about 7.6%, and a further reduction towards 7% is foreseen by the projections for the next 2 years. Long-term unemployment, in 2015 is about 4.1%, while at the national level it is at 7.8%. These rates are considered unusual by the region’s standards.

The labour market participation rate in the region is in line with European average, that is, for people in the active age range (15-64 years) 72.4%, with men at 79.5%, women at 65.5%; both statistics also exceed the national average by almost 10 percentage points.

In Emilia-Romagna the business sector is largely based on SMEs. There are around 400,000 firms, most of which of very limited size. Manufacturing firms are more than 45,000 (Istat). During the economic crisis, more than 5,000 small manufacturing companies, in large part subcontractors, closed down (Unioncamere).

SMEs remain dominant actors in the region, but in recent decades there has been a slow but constant growth of the average size of the companies; globalisation,
participation to the Euro Area, and the need of increasing innovation activity, induced to reinforce strategic functions like R&D, marketing, data management, and finance. This determined a selection in favour of medium and medium-large companies, together with a high number of mergers and acquisitions that generated local industrial groups, and acquisitions from national and international industrial and financial holdings. In this context, the period of the crisis seems to have accentuated also the need of increasing efforts in innovation and R&D activities.

Despite these processes of industrial concentration, the productive structure of the region remained strongly clustered. In almost every cluster the presence of mechanical engineering niches allows for a strong innovation potential, even in apparently less innovative clusters.

Emilia-Romagna’s manufacturing sector can be considered a medium-advanced manufacturing system. Although some of the existing clusters could appear highly traditional (like agro-food or construction) and there are few purely high-tech industries, they are also strong absorbers of new technologies and highly specialised (especially mechanical engineering), and able to reflect the increasingly complex needs of the markets and society. In addition, as pointed out in the Regional Smart Specialisation Strategy (the regional strategic document for innovation policies for ERDF 2014-2020), regional productive specialisation is very strong and articulated. The new vision is going towards the strengthening of regional articulated clusters, composed of interconnected industries along specific production and technological value chains, throughout the regional territory.

They can be identified as follows:

- The agro-food system involves around 313,000 employees (more than 16% of the regional workforce) distributed between agriculture (80,000), food industries (60,000), chemical and complementary industries (5,400), mechanical engineering (33,500), retail (65,000) restaurants and canteens (64,500), and sector specific business services (2,200). The sector presents a high degree of specialisation and counts several leader companies within the national panorama (often cooperative firms). The region produces and distributes well-known products at national and international level in several product categories (i.e. dairy, meat, preserves, pasta and cereals, wine and beverage).

- The building and construction sector represents a crucial one for the region, especially when taking into account the other industries and sectors linked to it; one example is the production of ceramics, that represents an important regional exporting sector, also requiring a unique mix of specialised knowledge and competencies. The construction system counts about 350,000 workers, in which are included: construction components (metal, wood, plastic, ceramic, with 58,000 employees), mechanical engineering (32,500), the construction sector itself (134,500), public utilities (11,300), retail and real estate agencies (55,000), architecture, engineering and other services (58,000).

- The mechanical engineering and automotive industries represent the core of the regional industrial system: about 50% of manufacturing employment and 60% of exports are associated to this sector. The sector also counts on several niche leaders and medium-sized firms, with the main areas of excellence being: sports cars, motorcycles, engines and other automotive components; shipbuilding; industrial automation and robotics; specific industrial equipment (food processing, woodworking, ceramics, industrial logistics, etc.); agriculture machines; oleo-dynamics; earthmoving machines; filtration; elevators; controls and precision
instruments; electro-medicals; power technologies, and heating. In total, accounting for approximately 340,000 employees.

Overall, more than one million people work within these three big consolidated clusters, which represent the core asset of the region, the basis for the development of the service sector and of emerging industries.

In the Smart Specialisation Strategy, two other emerging groups of industries are introduced:

- Health and wellness industries, where it is possible to see the presence of two already important industries; biomedical products (disposals, medical equipment, prosthesis) and fitness equipment, while biotechnology and pharmaceuticals are more limited.
- Cultural and creative industries, where a large number of initiatives are being undertaken in audio-video, publishing, design, arts, entertainment and creative software, all however still relatively limited in size.

Industry 4.0 and smart manufacturing can have a transversal impact both on consolidated and emerging clusters (mainly in mechanical engineering), and creating also opportunities of virtuous cross-fertilisation.

1.2 Business sector perspectives

As mentioned above, the industrial and socioeconomic system of the region can be considered as a highly dynamic ecosystem. The main element of dynamism can be attributed to the business environment, characterised by a strong and diffused culture of entrepreneurship. The industrial structure has its foundations in highly specialised SMEs. As told before, in the last two decades, the region has experienced a process of gradual consolidation of SMEs in larger companies or groups of companies, which in turn led to the affirmation of clusters’ leadership. The capacity of existing companies to withhold these changes can be attributed to the following characteristics:

- Strong technical competencies, accumulated during the years and reinforced by a handicraft approach, flexible organisation, problem-solving attitude and team-working,
- Highly focused and specialised product strategies,
- Collaborative networking and trust-based relationships,
- Utilisation of highly qualified people due to a tradition of territorial specialisation,
- Strong will to succeed and to emerge,
- Strong dialogue between the public and the private sector, with common interest for growth and development.

At the level of the general business environment two other crucial elements must be considered:

- Firstly, the strong level of clusterisation, not only at for single industries, but also at inter-industry level along the value chain, leveraging on market and technology synergies; this complex structure is in favour of the exchange of information, knowledge accumulation, generation of projects and business ideas; it is also in favour of long terms processes of gradual change, even for those industries that can be considered low-tech and traditional.
- Secondly, the multiplicity of business models: Emilia Romagna’s industrial fabric is not only characterised by specialised SMEs, but it is also the region with the strongest tradition of cooperative firms in Italy.
The latter are concentrated in the agro-food, construction, retail, social services, and, partly, in the manufacturing sector. At the same time, the presence of several companies owned by multinationals or other kind of big industrial and financial groups contributes to generate a system with a large variety of business models in a very geographically concentrated business environment. This aspect favours mechanisms of organisational learning and contamination of approaches and values. Currently, the leading role is in the hands of cluster leaders, often owned by external industrial and financial groups, that seem to be attentive to the health of the social environment and to keeping alive the dynamism of all clusters’ members, considering these aspects as to be essential for competitiveness.

It is important to remember the strategic role played by the mechanical and engineering cluster: not only does it represent more than 50% of manufacturing employment, and more than 60% of the total exports, but it also plays an essential role in knowledge transfer. In particular, industrial engineering, plants and industrial equipment industries, now characterised by extremely high export propensity (around 80% of turnover), are at the basis of and the example for the modernisation of other industries in the regional industrial system, such as for instance agriculture and food, construction, wood processing, ceramics, textile, and pharmaceuticals.

Table 1 Leaders in the mechanical and engineering industry

<table>
<thead>
<tr>
<th>Sector</th>
<th>Company</th>
<th>Products</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Automotive</strong></td>
<td>Ferrari (FCA group)</td>
<td>Sport and luxury cars</td>
</tr>
<tr>
<td></td>
<td>Maserati (FCA group)</td>
<td>Luxury cars</td>
</tr>
<tr>
<td></td>
<td>Lamborghini (Audi-VW)</td>
<td>Luxury cars</td>
</tr>
<tr>
<td></td>
<td>Ducati (Audi-VW)</td>
<td>Motorbikes</td>
</tr>
<tr>
<td></td>
<td>Bonfiglioli</td>
<td>Automotive components</td>
</tr>
<tr>
<td></td>
<td>Bosch</td>
<td>Automotive components</td>
</tr>
<tr>
<td><strong>Industrial automation</strong></td>
<td>IMA</td>
<td>Pharmaceutical packaging</td>
</tr>
<tr>
<td></td>
<td>GD</td>
<td>Cigarettes packaging</td>
</tr>
<tr>
<td></td>
<td>SACMI (cooperative)</td>
<td>Food processing and ceramic equip.</td>
</tr>
<tr>
<td></td>
<td>Marchesini</td>
<td>Pharmaceutical packaging</td>
</tr>
<tr>
<td></td>
<td>OCME</td>
<td>Beverage packaging</td>
</tr>
<tr>
<td></td>
<td>Tetrapack</td>
<td>Food packaging</td>
</tr>
<tr>
<td></td>
<td>Electric80</td>
<td>System integration</td>
</tr>
<tr>
<td></td>
<td>SCM</td>
<td>Wood processing equipment</td>
</tr>
<tr>
<td></td>
<td>SCM</td>
<td>Ceramic processing equipment</td>
</tr>
<tr>
<td><strong>Shipbuilding and off shore</strong></td>
<td>Ferretti</td>
<td>Luxury yachts</td>
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<tr>
<td></td>
<td>Rosetti Marino</td>
<td>Off shore</td>
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<td></td>
<td>Micoperi</td>
<td>Off shore</td>
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<td></td>
<td>Trevi</td>
<td>Off shore</td>
</tr>
<tr>
<td><strong>Agricultural machines</strong></td>
<td>Case New Holland</td>
<td>Tractors</td>
</tr>
<tr>
<td></td>
<td>ARGO</td>
<td>Tractors</td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td>Technogym</td>
<td>Fitness and bio-engineering instr.</td>
</tr>
<tr>
<td></td>
<td>Bellco</td>
<td>Biomedical</td>
</tr>
<tr>
<td></td>
<td>B. Braun</td>
<td>Biomedical</td>
</tr>
</tbody>
</table>
Since 2014, the turnover in the mechanical sector has been increasing sharply with very few exceptions (i.e. offshore plants, because of low oil prices). Typically, these firms are export-oriented (most of them export between 70% to 95 % of their turnover), and have a good reputation to sell their products in high-income markets. The table below reports a list of some of the main leaders in the mechanical and engineering industry.

In synthesis, the Emilia Romagna’s business ecosystem appears very well positioned in the global market; it is one of the most competitive ecosystems in Italy, and can be considered among the best performing in Europe.

The typology of business model in Emilia Romagna is oriented to customised products with a high level of specialisation. Producers tend to be market leaders in specific global niches and technology followers-adapters in terms of technology. Their greatest ability is to combine technologies to improve the final performance for the market needs. In this sense, they can be considered “smart followers”.

One example can be Technogym, world leader in fitness equipment applying ergonomic and bioengineering principles to fitness equipment. Another example could be Dallara, excellent producer of cars for race competition, carefully studying advanced materials and aerodynamics. Electric80 is another example, a company producing robot systems for internal logistics in factories with high levels of automation both for single machines and for groups of machines for entire production plants and stores.

Such industries have their main competitors partly in the other Northern Italian regions with high presence of the mechanical engineering sector, like Lombardy and Piedmont, and the main international competitors in Germany, especially in Baden-Württemberg. Despite competition, there are also cases of cooperation and several interregional mergers and acquisitions.

Coming specifically to Industry 4.0, the first sector to consider is again the mechanical one. In the mechanical and engineering sectors, innovation is an important objective of the firms, but often not enough formalised and managed. The search for new solutions, improvements, and new projects is part of the sector’s predominant business model. Several companies look like experimental laboratories testing and producing prototypes and pilot series.

The region, as mentioned above, is not a technology leader, but it has proven to withstand low-price competition and its competitive advantages thanks to resilience and a capacity of redesigning and improving products continuously. New technology trends are not predominantly generated in the region, but they are quickly and successfully adopted by local companies. This happened in the 1980s with the microelectronic revolution, and there are expectations that it could happen again with Industry 4.0. In this perspective, an important contribution can be given by innovative start-ups, especially for the moment in the area of digital applications, and not directly in the engineering sector.

Industry 4.0 innovation pathways can influence both mechanical engineering and other sectors. Reciprocal cluster interaction between engineering and final user industries can be a favourable factor for a rapid diffusion of these types of innovation. At the moment, though, the uptake of this new paradigm by not yet complete and varies a lot among companies.
Table 2 General position of Emilia-Romagna in Industry 4.0 in comparison to best competitors

<table>
<thead>
<tr>
<th>Industry 4.0 fields of innovation</th>
<th>Main sectors involved</th>
<th>Enabling sectors</th>
<th>Position of Emilia-Romagna</th>
</tr>
</thead>
<tbody>
<tr>
<td>3D printing</td>
<td>Mechanical and automotive components, Cultural and creative industries, biomedical</td>
<td>ICT, Design</td>
<td>Medium</td>
</tr>
<tr>
<td>IoT</td>
<td>Mechanics and almost all manufacturing industries</td>
<td>ICT, Design</td>
<td>Low</td>
</tr>
<tr>
<td>Remote control</td>
<td>Mechanics</td>
<td>ICT</td>
<td>Medium</td>
</tr>
<tr>
<td>Human-machine interface</td>
<td>Mechanics</td>
<td>ICT</td>
<td>Medium</td>
</tr>
<tr>
<td>Augmented reality</td>
<td>Mechanics and almost all manufacturing industries</td>
<td>ICT, Design</td>
<td>Low</td>
</tr>
<tr>
<td>Sensors and intelligent robotics</td>
<td>Mechanics, logistics, automotive</td>
<td>ICT</td>
<td>Good</td>
</tr>
<tr>
<td>Advanced and smart materials</td>
<td>Mechanics and almost all manufacturing industries</td>
<td>ICT, Nanotech</td>
<td>Good</td>
</tr>
<tr>
<td>Cloud manufacturing</td>
<td>All industries</td>
<td>ICT, Big Data</td>
<td>Medium-Low</td>
</tr>
</tbody>
</table>

Source: author’s elaboration

Some typologies of single innovations linked to the new digital manufacturing are familiar to most of the local companies, in particular sensors applications and advanced materials. Other innovative solutions, like 3D printing or intelligent robotic systems don’t represent a strong barrier and many companies have already assumed this perspective.

The types of innovation that represent the most difficult advancement are those that imply an open view of the business organisation: for example, the Internet of Things, augmented reality and systems of remote assistance involving constant collaboration with designers, partners, clients and stakeholders. For these types of innovation, a structural and longer path of change is ongoing but not yet fully developed, and requires, among other actions, a strong integration with the ICT sector and the application of new management approaches. In this context, the main weaknesses can be attributed to the low degree of development of the ICT sector, to a management approach too much focused on product and process innovation (but not enough on service innovation and marketing) and to the old style management, due to family ownership. This means companies encounter difficulties in the context of global competition in the commercialisation of these innovations, even when offering successful products. One of the consequences is that foreign ownership of leading companies is becoming a trend in recent years.

1.3 Scientific Research potential

Despite public R&D spending representing only 0.5% of GDP until 2013, the scientific potential of Emilia-Romagna is remarkable within the Italian context.
The regional system is characterised by a diffused presence of universities and research organisations in the main cities, even if it is clear that Bologna (the capital city) presents a strong concentration of institutions and activities in the scientific and technological field. While this regional research system has some duplications and several sub-optimal structures, it also has some points of excellence.

There are four regional multidisciplinary universities:

i) the University of Bologna; the biggest in the region and the oldest University in Europe (founded in 1089)

ii) the University of Ferrara

iii) the University of Modena and Reggio Emilia

iv) the University of Parma.

The University of Bologna has established other decentralised seats in the eastern part of the region, namely in Ravenna, Faenza, Forlì, Cesena, and Rimini. In the western part of the region, in the city of Piacenza, there are two decentralised branches of the Polytechnic of Milano and of the Catholic University, both based in Milano (Lombardy). There are also three arts academies, five conservatories and five musical institutes in the region.

At present, in total there are about 8,000 professors and researchers in the university system, of which 60% are in scientific and technological disciplines. They are distributed across 82 university departments in total, 50 of which are in S&T disciplines, while 12 departments deal with digital manufacturing and Industry 4.0.

Emilia-Romagna is the most attractive region in Italy for extra-regional students, with a net flow of 25% of the total students enrolled at university (i.e. around 150,000).

Table 3 University departments in Emilia-Romagna

<table>
<thead>
<tr>
<th>University</th>
<th>Social, human, arts</th>
<th>Science and Technology</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>University of Bologna</td>
<td>16</td>
<td>16 (4)</td>
<td>32</td>
</tr>
<tr>
<td>University of Ferrara</td>
<td>5</td>
<td>10 (2)</td>
<td>15</td>
</tr>
<tr>
<td>University of Modena and Reggio Emilia</td>
<td>5</td>
<td>10 (3)</td>
<td>15</td>
</tr>
<tr>
<td>University of Parma</td>
<td>4</td>
<td>14 (3)</td>
<td>18</td>
</tr>
<tr>
<td>Piacenza</td>
<td>2</td>
<td>--</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>32</strong></td>
<td><strong>50 (12)</strong></td>
<td><strong>82</strong></td>
</tr>
</tbody>
</table>

Source: ASTER

In addition to academia, the other important element of the regional scientific potential consists in the presence of important branches of national public research organisations.

- The CNR (the National Research Council), is the most important public research organisation in Italy and has 16 institutes in Emilia-Romagna, of which six are headquartered there. Researchers working for the CNR number more than 800. The main areas of specialisation are: advanced materials, photonics, magnetism, microelectronics, micro systems and sensor technologies, nanotechnologies, and climate change. CNR’s institutes are mainly located in Bologna.
- ENEA (the National Agency for New Technologies, Energy and Sustainable Development) is another important public research organisation, specialised in energy (nuclear and renewable sources), environment technologies and ICT applications. It has about 600 researchers and several experimental laboratories.

Other research institutes include the following:

- INAF, National Institutes of Astrophysics, which has a very important radio-telescope infrastructure
- INFN, National Institutes of Nuclear Physics, which, among other things, has a very relevant GRID computing infrastructure
- INGV, National Institute for Geophysics and Volcanology
- Born as an inter-university consortium, another important research asset of the region is CINECA. CINECA is one of the biggest computing centres in the world and it has both a service and a research unit on Big Data.

In the health sector, in parallel with universities there are a special typology of institutes (IRCS, Institutes of Research and Care), combining care for patients with high levels of technology applications and experimental research. The most important of these is the Rizzoli Institute, specialised in orthopaedic pathologies, prosthesis and disabilities.

Considering all this scientific presence, recently the region promoted a map of various technology research infrastructures in the region, in order to identify the fields of major specialisation, and to valorise and integrate them in a network. The result is that Emilia-Romagna has a strong relevance and potential leadership in three main areas, in which the region is activating plans to reinforce specific fields of application:

- Big Data and computing, led by CINECA and INFN
- Advanced materials, led by CNR
- Regenerative medicine and bio-banks, led by Rizzoli Institute and some universities.

Summarising, in relation to Industry 4.0 challenges, the situation can be represented by the following table.

<table>
<thead>
<tr>
<th>Relevant fields of research for Industry 4.0</th>
<th>Main actors</th>
<th>Position of the region</th>
</tr>
</thead>
<tbody>
<tr>
<td>Big Data</td>
<td>CINECA, INFN</td>
<td>Good</td>
</tr>
<tr>
<td>Advanced materials and nanotech</td>
<td>CNR</td>
<td>Good</td>
</tr>
<tr>
<td>Digital imaging, gaming, augmented reality, sensors</td>
<td>Universities</td>
<td>Medium</td>
</tr>
<tr>
<td>Broadband business applications</td>
<td>Universities</td>
<td>Medium-Low</td>
</tr>
</tbody>
</table>

Source: Emilia-Romagna, author’s elaboration

In order to smooth communication between research and industry, the region has promoted the creation of a network of industrial research laboratories that constitutes, together with innovation centres, the Regional High-Tech Network, coordinated by Aster (Section 2.2). There are 82 of them and they are grouped into 6 thematic platforms: advanced mechanics and materials, energy and environment, construction,
food, life sciences and ICT. For developing policies oriented to Industry 4.0, it is not only mechanical and ICT that are relevant, but also laboratories in different platforms can be involved.

Some indicators concerning scientific potential give some positive images of the region. It has been, for a long time, the region with the highest rate of patents registered at the EPO in relation to the number of inhabitants (about 127 per inhabitant).

Emilia-Romagna is also well positioned at the European level in terms of its rate of scientific publications. In particular, according to recent research, it is the number one region in terms of publications in relation to the available public budget (Source: Fondazione Rosselli, 2010).

1.4 Role of intermediary institutions

The regional context is traditionally characterised by a significant network of intermediaries: business organisations, chambers of commerce, public agencies, centres of innovation and competence centres, emerging spontaneous cluster organisations.

Most of these organisations were established in previous historic periods and different phase of development, and they play a transversal role. Business organisations are mainly organised in a horizontal way, according to typology of firms (handicraft, industry, cooperatives). They have vertical organisations inside, but they don’t play a particular role in policy negotiations. Chambers of Commerce are semi-institutional organisations that have a territorial organisation aimed at promoting trade and economic growth, keeping a public register of firms and data and elaborating studies and analysis of the local and regional economy. These intermediaries are under pressure and in strong process of reorganisation and redefinition of tasks, in order to recover efficiency and strategic mission in this phase of globalisation and innovation based economy.

Regional agencies are a bridge between the policy level and stakeholders of development and innovation policies and actors for attractiveness at the local level.

There are three main regional agencies:

- **ERVET**: dedicated to coordinate territorial development initiatives in relation with regional policies;
- **Lepida**: dedicated to ensuring broadband access all over the territory, reducing the digital divide and developing the information society;
- **ASTER**: co-participated by all universities and the main public research organisations in the region, its mission is to coordinate technology transfer, industrial research and promotion of innovation, through the coordination of the Regional High-Tech Network.

In addition, at local level there are also agencies mostly dedicated to manage industrial parks and promote local development. At the same time there are a lot of public and private initiatives promoting start-ups in various forms: incubators, accelerators, hubs and co-working spaces. ASTER is the institution that works the most for networking and coordinating the various intermediaries linked to technology transfer and start-ups, through the Regional High-Tech Network and EmiliaRomagnaStartUp.

Important intermediary actors are innovation centres participating in the regional High-Tech Network. They are dedicated to assess technology needs and support firms for innovation by providing technical services, consultancy, and technology brokerage.

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1 EmiliaRomagnaStartUp is a network for the creation of innovative start-ups.
The innovation centres more focused on mechanical engineering and digital manufacturing are located in the central part of the region:

- CRIT,
- Democenter,
- Reggio Emilia Innovazione,
- Warrant.

It can be considered that this action to network intermediary actors has developed original virtual infrastructure based on the concept of community. In particular the following examples can be found in relation to Industry 4.0:

- The Regional High-Tech Network; network of industrial research laboratories and innovation centres and community of industrial researchers, already mentioned, mostly for its mechanical engineering and ICT platforms;
- EmiliaRomagnaStartUp, the community of start-ups, incubators, accelerators, hubs, co-working spaces;
- IncrediBol!; network of firms, professionals, associations belonging to cultural and creative industries (within Bologna city);
- Mak-ER; the network of fab-labs and 3D printers.

There is also a phenomenon of new spontaneous cluster organisations based on free association of companies. Among others, they include:

- ERAMIAT, representing a relevant number of leading companies of the regional mechanical engineering cluster of the region;
- Associazione Meccanica,
- ROCA, a cluster generated by companies of offshore plants;
- IR4I, a cluster for aerospace providers;
- Wellness Valley Foundation, cluster dedicated to companies of various sectors dedicated to wellness;
- Club Mechatronics; dedicated to the mechatronics sector.

Other initiatives are typical associations of people involved in promoting innovation culture, through workshops and seminars, matching events, training courses. In the field of Industry 4.0, the most active of such associations are:

- AASPECT, Association for the Promotion of technical culture, especially active in connecting students and University with firms and their innovation needs;
- Associazione Meccanica, composed by managers, engineers, professionals, entrepreneurs, students.

1.5 Developing Skills for the future

One of the most relevant initiatives for developing skills in Emilia-Romagna, outside of the context of academic education is the network of Superior Institutes of Technology education (ITS). There are 13 foundations managing these institutes across the region. The ITS aim at developing the highly qualified technicians required by companies in strategic sectors of the regional economy. Training courses have the duration of 2 years and require one obligatory period of apprenticeship, eventually abroad. One of these institutes is dedicated to “mechanics, mechatronics, automotive, packaging (automation)”. It is one of the most active, and the recent training supply is focused on the development of highly skilled technicians in automation and
packaging, materials, endothermic, hybrid and electric engines, mechatronic systems, design of innovative products based on composites and additive manufacturing, etc. Teachers are partly university professors, and partly technicians and managers of companies.

This ITS network plays a crucial role in the timely provision of young and well-trained technicians to companies. In addition, especially for in going uThe ITSs work on the basis of annual calls and are completely free of charge for students (all costs are covered by the region through the ESF). This network is integrated also with the pre-existing network of technical schools that represent a strong tradition in the region. Most of them are multidisciplinary, with option possibilities for students, but many of them are focused on mechanical technicians. One of the most famous, the Aldini-Valeriani Institute in Bologna, played a crucial role in enabling young students to take up technical work and entrepreneurship in the mechanical sector.

The university system, on the other side, has a good supply of courses connected with engineering and Industry 4.0. All the regional universities have engineering faculties. Bologna presents the largest variety of courses: automation engineering, electronic engineering, biomedical engineering, aerospace, and ICT. The mix of mechanical, materials, ICT, electronics, nanotechnologies, and sensor technologies represents an interdisciplinary base for a rapid development of Industry 4.0. The region launched a call for researchers, establishing various priorities, including Industry 4.0 and Big Data.

Finally, an important role for developing new innovative skills could also be played by the phenomenon of Business Academies created by several leading firms in the region. These firms are increasingly valorising the importance of the local environment and local knowledge for their competitiveness and they are conscious of playing a critical role in driving economic and technological change in their providers and in the local workers, even outside the company.

1.6 Major investment projects

Emilia-Romagna has placed strategic importance on the competitiveness of the mechanical engineering cluster since 2002, the year of the approbation of a regional law on industrial research, innovation and technology transfer (Regional Law n.7/2002). This new law introduced a vision of clusters at the regional level and it was clear that mechanical engineering clusters had a regional dimension and involved a large variety of specialised sectors and sub-sectors. The reinforcement of the technological potential and competitiveness of the mechanical cluster was a milestone of the policy strategy from the beginning.

Emilia-Romagna was also individuated by the Italian Minister of Research as the seat of the Advanced Mechanics Technological Cluster (HIMECH) since 2005.

Over the years, the region has supported the establishment of specialised industrial research laboratories involved in introducing innovative technologies and new approaches in the mechanical industries,, which are now intensively working on the digitalisation of manufacturing. The support of these laboratories took place in two main stages and has strongly helped to prepare for the Industry 4.0 revolution:

1. support to research programmes, including activities of transfer and valorisation of results, especially involving new full time researchers;
2. realisation of dedicated infrastructure to locate instruments and research groups, technology transfer facilities, start-ups and/or research units of existing companies.
Concerning the support to research programmes, the table below reports the list of laboratories that the region has supported and included in the Advanced Mechanics and ICT platforms of the Regional High-Tech Network.

Table 5 Main laboratories of the advanced mechanics and ICT platforms of the Regional High-Tech Network

<table>
<thead>
<tr>
<th>Laboratories</th>
<th>Fields of research</th>
</tr>
</thead>
<tbody>
<tr>
<td>MUSP</td>
<td>Integrated production systems, Precision engineering, Advanced design and materials, Aerospace technologies</td>
</tr>
<tr>
<td>INTERMECH</td>
<td>Sensors, surfaces, advanced materials, Advanced engineering and design, prototyping, Virtual engineering, 3D visualisation, Automotive and engines, Mechatronics, Oleo dynamics</td>
</tr>
<tr>
<td>CIRI MECCANICA</td>
<td>Automation, Robotics, Mechatronics, Materials and technologies for shipbuilding, Photonic applications, Advanced composites, Virtual prototyping, Materials toxicology and chemistry</td>
</tr>
<tr>
<td>MISTER</td>
<td>Micro and Nano-manufacturing, Photonic applications and sensors</td>
</tr>
<tr>
<td>MECH LAV</td>
<td>Vibro-acoustics, Aero-acoustics and Thermo-acoustics analysis, Control systems</td>
</tr>
<tr>
<td>CIRI AERONAUTICA</td>
<td>Engineering for aeronautics, space, mobility, fluid dynamics</td>
</tr>
<tr>
<td>FUTURE TECHNOLOGY</td>
<td>Product evaluation and development, RFID applications, Signal processing, Sensor identification</td>
</tr>
<tr>
<td>LAB</td>
<td></td>
</tr>
<tr>
<td>T3LAB</td>
<td>Computer vision, Industrial IoT, Augmented reality and Human interface, Embedded systems, Mobile platforms</td>
</tr>
<tr>
<td>SOFTECH</td>
<td>Software systems, Big Data applications and Business intelligence, Multimedia and multimodal vision, Digital systems</td>
</tr>
<tr>
<td>CIRI ICT</td>
<td>Cloud computing, Business intelligence, Mobility</td>
</tr>
<tr>
<td>RINNOVA</td>
<td>Design and prototyping</td>
</tr>
</tbody>
</table>

Source: ASTER

The consolidation of the whole network required about €90m of investments for the region and a global investment of €180m in the 2007-2013 period. The mechanical engineering and ICT platforms represented one third of these costs.

Recently, the region made a call for strategic research projects to be developed by such laboratories in the context of the ERDF ROP 2014-2020; the projects have been already approved, including, in the mechanical engineering areas of specialisation, the following:

- “Integrated technology for Electric Mobility”,
- “Nano composites and MEMS based integrated circuit sensor systems”,
- “Integrated solutions for next generation automatic machines”,
- “Process innovation for ceramic production”,
- “Sustainable evolution of fibre-reinforced composites with ceramic matrix”,
- “Development of sensors and methods for predictive diagnosis in automatic packaging machines”,
- “Magnetic refrigeration”.

In total, 47 projects have been approved, considering all sector priorities of the Smart Specialisation Strategy. Total regional funding of the projects is €41.5m out of total
R&D expenses of around €60m in the next 2 years by the research laboratories (mainly spent for young researchers involved in the projects); 25% of the budget was absorbed by the mechanical engineering area.

Concerning the realisation of dedicated infrastructures, the Region, in the previous programming period (2007-2013) supported the university or the municipalities in the realisation of technology transfer infrastructures as described above. These infrastructures are defined as “Technopoles” and they are located in the main cities of the region. This physical presence is essential to develop relationships and sub-communities at local level, to be integrated in the whole regional innovation community. For this network of technology transfer infrastructures the region spent €38m in supporting a total investment of €58m.

The technopoles strongly dedicated to Industry 4.0 are those located in Piacenza, Modena, and Forlì. Laboratories related to Industry 4.0 are also located in Bologna, Reggio Emilia, Parma, Ferrara, Forlì, and Ravenna. They represent an asset for the region also in the present programming period.

A new target action to be implemented in the programming period 2014-2020 is the reinforcement of a research infrastructure aiming at national and international relevance. As mentioned above, one of the main areas is Big Data. The reinforcement of such infrastructure is the goal of support to a limited number of programmes aimed at involving specific users and stakeholders. It was agreed that digital manufacturing should be one of these programmes. It also matches with a second important research infrastructure in the region for advanced, high-performing materials. This measure has not yet started. Available resources are about €8m, but there is the expectation to involve funds from other sources than ERDF.

1.7 International cooperation

In considering interregional and international cooperation, it is relevant to consider the regional participation in these projects. In particular, mainly through ASTER, the region is involved in various interregional activities.

The first one to be mentioned is the National Technological Cluster named “Factory of the Future”, established in 2012. This involves several Italian regions and it is basic in participation in other important networks. Emilia-Romagna is playing a leading role in it together with Piedmont. The cluster is coordinating four big multiregional projects concerning: sustainable manufacturing, adaptive manufacturing, smart manufacturing, and high-performance manufacturing.

Through this national cluster, the region could facilitate participation in the European Factory of the Future Research Association (EFFRA). EFFRA is an industry-driven association promoting the development of new and innovative production technologies. Emilia-Romagna participates with ASTER; its technology consortium and governance organisation of the research and innovation ecosystem, and with ER-AMIAT; the association that represents the major cluster organisations of the mechanical engineering industry of the region. As is clearly explained in EFFRA’s mission description, the key objective is to promote pre-competitive research on production technologies by engaging in a public-private partnership with the European Union called “Factories of the Future” whose roadmap for 2014-2020 has established the following priorities:

- Advanced manufacturing processes,
- Adaptive and smart manufacturing systems,
- Digital, virtual and resource-efficient factories,
- Collaborative and mobile enterprises,
Another very important network is the Vanguard Initiative, of which Emilia-Romagna is member since 2015. This is a network of regions that seeks to develop interregional cooperation and multi-level governance for supporting clusters and regional eco-systems to focus on smart specialisations in priority areas for transforming and emerging industries. Pilot projects carried out by the Vanguard Initiative are bottom up initiatives and mainly concentrated on the manufacturing transformation and modernisation. It is important to mention:

- Efficient and sustainable manufacturing,
- High-performance production through 3D printing,
- Components and technologies for marine renewables and offshore energy applications,
- New Nano-enabled products.

The participation to the Vanguard pilot projects is strategic for Emilia Romagna in successfully developing its Smart Specialisation Strategy, especially in relation to mechanical industries in a context of European integration.

Finally, within the ERDF interregional cooperation program, Emilia-Romagna has assumed the leadership of a project specifically aimed at connecting and promoting reciprocal policy learning for developing regional innovation ecosystems, approved in 2016. The acronym of the project is INKREASE, which stands for “increasing the penetration of renewable energy sources”.

This project aims at comparing regional innovation ecosystems and policy instruments for their development and improvement. All the regions involved already developed articulated strategies to develop efficient industrial research, innovation and technology transfer systems according to their institutional framework and technology and industrial specialisations, but digital revolution and Industry 4.0 is widely transversal. The output of the project will be specific action plans for improving policy instruments of the various partners by learning from each other and, on the other side, promoting initiatives of collaboration between innovation stakeholders from different regions along specific technology items, or clusters, or value chains.

1.8 Policy support and delivery mechanisms

The Regional Smart Specialisation Strategy has established priorities, policy objectives and technology orientations that will address innovation programmes for innovating and changing consolidated and emerging industrial clusters in the 2014-2020 period. As mentioned before mechanical engineering and automotive represent one of three consolidated systems in which the region has a leading position, but it is largely the most important strategically.

In relation to Industry 4.0, the main technology orientations established in 2013 through the entrepreneurial discovery process (Guide for Research and Innovation Strategies for Smart Specialisation, European Commission, 2012), are the following:

1. Development of smart, adaptive and safe manufacturing. Under this group can be included the design of production lines and intelligent and adaptive machines, manufacturing 2.0 (anticipating the concept of industry 4.0), autonomous robotic systems, miniaturisation of technical solutions (essentially through nanotechnologies).
2. Development of an integrated and user centred manufacturing. This group contains the item relative to human-machine interaction, advanced maintenance, innovative design approaches.

3. Development of sustainable manufacturing including systems for energy generation, storage and distribution, materials, coatings and surface treatments, low environmental impact mobility.

It is clear that part of these orientations could already be coherent with Industry 4.0, not yet clarified or diffused at that time. Anyway, all these items can be better redefined according to the Industry 4.0 approach, recently emerged.

It must be said that also in other technological priorities it is possible that Industry 4.0, in particular in the health and wellness industries (e.g. prosthesis) and in cultural and creative industries (e.g. restoring cultural goods and their virtualisation in 3D), will be a crucial item.

At the moment, regional measures emphasise the priorities established in the Smart Specialisation Strategy, but have a horizontal character. So there is not a specific measure for Industry 4.0, but measures in which projects can contribute to it. The basic measure, in this sense, is the one that supported the strategic R&D projects mentioned above, in 1.6 paragraph. The main objective is to deal with a medium long-term innovation perspective.

The call already concluded selected various projects aimed at developing Industry 4.0 approach. According to the requirements, the projects liable to be selected must be developed by consortia of laboratories, of maximum five members, belonging to the Regional High-Tech Network and able to give adequate answer to cluster priorities and technology orientations established in the Smart Specialisation Strategy. Projects must be basically structured in three main steps: 1) research activity at TRL 4 (Technology Readiness Level 4) that means to test a technology at laboratory level, for its enabling features; 2) diffusion and dissemination activity of the potential of the new technology to all firms that could be interested in; and 3) R&D activity at TRL 5 and possibly TRL 6 in collaboration with at least two different companies, in order to verify some possible industrial application.

Next to this call, the objective of the region is the establishment of thematic associations that must group laboratories of similar or complementary applied disciplines, other facilitators, like innovation centres, firms and/or their cluster organisations. Programs of such thematic associations must be demand driven.

It has not yet been officially decided which thematic associations will be established, but “Digital manufacturing”, “Advanced automotive”, “Wellness, prosthesis and disabilities”, and “Materials and technologies for cultural heritage” are almost secure and they are four domains strongly affected by Industry 4.0. Such associations laboratories/firms will be coordinated by ASTER and will have the following tasks:

- sharing knowledge and information between participants for what concerns IPR and technologies, competencies and human resources, and laboratory instruments;
- developing research priorities and joint projects, also for participating in European calls;
- developing strategic demand-driven project and research activities;
- connecting with other platform organisations and partnerships at the national and European level;
- organising events of information and dissemination of research results.
They will also contribute to the planning and revision of the Smart Specialisation Strategy.

A second element to consider is the one of R&D and innovation initiatives to be supported. Firms supported will be the initial natural representatives of the business sector within the associations. In this area, there are the following actions:

i) Business R&D collaborative projects. They are projects carried out by firms with the requirement of collaboration with a research organisation and the employment of young technology graduates, in order to introduce relevant innovation in the company. This call was already concluded and projects already approved. As could be expected, over 107 projects there are several cases concerning Industry 4.0 and connected items, not only within the mechanical engineering and automotive cluster, but also in the health and wellness, as well as in the cultural and creative industries.

ii) Promotion of quick innovation and product/service innovation projects to be proposed by SMEs, with the regional financial support for acquiring innovative services needed: technology consultancy, testing, measurement, computing, design, prototyping, digital and multimedia components, and temporary management for the project implementation. Innovation projects can consist of new product/services, radically modified products/services their strong digital integration and characterisation, their redesign according to strong principles of sustainability. Services can be acquired by laboratories and centres of the Regional High-Tech Network, by the Design Centre of Bologna (in the Arts Academy), or by the members of the MAK-ER Network (later described in the chapter “Good practice case”) for at least 80% of the budget.

iii) Network projects. The realisation of innovative projects through the establishment of a formalised network in the form of network contract (“contratto di rete”) is a positive experience to be replicated. It gives the possibility to form interindustry networks in order to combine different competencies for common innovation objectives.

A final important mechanism to promote the diffusion and adoption of Industry 4.0 is that of Fablabs. In this case the region took into account this phenomenon and decided to support them and to support their networking process. It completes the general picture of the regional environment and of its reaction for Industry 4.0.

1.9 Good practice case

A good practice case in Emilia-Romagna is not based on a massive investment project as it can be in other regions, but can be individuated in a spontaneous pioneer network of small initiatives widespread in all the regional territory, that, for several years, anticipated the emergence of the new paradigm of additive manufacturing and 3D printing. This was a bottom-up experience characterised by a learning process; it means that not all of the initiatives in the network are able to cover all the aspects of Industry 4.0, but this type of experience needs to be mentioned, since it is a typical approach to processes of widespread innovation and change in the Emilia-Romagna region. The initiative goes under the name MAK-ER, the network of digital manufacturing in Emilia-Romagna. It is composed of 18 associates, most of them defined as Fablabs, other companies or non-profit initiatives.

The network MAK-ER has the objective to create networks of laboratories, firms and communities involved in 3D printing and digital manufacturing with advanced manufacturing companies of Emilia-Romagna.

The network is composed of subjects characterised by three basic elements: physical spaces, equipment and people. The spaces must be open and accessible to all potential
users. At the same time, they can be connected to extra-regional similar initiatives, in order to participate to specific international standards (like the Fab Charter) and ensure such standards in the regional context.

The MAK-ER network consider itself as an instrument to promote intelligent, sustainable and inclusive growth in Emilia-Romagna, thanks to the use of new technologies and the involvement of creative talents, to make the region attractive for smart manufacturing. The approach of the network, for this perspective, is that of sharing knowledge, giving visibility to participants’ initiatives, facilitating their coordination and good governance.

The principles and values of the network are:

- creativity
- collaboration
- knowledge sharing
- digital manufacturing
- bottom-up innovation
- combining handicraft tradition with advanced technology and small-scale production
- playing an active role in local development;
- creating community
- participating in training and educational initiatives for the diffusion of the digital making culture.

The following is the list of the members of the network:

- RaspiBo ([www.raspibo.org](http://www.raspibo.org)). It is a informal and voluntary group for promoting reciprocal learning on digital making and its combination with handicraft work.
- On/Off Office, Fablab Parma ([www.fablabparma.org](http://www.fablabparma.org)). It is a co-working space organised by a cooperative of young makers of heterogeneous competences: software developers, film producer, product designer, aerospace engineer, graphic designer, archaeologist, 3D prototypes), open to support ideas, develop projects and start-ups.
- FabLab Reggio Emilia ([www.fablabreggiormilia.org](http://www.fablabreggiormilia.org)). It is located in the Museum in the historical centre and it is open to firms, schools and designers.
- FablabRomagna ([www.fablabromagna.org](http://www.fablabromagna.org)). It has two locations in Rimini and Cesena and it is composed by young specialists in digital making and it makes training activities and projects.
- FablabBologna ([www.fablabbologna.org](http://www.fablabbologna.org)). It is one of the biggest and it derives from a big association (MakeinBo) and provides a wide range of services in electronic design and prototyping with a relevant availability of instruments.
- FablabValsamoggia ([www.fablabvalsamoggia.xyz](http://www.fablabvalsamoggia.xyz)).
- FablabImola ([http://fablabimola.it](http://fablabimola.it)). It is an organisation of entrepreneurs and professionals aiming at diffusing digital culture in design and manufacturing.
- Maker Station - Fablab Bassa Romagna ([www.makerstation.it](http://www.makerstation.it)).
- MakeInCo ([www.spaziomarconi.it](http://www.spaziomarconi.it)). It is a Fablab located in Comacchio, very peripheral area, and has a great multidisciplinary vocation especially in the field of creative industries.
• MakeIt Modena ([http://makeitmodena.it](http://makeitmodena.it)). It is one of the few Fablabs managed directly by the local municipality, and it is specialised in creating virtual space and prototyping.

• Wake ’n’ Make ([www.wakenmake.it](http://www.wakenmake.it)). It is managed by an association and it cares training courses and co-working activity.

• WASP ([www.wasproject.it](http://www.wasproject.it)). It is a innovative and ambitious company, applying 3D printing to the construction and ceramic sector and it could produce even real small, energy efficient houses by 3D printing technology; it is a producer and exporter of big 3D printers.

• MakeRN (www.makern.it). It is located in Rimini, managed by an association and it is focused on training and divulgation of digital making.

• Fablab Faenza (www.fablabfaenza.org). It is a very active cultural association involving a wider community through training, information and co-working and it develops several 3D design and making.

• Fablab Terre dei Castelli (www.fablabetredeicastelli.it). It is located near an important business incubator, in the middle of a very industrialised area. It makes available digital manufacturing machines for printing, cutting and visualising, and organises courses and workshops.

• Makers Modena Fablab (http://makers.modena.it). It provides, as do other Fablabs, training courses, workshops and services based on the digital equipment available. It developed 3D printing for aesthetic goods.

• Fablab Forlì (www.fablabforli.org). It is one of the most recent Fablabs, but it has already some experimental projects on process and has organised courses.

• Industrie Creative Piacenza Urban Hub (www.urbanhub.piacenza.it). It is a Fablab especially oriented to cultural and creative industries or digital industries in the strict sense, and it is managed by a very motivated group of young people.

The experience of this network shows that virtuous experiences for the creation of Industry 4.0 and smart manufacturing network do not necessarily require a strong top-down approach coming from big research organisations, or technology centres or large firms, but can be also a bottom-up process, carried out by young people. The message of this experience is that the innovation processes in this historical phase can follow informal and unexpected forms of learning and diffusion.

1.10 Leveraging the existing potential

Despite being a very reactive social and industrial context, Emilia-Romagna, in this phase of strong change of technology and business environment, has several challenges to face in the next years. The nature of the region requires not a sum of individual cases, but a systematic change, to be diffused among firms and people. The milestones of change for developing a smart region can be summarised in three basic elements: i) Science and Technology, ii) Digital Agenda, and iii) Culture and Creativity. Around these three elements the main challenges for the future can be individuated.

• **Challenge 1. Increasing awareness of the potential of broadband infrastructure:** First challenge is that of making companies aware of the potential of broadband. Most users imagine that broadband will simply facilitate trade, through e-commerce, and not that it is possible to reorganise entire value chains and that the nature of work will change. The region has achieved a remarkable broadband access all over the major and minor population centres; companies individually or by consortia can easily access connection and broadband services, but of course they need to understand which are the real advantages they can obtain, the risks linked to missing these opportunities, and
what changes will occur in their business model and in the organisation of their value chains.

- **Challenge 2. Better connecting research to industrial innovation:** A second challenge is that of further improving the connection and positive interaction between the sphere of research and the world of companies. After several years of work, and despite some significant improvements, there is still a significant separation between the two spheres. The future efforts of the region shall consist of determining a wider autonomy in the industrial research laboratories, especially those operating in the techno-poles, increasing their attention to the market. It will be essential to develop finalised projects both involving actors and combining mechanical, materials and digital competencies largely available in the research and university system and in the Regional High-Tech Network. In addition, Technopoles represent the right context in which to develop experimental initiatives of high technological relevance and organise possible service units accessible to SMEs. Still, several technological results remain unexploited for lack of adequate motivation context and opportunities and it remains a crucial challenge for further increasing the competitiveness of the region, considering the dynamism and the ability of quick reaction of its social and entrepreneurial environment.

- **Challenge 3. Absorbing creative resources into firms:** For traditional companies it is not common to introduce some types of protagonists typical of the creative economy. Creative people are normally difficult to manage and include in an organisational scheme, because they need freedom of thinking and of initiative. But it is a fact that the world of creative people has been very quick to adopt the concept of digital making or manufacturing, in many cases much quicker than consolidated firms, as it is shown by the protagonists of the MAK-ER network. It is necessary to find new managerial schemes to valorise this new propensity and to transform it in real value. From a business point of view, Industry 4.0, especially in the dimension of Internet of Things, requires first of all a reinforcement of the creative and technical design function within firms, in order to have control over the value chains. The experience of Fablabs, especially in that original aspect of matching traditional handicraft production with digital design and 3D printing can be a great source of strategic human resources for the industrial system.

- **Challenge 4. Redesign business and network models and managerial approaches:** It is evident that several organisational changes will take place within firms and they will change the business and the network models of firms. The capacity of firms to successfully compete will depend on their capacity to mobilise adequate creative and innovative resources according to teamwork in a context of open innovation. This is a very complicated cultural change for the great majority of firms. The part of the system more exposed to such changes are providers and subcontractors, normally the weaker components of the value chains, since they are excessively specialised and most of them, little innovative. It is true that not everything will be made by 3D printing or Internet of Things, but several of these firms risk being excluded by their traditional collaboration networks or reducing their contractual power. There is the need of a careful policy action for extending the participation of the majority of protagonists to this phase of change in manufacturing, and it is possible to involve leading firms in programmes of reorganisation at the cluster level.

- **Challenge 5. Reinforcing ICT and service innovation:** Two of the main weaknesses of Emilia-Romagna productive system can be jointly individuated in the ICT sector and in the service sector in general. The ICT sector, excluding some cases of excellence, is not developed enough and it is widely represented by very
small software developers with little management or innovation capacity. This is of little attraction for young ICT engineers; the best ICT competences are embodied in manufacturing companies, but this means that innovation is led by manufacturing and not by ICT. The same happens with other services, especially knowledge-intensive services. The level of productivity in this sector is quite low, since most of the time they are individual or micro firms, or sometimes, simple professionals. It is necessary to stimulate the transforming power linked to service innovation by a structural reinforcement of this sector, which can have a relevant impact also in other fields, not only manufacturing, but also tourism, retail and social services. It is absolutely crucial that Industry 4.0 will be accompanied by service innovation in order to establish completely new relationships at the market level.

- **Challenge 6. Exploring new applications for business related to Industry 4.0:** It is not yet clear if Industry 4.0 will determine the increase or the reduction of employment in consolidated sectors. But we can say it is almost sure that it will create new production possibilities, new markets, new sectors and business opportunities. In the world of arts, handicrafts, architectural recovery, reconstructing cultural goods, or in the health and wellness sector, for building artificial bones or prosthesis. In a few words, it is possible to generate new industries and humanistic competencies and creativity can give an important contribute to this challenge.
2. Regional Innovation Performance Trends, Governance and Instruments

2.1. Recent trends in regional innovation performance

Emilia-Romagna is generally considered to offer a favourable environment for businesses, at least with respect to many other Italian regions: it is a good example of successful institutional public-private sector cooperation involving political, social and economic actors. The regional system relies on intensive and complex networks involving private businesses, government agencies and research institutions.

In 2013, Emilia-Romagna Business R&D expenditure accounted for €356 per inhabitant, while the Italian average is €190.6. It scores second after Piedmont (a region with presence of large private research units of big companies). At the same time, public research expenditure per capita is less than half this value. This means that the private sector is able to greatly mobilise and maximise knowledge resources.

More in details, in the 2000s the regional expenditure in R&D grew very quickly and passed from less than 1% of GDP to 1.66%, in 2013. The growth was totally led by private R&D growth, that represents more than two thirds of the total expenditure. Of course it is still far away from the European objectives established in with the Lisbon strategy and from the trends in Northern Europe, but it still a remarkable result, especially when considering that in recent years the Italian government has spent very little money to support research and development.

Employment in R&D is around 29,500 units out of a total workforce of 2.1 million people in 2013. More than 18,500 are employed in firms, more or less the same ratio as for R&D expenses. An important figure in the Italian panorama that presents a relevant negative gap with Northern Europe is the share of S&T graduates aged between 20 and 29; these account for 18.7% in Emilia-Romagna, compared to 13.2% in Italy.

Taken this context into account, according to 2011 data, Emilia-Romagna scores higher than the national and EU average in terms of euros per inhabitant invested in Higher Education R&D (€124 vs. €93.6 (national) and €119.2 (EU)). However, while the share of Higher Education R&D over GDP is higher than the Italian average (0.36%) it is much lower than the EU average (0.49%), which is also growing rapidly.

As far as the output indicators are concerned, they must be considered in the context of the Italian performance in the indicators discussed above:

i) First, a high level of exports. Emilia-Romagna is in the group of Italian regions with the highest share of exports in its GDP, and the top region when considering the value of exports per capita. Given that the region is not characterised by particular cost advantages, whether in labour, taxation or safety and environment controls and energy, it implies that exports are strongly based on quality and innovation value.

ii) Secondly, the high number of industrial patents registered, which traditionally stands out among other Italian regions (15% of Italian patents on 7.8% of demographic weight in 2015). Recently the indicator of patents registered at the EPO declined, as it appears that in general this instrument to protect innovation is becoming less attractive and less effective, in a context where other aspects of innovation dynamism are gaining in importance. It seems that patenting becomes relevant only for trading IPR, but not for protecting firms’ innovation results. Anyway, in 2015, there was a new unexpected increase of 9% of Italian EPO registrations. Patents of Emilia-Romagna are normally registered in consolidated sectors (not high- but rather medium- low-tech) and
this can explain why despite increasing efforts in innovation there is not a parallel growth in patent registration.

iii) Finally, the high number of innovative start-ups, both in high-tech and digital applications. After a national law of 2012 there is a special register in Italy for innovative start-ups, and Emilia-Romagna has already registered almost 600 firms, about 11% of the whole Italy. The community of start-ups is constantly increasing around universities and technopoles, business incubators, hubs and Fablabs.

Emilia-Romagna benefits from EU Structural Funds, mostly for “objective competitiveness” of the region; resources available for “objective competitiveness” are much smaller than those available to “objective convergence” regions. For the whole period 2014-2020 Emilia-Romagna has an availability of €140m for Objective 1 (Research and Innovation), and €100m for Objective 3 (Competitiveness). The first calls under Objective 1 already absorbed €80m. The availability of resources to support research and innovation efforts of firms are quite limited and largely insufficient in relation to the potential demand.

It must be considered that in the phase 2007-2013, the Axis 1, dedicated to research and innovation, registered an overbooking in certified expenses of at least 20% higher than foreseen, despite not being given easy access, prioritising grants to firms on complex system programs, like technopoles and the High-Tech Network. In the context of an availability of €125m, final expenses to be certified will be around €150m.

Considering that the Italian banking system provides relatively little support for research and innovation investments, the region lives in a paradox: an economic context highly dynamic and oriented to innovation, and a consistent shortage of public and credit resources that can support them in such efforts.

In addition to this, relevant efforts are now dedicated to obtain more resources from Horizon 2020. In the Seventh Framework Program Emilia-Romagna obtained a good result, since it was able to attract a substantial share of Framework Programme funding, approximately 10% of the Italian contribution to the Programme (€1.4m) and is the fourth region in Italy in terms of rate of absorption (after Lazio, Lombardy and Tuscany). Considering that the total level of absorption of Italy is quite low, the objective is to obtain a relevant increase in Horizon 2020.

In summary, the key drivers to innovation performance in Emilia-Romagna are:

- The peculiarity of the large industrial base. Emilia-Romagna is one of the most industrialised regions in Europe and most of this economic success is due to its clusters of SMEs, which rely heavily on tacitly on embedded knowledge and division of labour. Firms’ clustering allows the identification of common technological needs and rapid implementation of viable solutions.
- Firms’ increasing awareness towards innovation and their growing interaction with the academic system within the regional system, or even outside of the region and outside of Italy. The region made significant efforts to stimulate firms’ interaction with the regional research system and there is some evidence that university-industry interactions are growing, but it is leading also to the creation of relationships of collaboration, even outside of the region.
- The dynamism of the regional society, starting from young people who are ready to use new technologies in their fields of interest, starting from cultural and creative industries and social activities. Almost spontaneously they have created a network of hubs and co-working spaces that will accelerate the process of learning and change through the new technologies.
2.2. Institutional framework and set-up

Regional innovation policy is designed and delivered by regional governmental bodies, with the consultation of local stakeholders (local administrations, industry associations, research institutions, etc.). After one phase of reinforcement of regionalisation of policy making at the beginning of the Century, the opposite tendency is now taking place. In 2008 the National Fund for Investment, the main source of autonomous resources for regions for development policies, was eliminated. In addition, in the most recent years, after 2011, there are increasing pressures to further recentralise industrial policies, despite evidence of low effectiveness of innovation policies managed at the central national level, for bureaucratic difficulties in providing grants (Industry 2015 Program, National Technological Clusters, for instance). In addition to this, increasing limitation of expenditure due to the Stability Pact and other macroeconomic constraints are strongly limiting the financial capacity of the region.

Anyway, in Emilia-Romagna the regional government is still playing a role of leadership despite increasingly limited resources. The tradition of strong consultation with all types of regional stakeholders makes the region the key player to maintain a balanced distribution of competences.

The regional administration has a central role in designing innovation and economic development policy and strategy. The offices of the Industry and of the Innovation Department are in charge of programming, implementing and controlling the regional policy in the area of innovation. In particular, these offices carry out the following activities:

- Regional Program for the development of productive activity,
- Regional Program for industrial research, innovation and technology transfer,
- ERDF Operational Programs,
- Regional Smart Specialisation Strategy.

In particular, within this Directorate, the Unit “Economic Development, Industrial Research and Technology Innovation Policies” carry out the following specific policy measures:

- Promotion of R&D collaborative projects of firms,
- Promotion of industrial research project or programs to be developed by laboratories,
- Promotion of innovative greenfield or expansion investment,
- Promotion of innovative and creative start-ups,
- Realisation of innovation infrastructure: techno-poles, incubators, co-working and hubs,
- Promotion and realisation of living labs for urban development and diffusion of the digital agenda,
- Management in agreement with Ministry of Economic Development of the Framework Agreements for research and other framework agreements,
- Management of initiatives in support development and innovation of productive and technological districts and for the promotion of research networks,
- Promotion of local development programmes,
- Promotion of local economic activities and territorial marketing (Progetto Ervet Investinemiliaromagna),
Promotion of interregional cooperation projects and agreements in the field of innovation and technology transfer, start up promotion and local development.

The region pursues its policy through strong stakeholders’ consultation.

The main consultation institution is the “Tavolo per la Crescita” (Committee for Growth). In this institution, together with the regional government, represented by the President and by its departments involved in industrial and development policies, there are representatives of all business organisations (industry, retail and services, agriculture, handicraft, cooperatives), chambers of commerce, trade unions, local administrative levels, banks and credit guarantee funds, mission oriented in-house providers of the region. At this level, general strategies and major economic problems and trends are discussed.

With the need of implementation of the Smart Specialisation Strategy, the “Tavolo per la Crescita” will have a strategic role in promoting and organising specific thematic forums dedicated to the priorities individuated in the Strategy. Namely, there will be organised the following forums: Agro-food system, Construction system, Mechatronics and Automotive, Health and Wellness industries, Cultural and Creative industries, Service innovation. The forums will group regional departments involved in the management of ERDF and ESF, (EARDP FOR Agro-food), all other department included in the specific thematic, including the digital agenda, members of the High-Technology Network involved, firms, cluster organisations, business organisations, and any other actor with specific interest in the theme. Through these forums, the big effort will be that of coordinating policies of various natures (innovation, training, planning, regulation) in order to maximise their effectiveness and promote coherent behaviour of the private sector.

One second important institution of this consultation is the Regional Conference of University Rectors, occasionally extended to the directors of the public research institutions working in the region. This conference discusses policies concerning industrial research and technology transfer to industry, to the health system and to other fields of applied research; strategies to better participate in European and national calls; project ideas for interregional cooperation; policies for facilitating the job placement of graduates or for promoting research jobs or doctorates, and what else can be of interest in terms of regional coordination concerning university, advanced training and research.

The regional administration is supported in the process of policy-making and delivery by ASTER, a consortium for industrial research, technology transfer and innovation created between Emilia-Romagna regional government, regional universities and national research organisations with some of their institutes or departments located in the region. ASTER has the scope established by a regional law of:

- coordinating and assisting the Regional High-Tech Network of industrial research laboratories and innovation centres, and of the techno-poles infrastructure,
- making available to firms information about technology and science competencies in the regional university and research system, and information about financing opportunities,
- developing other online and offline instruments to facilitate firms in accessing to technology resources of the regional system,
- promoting the regional industrial research and innovation system in the national and international context together with industry,
- developing strategic projects of regional relevance for participating in European and national financing opportunities,
• supporting researchers in developing managerial skills for their employment in companies or, eventually, for their future start-up initiative.

ASTER, being a consortium, works on the base of an annual shared program of common interest for associates that it supported both by financial and by in-kind resources. ASTER can participate to interregional projects together with the region or representing it in the items concerning technology and industry, or it can participate to European calls, especially Horizon 2020, in support action projects or in the role of coordinating unit.

ASTER has the typical societal bodies (assembly, board of administrators, and so on), but has also a consultation Committee (composed by the representatives of the associates organisations, local administrations and representatives of the business organisations) that is aimed at better organising its activity for technology transfer and involving firms.

Finally, ASTER has the role to coordinate and ensure the governance of the High-Tech Network. To date, the network has been organised according to thematic areas of technology interest. The following platforms have been identified for at least 10 years: Advanced Mechanics and Materials, Construction Technologies, Energy and Environment, Food, Life Sciences, ICT. Each laboratory must participate at least in one platform, but can have also a second or third platform. Platforms have the role of sharing competencies, networking resources, elaborating and proposing strategic projects, organise a coordinated communication to local industry and to foreign partners. To be members of the Regional High-Tech Network industrial research laboratories and innovation centres need an accreditation that is given on the base of a specific procedure based on technical inspection and evaluation. Criteria of accreditation are not so much based on technological capabilities, but on organisational and performance indicators. Members are not only university centres, but also public-private consortia, other institutions, private R&D companies, research units of firms that can independently provide research and innovation services to the market.

The synthesis between the general economic institutional governance and the technological governance will take place with the promotion of technological cluster organisations, in the form of associations, composed of laboratories, centres and firms. Probably platforms will evolve into such new, more focused cluster associations, whose scope is to propose finalised projects to various calls, from the European to the regional level. For each priority of the Smart Specialisation Strategy it will be possible to develop a limited number of associations. It is sure that one of these associations will be dedicated to “Digital Manufacturing”. In this sense, it is expected that there will be a concentration of competencies and interests on manufacturing transformation in this context. And it will be the context in which to elaborate and promote strategic projects for this crucial aspect of technological change of the next years.

2.3. Regional innovation policy mix

The experience of approaching innovation policy according to an ecosystem approach started more than a decade ago.

The first Program for Industrial Research, Innovation and technology Transfer (PRRIITT, 2003) introduced a balanced policy mix that combined demand-pull and technology-push initiatives and was focused on the consolidation of the regional innovation system. The PRRIITT aimed at increasing the capacity of regional research institutions to support the local production system, promoting high-tech start-ups, technology transfer and the collaboration between universities, research organisations and industry. The implementation of the PRRIITT programme
required the investigation of the local demand for research services and the availability of local research competencies; a sort of initial smart specialisation strategy.

The core action of the PRRIITT programme was the promotion of the creation of the Emilia-Romagna High Technology Network. The High-Technology Network was established in 2005 with the aim to boost the supply of qualified industrial research services, increasing synergies between regional universities and research centres. The PRRIITT has been recently updated with the PRRIITT for 2012-2015. The PRRIITT 2012-2015 is based on three fundamental concepts that define the objective of the current regional innovation policy, namely: i) ecosystem of innovation, ii) smart specialisation and iii) creativity. The PRRIITT 2012-2015 is articulated into five objectives that address the reinforcement of the High-Technology Network support for technology transfer; the regional demand for innovation promoting collaborative research business start-ups; and the development of integrated value chain programmes. These objectives define the initiatives that are currently under development and that will be launched during the next programming period. The Guidelines for the creation of technopoles (2008) is another important document for the definition of the regional innovation strategy. This strategy allowed the creation of regional research laboratories, involving 177 research groups, 110 firms participating in the labs, 234 sponsoring firms and 128 other sponsoring organisations, and 10 local infrastructures for technology transfer (technopoles).

Another action has been developed since 2009 and 2013, thanks to a program co-financed by the Minister of Economic Development for promoting innovation in industrial clusters. Emilia-Romagna developed two types of action in two different stages:

- In the first stage the region made a call for leading companies of clusters, requiring them to develop an action of involvement and divulgation of results to the whole value chain and the entire cluster; 36 projects have been approved for 14 different clusters.
- In a second stage, the region decided to stimulate innovation and aggregation of SMEs for developing research and innovation initiatives. In this cases the call worked for 16 clusters and with the support of innovation centres, 93 research network were created, involving about 280 small firms and generating new employment for about 300 young graduates in S&T.

At present, the regional strategy for 2020 is a bit more complex. There are three reasons for this higher complexity: i) the greater maturity of the innovation ecosystem; ii) the impact of crisis of the last years and iii) the increase of unemployment. In addition, the earthquake of 2012 risked to destroy some important parts of the regional industry and in particular the biomedical cluster. For these reasons, the current objectives are:

- reinforcing the innovation ecosystem along the strategic priorities individuated in the Smart Specialisation Strategy,
- regenerating the industrial system after the crisis and earthquake, combining innovation impact and generation of new employment.

There are three basic funding programs running at present:

i) A fund from the law of reconstruction in the areas of the earthquake for promoting research and innovation for the local firms (€50m allocated since 2013),

ii) A law for promotion and attraction of investment by supporting basically, R&D and training (Law n.14/2014 “Promotion of investment in Emilia-Romagna, €25m since 2016),
iii) The ERDF Operational Program 2014-2020, Axis 1, €140m until 2020.

In the framework of the first fund, the region, in the perspective of an extraordinary intervention, decided to sustain three types of projects:

i) Very simple projects for SMEs with a share of external expenses for research and innovation (R&D consultancy, tests, design, prototyping, etc.),

ii) The usual scheme supporting R&D projects for SMEs;

iii) Large R&D projects addressed also to large companies, under the condition of generating employment and of diffusing results to the clusters and the value chain.

These projects are being under realisation by companies and are going to finish by 2017.

Under the recent Law n.14/2014 was published a call with the scope to approve agreements for R&D projects, training and employment and energy re-qualification projects. It is important to mention that Emilia-Romagna cannot support investment of large firms in itself, but only some specific projects eligible by State Aid disciplines.

The call is structured in two stages. In the first stage companies must present an overall investment strategy with description of typology of investment and employment impact, with some initial draft of specific R&D projects. In the second stage, companies selected in the first stage must present detailed projects to be evaluated and eventually included in the agreement with the region.

By sustaining mainly research and training, this instrument seems to be able to combine innovation and generation of employment.

Based on the policy mix included in the ERDF 2014-2020 Operational Program, the reinforcement of the regional innovation ecosystem, together with the priorities of the Smart Specialisation Strategy, has established the following needs/objectives:

- making laboratories of the High-Tech Network more dynamic and oriented to propose specific advanced solutions to firms;
- stimulate innovation and diversification of firms with the primary support of the High-Tech Network and the regional innovation system;
- increase the technological competitiveness of the regional research system in the European and international context;
- promoting the reorganisation of the High-Tech Network and their operational settlement in the Technopoles;
- promoting the creation and the expansion of innovative and creative start-ups.

In view of the current ERDF programming period, the following instruments have been included in the policy mix:

i) **Strategic projects of industrial research**

This is quite a new scheme aimed at creating a stronger connection between research laboratories and companies and it represents the crucial measure in the implementation of the Smart Specialisation Strategy (S3), for promoting new advanced technological approaches and solutions for medium long-term innovation perspectives. In the S3, approved in 2014, the region individuated the mechatronic and automotive cluster as one of the main consolidated industrial systems to reinforce especially through research and innovation; in this view the main technology items underlined in the strategy were: a) smart, adaptive and safe production systems, b) integrated and human-centred manufacturing, c) sustainable processes.
The measure was a call dedicated to regional industrial research laboratories for developing strategic research projects aimed at generating innovative impacts in the S3 investment priorities in the medium long-term. Projects must involve a project leader and other partners, with a maximum of five. Other partners can be:

- other laboratories, that can develop complementary research activities, according to a multidisciplinary approach;
- innovation centres, involved in dissemination and technology transfer activities;
- other stakeholders that can be useful for better finalising research (like hospitals, museums, other institutions, associations and organisations).

For a maximum of 10% of the budget, beneficiaries external to the region can be involved. Projects must also individuate and present agreements with a minimum of two firms available to participate in the project with their technical, equipment and, eventually, financial resources, and available to start the application of the new strategy for future products. Firms will not receive grants from the region, but can obtain some rights on part of the final results.

Projects must present activities starting from TRL 4 (final stage in laboratory testing) and be completed with TRL 5 (or 6 for more adaptive technologies). Results of TRL 4 research activity can be disseminated and promoted to all interested firms by innovation centres. TRL 5 and 6 must be developed in collaboration with firms in order to develop specific applications of the new technology.

Regional grants are 70% for R&D activity and 100% for dissemination activity. The selection criteria are the following:

- Scientific and technological quality in terms of; clearness in definition of the objectives and S3 priorities, methodology and competencies,
- Financial and economic sustainability,
- Industrial feasibility and impact,
- Degree of advancement in relation to the state of art and KETs used.

**ii) Business R&D collaborative projects**

A second measure for the implementation of the S3 is a call to support business R&D projects and collaboration research-industry by a demand-pull approach. The call established two typologies of projects:

- R&D projects aimed at innovating and diversifying products and services,
- R&D projects aimed at activating new investment and/or production units.

Beneficiaries of projects of type “a” must present a marketing plan, while beneficiaries of projects of type “b” must present a plan of investment. Both SMEs and large firms can participate. Large firms must necessarily employ two new researchers for projects type-“a”, and three new researchers for project type-“b”. SMEs are not obliged to employ new researchers, but it is evaluated positively in the selection process. Firms must implement the project establishing a formal collaboration with a research laboratory.

Regional grants are coherent with the limits of State Aid disciplines for R&D. If the firm does not increase employment according to specific parameters, grant is reduced by 5%. Selection criteria are the following:

- Quality of the proposal, clearness of objectives and methodology,
- Financial sustainability,
- Advancement respect to the state of art in the market,
• Impact on the regional cluster,
• Level of competencies and experience,
• Impact on sustainability, health, information society.

iii) Support to innovative start-ups for their initial or expansion investment

The contribution of start-ups to change is getting increasingly relevant and this instrument, not very expensive, keeps its role in the regional policy mix. The new call for innovative start-ups, with two typologies of projects:

a. Initial investment.

• Expansion investment, for start-ups with at least 2 years of life, €200,000 budget and 3 employees.

• In addition, it considers two categories of start-ups:
  – High-tech start-ups, based on the exploitation of results linked to KETs or other relevant technologies;
  – Digital and immaterial start-ups, operating in the creative industries, social activities, knowledge intensive services.

The selection criteria are the degree of innovativeness of the product/service; and the sustainability of the business plan.

iv) Projects of innovation and product/service diversification for SMEs

This instrument, still to be implemented, aims at supporting SMEs unable to participate to R&D calls, but very oriented to innovation as well. The measure will support external expenses for completing the process of innovation (technology consultancy, testing, measurement, computing, design, digital content, prototyping) and expenses for temporary management, needed to introduce the innovation in the market. Projects can have the following features:

• new product/service;
• product/service strongly modified, especially through the contribution of digital elements in the production process, in the product itself, in relation with clients and stakeholders;
• significant redesign of products/services in terms of sustainability.

Projects will be evaluated on the base of the relevance of the diversification impact and of the quality of external services.

v) Contract networks between SMEs for innovation

One of the main mechanisms of technology improvement and innovation for SMEs is not only collaboration with research organisations, but reciprocal collaboration. On the basis of a previous experience mentioned above, which can be considered a good practice, the measure proposes the formation of formalised networks between SMEs with two possible scopes:

• developing joint R&D projects;
• developing joint innovative post production or after-market services based on digital applications.

vi) Research infrastructure valorisation

This measure, still to be implemented, aims at valorising research infrastructure of national and European relevance, supporting investment and research activity for developing specific in depth applications in relation with S3 priorities. The region has
already identified three basic research infrastructures in the region on the following items: big data, advanced materials, regenerative medicine and biobanks. The measure will work through an expression of interest by identified institutions linked to such items. The region intends to promote projects oriented to manufacturing 4.0 both in the context of Big Data and of Advanced materials, possibly favouring connection and intersections between the two projects.

vii) Governance of technopoles. In the previous ERDF Program 2007-2013

It has financed the realisation of technopoles. It is almost completed and most of them are already in condition to work. To accelerate this process of inducing a managerial approach for the development of these technology transfer infrastructures and optimising the information flows concerning regional measures, the region will support the organisation responsible for making the technopole work efficiently. It requires the capacity to cover costs and to organise initiatives, events, communication and promotion, services. The region can support these activities directly with ASTER contributions for the first two years.

viii) Research fellowships for S3

Through the ESF Programme, a measure to give research fellowships to young graduates in the regional universities was implemented, primarily finalised to specific applied research items, coherent with the S3 strategy. The objective is to give 1000 fellowships.

ix) Promotion of investment agreements for growth

This measure, external to the ERDF Program relates with a new regional law approved in 2014, "Promotion of investment in Emilia-Romagna", which aims to promote new greenfield or expansion investment in the region, in order to reduce the levels of unemployment accumulated after the crisis. The key instruments foreseen is the promotion of agreements with investors able to generate employment and possibly, high-quality employment and innovative investment.

The call requires to present the description of the investment plan. Material investment cannot be co-financed by the region to large firms, but only to SMEs. Together with the investment plan, the company must present specific R&D projects, training and employment projects, projects for energy efficiency and environment. All the projects, after the evaluation process, will be approved with a single act within an agreement between the region and the company. Typologies of investments are:

- Investment generating over 150 employees,
- Investment generating at least 50 employees, but 40% of which with university degree and operating in high-tech sectors,
- Investment in new private industrial research centres with minimum 20 researchers,
- Re-structuring of industrial plants increasing employment by 10%.

Table 6 Existing regional innovation support measures

<table>
<thead>
<tr>
<th>Title</th>
<th>Duration</th>
<th>Budget</th>
<th>More information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategic industrial research projects</td>
<td>2016-2019</td>
<td>€41.5m</td>
<td><a href="http://fesr.regione.emilia-romagna.it">http://fesr.regione.emilia-romagna.it</a></td>
</tr>
<tr>
<td>Business R&amp;D collaborative projects</td>
<td>2016-2019</td>
<td>€31.5m</td>
<td><a href="http://fesr.regione.emilia-romagna.it">http://fesr.regione.emilia-romagna.it</a></td>
</tr>
<tr>
<td>Title</td>
<td>Duration</td>
<td>Budget</td>
<td>More information</td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>------------</td>
<td>--------</td>
<td>-----------------------------------------</td>
</tr>
<tr>
<td>Support to high-tech and digital start ups</td>
<td>2016-2018</td>
<td>€6m</td>
<td><a href="http://fesr.regione.emilia-romagna.it">http://fesr.regione.emilia-romagna.it</a></td>
</tr>
<tr>
<td>Innovation and diversification projects for SMEs</td>
<td>2016-2018</td>
<td>€7m</td>
<td><a href="http://fesr.regione.emilia-romagna.it">http://fesr.regione.emilia-romagna.it</a></td>
</tr>
<tr>
<td>Contract networks for research and digital innovation</td>
<td>2016-2019</td>
<td>€5m</td>
<td><a href="http://fesr.regione.emilia-romagna.it">http://fesr.regione.emilia-romagna.it</a></td>
</tr>
<tr>
<td>Research infrastructure valorisation</td>
<td>2016-2020</td>
<td>€8m</td>
<td><a href="http://fesr.regione.emilia-romagna.it">http://fesr.regione.emilia-romagna.it</a></td>
</tr>
<tr>
<td>Governance of technopoles</td>
<td>2016-2019</td>
<td>€3m</td>
<td><a href="http://fesr.regione.emilia-romagna.it">http://fesr.regione.emilia-romagna.it</a></td>
</tr>
<tr>
<td>Research fellowships for S3</td>
<td>2016-2018</td>
<td>€20m</td>
<td><a href="http://formazionelavoro.regione.emilia-romagna.it">http://formazionelavoro.regione.emilia-romagna.it</a></td>
</tr>
<tr>
<td>Promotion of agreements for investors</td>
<td>2016-2021</td>
<td>€25m</td>
<td><a href="http://imprese.regione.emilia-romagna.it">http://imprese.regione.emilia-romagna.it</a></td>
</tr>
</tbody>
</table>

Source: RIM Plus repository (Emilia-Romagna/Italy).

2.4. Appraisal of regional innovation policies

As described above, structural adjustment and innovation objectives are in this moment balanced, from a political point of view, with the need to re-expand productive capacity, as the region is coming out from the crisis post 2008 and the effects of the earthquake of 2012.

In any case, innovation remains a crucial objective of policy, since firms can keep their competitive position only thanks to the promotion and uptake of innovative capabilities. The revolution of the manufacturing system is at this moment at the centre of attention. Even if not using a systematic approach the regional ecosystem is not in a condition of falling greatly behind, considering its tradition as a smart follower. The greatest limit is the variety of individual solutions without a codified scheme, the uncoordinated distribution of competencies among laboratories and other types of competence centres. So there is a fragmented approach both in the technological and scientific supply side, and in the business sector where new technologies are adopted one by one, without redesigning the complete strategic approach and the organisation. So there is an implicit strategy of step-by-step adaptation.

Meanwhile, the regional actor coordinating the mix of policies has to face a regional context of a large number of actors and protagonists, and a large number of agendas in several sectors that makes it difficult to take strongly incisive action. In this context, the region is adopting its more usual strategy (with just a few exceptions), of accompanying and favouring processes of change and addressing them towards virtuous pathways. This choice is also determined by the unavailability of sufficient resources to develop a disruptive initiative.

Examining the key challenges individuated, we can analyse how they fit with the policy mix described above:

- Challenge 1. Increasing awareness about the potential of broadband infrastructure.
• Challenge 2. Better connecting research to industrial innovation
• Challenge 3. Absorbing creative resources into firms.
• Challenge 4. Redesign business and network models and managerial approaches.
• Challenge 5. Reinforcing ICT and service innovation.
• Challenge 6. Exploring new applications for Industry 4.0 related industries.

The table below contains an overview of the key challenges:

Table 7 Key challenges for regional innovation policies in Emilia Romagna

<table>
<thead>
<tr>
<th>Policy instruments</th>
<th>Challenge 1</th>
<th>Challenge 2</th>
<th>Challenge 3</th>
<th>Challenge 4</th>
<th>Challenge 5</th>
<th>Challenge 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategic industrial research projects</td>
<td>X</td>
<td>XX</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Business R&amp;D projects</td>
<td>XX</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Support to high tech and digital start ups</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>XX</td>
<td></td>
</tr>
<tr>
<td>Innovation and diversification projects for SMEs</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>XX</td>
<td></td>
</tr>
<tr>
<td>Contract network for research and digital innovation</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>XX</td>
<td>XX</td>
<td>X</td>
</tr>
<tr>
<td>Research infrastructure valorisation</td>
<td>XX</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Governance of technopoles</td>
<td>XX</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Research fellowships for S3</td>
<td>X</td>
<td>XX</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Promotion of investment agreements for growth</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

Source: author’s elaboration

As can be seen, all challenges are faced through complementary policies with variable intensity. The approach is that of promoting relationships, positive examples and if possible systemic projects. There are various types of stimuli to orient behaviours towards a virtuous process, but everything depends on the behaviour of individuals, groups, firms and institutions.

The measure on strategic research projects has the implication of requiring the formation of cluster associations between laboratories and firms. There is an optimistic expectation that the “Digital manufacturing” association will have a significant impact on the regional ecosystem for better finalising efforts for industry transformation embodying a complete digital strategy.

Those measures that appear to have limited impact on these challenges, actually have been conceived mainly for other aims. For instance, the measure for the valorisation of research infrastructure aims essentially to increase the regional technology
competitiveness in the European panorama. Similarly, the measure for promoting investment agreements aims primarily to promote the creation of additional employment.

The regional policy mix can find synergies and complementarities with national measures. Particularly, National Technology Clusters and between these the “Intelligent Factory” cluster, and possibly with measures linked to the implementation of the National Smart Specialisation Strategy. Emilia-Romagna is one of the leading regions in such cluster and two of the four pilot projects have a regional leadership. Working groups in the steering committee of the cluster are:

- customised production,
- methods and instruments for production sustainability,
- human valorisation within factories,
- high efficiency production,
- innovative productive systems,
- adaptive production systems,
- new management strategies for next generation production systems.

The national cluster should be further implemented in the framework of the national Smart Specialisation Strategy. It must be said that until now it had a very limited concrete impact, since no grants have been yet transferred to project beneficiaries. Also the multiplying impact of the cluster for the generation of further project initiatives to candidate for instance, in Horizon 2020 calls, seems to be very limited.

2.5. Policy good practice

In recent years, no more relevant innovative measure can be already considered a good practice. New innovative measures have been launched with the new ERDF Operational Programme. In particular, there are important expectations from the main measure of “Strategic industrial research project” for S3 implementation. But these projects have just started and there are not the conditions to consider it a good practice.

That’s why one can consider a good practice one that was reported in the previous RIM report on Emilia-Romagna (2013), in particular the second call of the initiative “From productive to technological districts - 2”.

Starting from a definition of district not locally limited, but opened to all relationships and synergy, at least at the regional level, the objective of the measure is ambitious as it promotes the upgrading of productive systems, to increase their R&D efforts and the introduction of innovation in products, processes and business methods. The whole measure has the aim to turn productive districts into technology districts, with the help of the High-Technology Network. According to the intentions of the policy maker, this should be achieved by linking each district to one research institution or network. Therefore the initiative aims to stimulate a greater awareness and increase in demand for innovation.

The call, “From productive districts to technological districts - 2”, was launched in 2011 and completed in 2015 and was addressed at SMEs and aims to promote the evolution of regional districts supporting:

- the implementation and management of organisational functions in the area of innovation, R&D, design and engineering in SMEs,
• the creation of enterprise R&D networks carrying out research projects and developing new enabling technologies that can generate product diversification in districts.

To this end, the call has the following objectives:

• Promote the adoption of knowledge management, design management and open innovation practices.

• Promote enterprise networks in the area of R&D with young professional staff that are focused on medium- and long-term objectives, stimulating collective demand for research and product diversification.

• Some of the institutions that are part of the High-Technology Network, especially the innovation centres, manage the networks promoted with the initiatives (nine in total). These institutions, together with regional research institutions, also provide technical support to the research networks and to researchers. The initiative is targeted at the 16 regional districts specialised in the following areas:

  • Agro-food industry
  • Fashion industry
  • Technologies and materials for the ceramic industry
  • Technologies and materials for the building industry
  • Pharmaceuticals and biotechnologies
  • Biomedical and prostheses
  • Materials for mechanical engineering
  • Agricultural mechanics
  • Automation/mechatronics
    – Industrial mechanics and robotics
    – Electronics and precision mechanics
  • Packaging machinery
  • Engines
    – Vehicles
    – Pumps and motors
  • Nautical industry
  • Technologies for energy networks and services
  • ICT/multimedia.

The support scheme provides grants for SME networks with the objective to improve the preparation and recruitment of skilled staff, tutoring, research collaboration agreements with regional laboratories and consultancies for know-how acquisition. As part of this initiative the regional administration identified an organisation (an industrial laboratory or a technology transfer office) which is part of the regional High-Technology Network and that is in charge of a research programme targeted at district firms. The regional administration published some guidelines for the selection of research programmes. With the second call, regional universities and the laboratories of the High-Technology Network of Emilia-Romagna were asked to provide technical and scientific skills in the phase of creation and implementation of research projects in each district.

The results of the call (to date) are the following:
• 93 enterprise groups eligible for funding and business network contracts (90 business contracts and three consortia that work on 77 different research themes),
• The participation of more than 280 enterprises participating,
• The recruitment of 289 new researchers,
• The organisation of 65 promotional and experimental events targeted at SMEs.

The original aspects of the measure can be summarised as the following:
• The methodology to introduce young graduates in companies; they are fully reimbursed by the region for a whole year, during which they can demonstrate their value working for a specific project and not being introduced in companies’ routines; it seems it worked because almost 80% of researchers have been confirmed and regularly employed, despite the difficult economic context until 2014, and these researchers developed good innovation projects working in teams.
• The formal network limited to a specific project made companies strongly involved, but, at the same time, they could assume this experience as a sort of experiment, which was paradoxically the winning aspect; in the network, firms belonging to completely different sectors could individuate synergy and complementarities that would have never discovered elsewhere.
• It led to experiments with a new very essential figure, the network manager, a very complex activity that has to combine technical, organisational, economic, psychological competencies; this type of figure is essential to lead firms to grow and innovate working together.

2.6. Possible future orientations and opportunities

Establishing realistic future orientations in Emilia-Romagna is not easy considering the general limited capacity of intervention of the region in financial terms. The government orientation is that of centralising several fields of policy, including R&I policies. In parallel, financial autonomy of regions, including Emilia-Romagna will remain very limited.

Being confident in the great capacity of reaction of the entrepreneurial and social context and considering the large variety of experiences at several levels of the socioeconomic environment there some possible concrete orientations to be identified. As a result of several consultations, it can be said that here are three main groups of strategic competencies that firms need, namely: i) scientific and technological; ii) digital; and iii) creative and cultural.

Each of them, and most importantly their combination, is responsible for the process of constant innovation, and at the same time the ability to manage in new ways the relationships with markets, stakeholders, and society in general. The problem is often constituted by the fact that such competencies are separated among different bodies and linked to different organisations.

Possible future orientation, beyond what is still on going, can be:

• **Maximising opportunities of relationships, contamination and collaboration between the different types of actors of change.**

Normally different categories of innovators have a strong identity and are not so easily available to collaborate with different groups. Considering the three typologies, scientists and engineers, informatics and creative workers, it is clear that spontaneous communication and integration is often not simple. One future orientation of policy measures could require multiplicity of relationships in order to valorise the
multidimensional aspects of innovation. Initial actions in this sense have already been attempted, both with support schemes and through governance and coordination activities. Some of the calls’ objectives that will be implemented in the next months are to support projects of innovation and diversification of products and services, in which a set of services of various nature can be required (technology consultancy, tests, measurement and computing, design, software and multimedia consultancy, prototyping). It is possible to give priority to projects that combine different types of support. Another possible action, already attempted, but probably to promote even more, is the match between existing consolidated firms and start-ups, especially digital start-ups. Small start-ups producing games, apps, sometimes apparently insignificant, can have a disruptive effect on business models and competitiveness if used in the right context.

In the future, also in the implementation of the Smart Specialisation Strategy and in particular, in the perspective of promoting the culture of smart manufacturing, events that will match the various protagonists can be increased. For instance, it is necessary to combine researchers working in technopoles with creative and digital figures working in Fablabs and co-working spaces, and of course with entrepreneurs and managers of final products and services, designers and consultants.

- Promoting new management approaches and culture.

For approaching the markets in this new perspective of involving, internally and externally to the company, different kind of competencies, there is the need of new management models and new capabilities. On one side, it is necessary to let creative resources express themselves in the best conditions of freedom. On the other side, it is necessary to orient this energy towards specific business models, specific products to industrialise, specific approaches to clients and stakeholders with adequate communication techniques. It is necessary to emphasise teamwork and networking methodologies, to stimulate creative solutions and collaborations between individuals and firms. Only in this way will everybody understand the complexity of the processes and understand the relevance of reciprocal contributions. In a nutshell, smart manufacturing needs to embody high levels of culture and knowledge, even of differentiated nature.

It is to be verified how much schools of management are adopting this new vision or are still following the vertical scheme of single business functions for large business organisations. It appears possible that the problem will be solved by another bottom-up phenomenon emerging in the region: that of business academies. Successful firms are recognising the value of the cluster they belong to, but also of the social context in which they work, and they are dedicating some of their resources to these “academies”, which are formal and informal training organisations for the real innovation challenges of the future, mainly connected with the business of the company but not only this.

- Developing strategic research projects for making available advanced and innovative demonstrators.

It is necessary that the most relevant research infrastructure organisation will be strongly involved in large strategic projects to be financed under Horizon2020 or national funds, in order to develop leading competencies and advanced demonstrator projects able to stimulate further innovative solutions by firms. For instance, it is possible to develop large strategic projects in fields like Big Data applications, or virtualisation of production.

In this field, the main action should not be to stimulate further specialisation or technology transfer, but mainly to anticipate market and technology evolution. With the support of a regional commitment, such a possibility in Emilia-Romagna is
absolutely realistic, thanks to the presence of the research organisations mentioned above.

In comparison with other systems, a limiting factor for the regional manufacturing system can be its fragmentation, however, this is often counterbalanced by a strong capacity of adaptation; in this perspective, the region could build a strong position in the future by leveraging on its position as smart follower.

- **Developing innovative policy schemes for R&I based on the mobilisation of non-public resources.**

Considering the situation of public funds, the Region must develop policy initiatives and innovative financial instruments such as revolving funds or venture capital, in order to promote more innovative and market oriented schemes to stimulate the dynamism of the ecosystem. In this sense, it is necessary to mobilise banks and other financial organisations to make private resources available for research and innovation, possibly with the support of adequate guarantees of EIF and other credit guarantee funds.
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Appendix B Stakeholders consulted

1. Francesco Paolo Ausiello, ASTER

2. Patrizio Bianchi Assessore Scuola, formazione professionale, università e ricerca, lavoro, Regione Emilia-Romagna

3. Leda Bologni, Lead Coordinator of the Emilia Romagna Technology Platforms, ASTER

4. Enrico Callegati, CRIT

5. Enzo Madrigali, Fondazione Democenter

6. Marco Padovani, Democenter, Meccanica Association

7. Giuseppe Padula, University of San Marino

8. Mario Salmon, AASPECT Association

9. Marina Silverii, Deputy Director, ASTER

10. Elisabetta Toschi, ASTER

11. Daniele Vacchi, IMA S.p.A., ERAMIAT Association