FONDAZIONE ARISTIDE MERLONI

ECONOMIA MARCHE **Journal of Applied Economics**

Vol. XLIV, No.1, Giugno 2025

# Implementation of Smart Specialisation Strategies and the Quadruple Helix: A Comparison between Emilia-Romagna and Catalonia

**A. Venturi,** *Alma Mater Studiorium – Università di Bologna, Italia*

**Abstract**

This article investigates how the regions of Emilia-Romagna and Catalonia have implemented Smart Specialisation Strategies (S3) within the framework of European cohesion policy during the 2014–2020 and 2021–2027 periods. It highlights the role of the Entrepreneurial Discovery Process and the Quadruple Helix model in shaping regional innovation. Despite alignment with EU guidelines, the two regions adopted distinct governance models and policy tools, tailored to their local contexts. A notable example is the 2022 bilateral agreement promoting joint action in areas such as AI, Big Data, and digital transformation. Drawing on document analysis and stakeholder observation, the study compares initiatives like Emilia-Romagna's Open Labs and Catalonia's CatLabs. Findings reveal how both regions foster sustainable development and social innovation through diverse yet complementary approaches. The article underscores the value of transregional collaboration in enhancing innovation capacity. It also identifies practices that may inform S3 implementation across other European regions.

## 1. Introduction

This article explores how the regions of Emilia-Romagna and Catalonia have implemented their Smart Specialisation Strategies (S3) within the framework of European cohesion policy, with a focus on the 2014-2020 and 2021-2027 programming periods. S3 are central instruments in the European Union's efforts to promote innovation-driven regional development, guided by the Entrepreneurial Discovery Process (EDP) and implemented through the Quadruple Helix model, which involves universities, government, industry, and civil society.

While existing literature underscores the importance of inclusive governance and stakeholder participation in designing and implementing S3, there is limited comparative research on how different

European regions tailor these strategies to local contexts. This study addresses this gap by examining how Emilia-Romagna and Catalonia have operationalised the common European guidelines through distinct governance models, policy tools, and stakeholder engagement practices.

Although both regions are formally aligned with the European Commission's framework – having satisfied the ex-ante conditionality required for access to European Structural and Investment Funds – they have adopted differentiated approaches in translating S3 into regional innovation agendas. A notable example of this adaptation is the bilateral cooperation agreement signed in July 2022 between Emilia-Romagna and Catalonia, which formalized collaboration on shared priorities such as Research and Innovation, Big Data, Artificial Intelligence and digital transformation, demonstrating how EU-level strategies can be locally reinterpreted and internationally synergised (Regione Emilia-Romagna, 2022). In fact, this agreement exemplifies the outward-looking dimension of S3, a topic debated in literature, as it fosters transregional collaboration to address shared challenges, such as encouraging innovation through knowledge exchange across different sectors, and supporting the diversification process into new economic activities (D'Adda, D. et.al., 2020).

This analysis is based on a qualitative methodology combining document analysis – such as regional strategy documents and adopted strategies – with direct observation of stakeholders involved in S3 implementation. By comparing key tools – such as Open Labs and Transformative Agendas in Emilia-Romagna, and CatLabs and Shared Agendas in Catalonia – the article sheds light on how these regions involved actors from the Quadruple Helix in the policy design and implementation processes and how they aim to promote sustainable development and social innovation through different, yet complementary, models.

In conclusion, although their implementation paths diverge, Emilia-Romagna and Catalonia share common goals and mutually benefit from European cooperation. Their partnership exemplifies how transnational exchange and peer learning can contribute to more effective and locally responsive innovation policies. This comparative case study also aims to identify transferable practices for other European regions seeking to enhance their S3 implementation.

# 2. Theoretical Framework

European Cohesion Policy – often used synonymously with regional policy – finds its roots in the Treaty of Rome of 1957, which established the European Economic Community (EEC) and initiated a process of economic and political integration among the founding Member States (European Economic Community, 1957). In its early stages, the policy aimed to reduce regional disparities through instruments such as the European Social Fund (ESF) and the European Investment Bank (EIB). These instruments were later consolidated into what are now known as the Structural and Investment Funds, which constitute the main financial mechanisms of Cohesion Policy: the common aim of investments supported by the Structural and Investment Funds is to facilitate the implementation of growth strategies that are smart, sustainable and inclusive, in line with the overarching priorities of the European Union (European Parliament and European Council, 2013).

A significant institutional step occurred in 1968 with the creation of the Directorate-General for Regional Policy, followed by the establishment of the European Regional Development Fund (ERDF) in 1975 (Brunazzo, 2016). Over time, the policy developed clear and structured principles – most notably with the 1988 Structural Funds reform, which introduced multiannual programming, concentration, additionality, and partnership (Bailey, D. & Propris, L. D., 2002). These principles reflected the growing political ambition of the European Union to not only fund development but also coordinate planning across multiple governance levels. The Maastricht Treaty of 1993 further strengthened the Cohesion

Policy by establishing the Cohesion Fund for States with a Gross National Income below the European average and introducing the European Committee of the Regions (COR) as well as the subsidiarity principle. These developments led to the creation of a multi-level governance model, where various institutions cooperate to achieve common goals (Wassenberg, B. et al., 2020).
In subsequent programming periods, the budget allocated to Structural and Cohesion Funds continued to grow, eventually representing approximately one-third of the EU budget during the 2000-2006 programming period. For the 2007-2013 programming period, the budget amounted to €347 billion, equivalent to 36% of the Union's budget, reflecting a sustained commitment to reducing regional disparities. Over time, the general objectives of Cohesion Policy were streamlined compared to previous programming periods and, for 2007-2013, were formally defined as convergence, regional competitiveness and territorial cooperation. (European Commission, n.d.).
In the aftermath of the 2008 global financial crisis, the European Council launched the Europe 2020 Strategy in 2010. This strategy aimed to guide Europe's recovery through three interconnected priorities: smart growth (based on knowledge and innovation), sustainable growth (fostering a greener economy), and inclusive growth (promoting employment and social cohesion) (European Commission, 2010). This strategy received significant financial support for the 2014-2020 period, with 32.5% of the EU budget allocated to Cohesion Policy. The funds were distributed across various instruments, including the European Regional Development Fund (ERDF), the European Social Fund (ESF), the Cohesion Fund, the European Agricultural Fund for Rural Development (EAFRD), and the European Maritime and Fisheries Fund (EMFF) (European Commission, 2015).

A significant innovation introduced in this period was the requirement for ex-ante conditionalities. These were of two types:

- Thematic conditionalities: applicable to specific policy areas (e.g., R&D, environmental policy, social inclusion);
- General conditionalities: which applied across all investment areas (e.g., anti-discrimination, public procurement, statistical systems).

Compliance with these requirements was mandatory prior to the adoption of operational programmes, ensuring that Member States had the institutional and strategic capacity to effectively absorb and use EU funds. One of the most impactful thematic conditionalities was the requirement for a national or regional Smart Specialisation Strategy. These strategies had to be evidence-based, linked to national reform plans, and aimed at leveraging private investment in research and innovation (European Commission et al, 2016). They became the cornerstone for allocating resources in research and innovation, making them central to regional policy implementation and the focus of this article. In fact, Emilia-Romagna and Catalonia were selected due to their leading role in S3 experimentation within their respective national contexts and their active engagement in European networks on innovation and regional policy.
The current programming period, 2021-2027, builds on this foundation and sets five overarching policy objectives: to create a smarter, greener, more connected, more social and closer to its citizens Europe. Italy, for instance, was allocated a budget of €42.7 billion (European Commission, 2022), with a focus on green and digital transitions aimed at reducing regional disparities, while Spain has earmarked €37.3 billion to promote a sustainable and competitive economy (European Commission, 2022). The programming was influenced by global challenges such as climate change and the post-COVID recovery, integrating instruments like Next Generation EU into the funding architecture.

S3, introduced during the 2014-2020 programming period, represent an innovative approach to address

the challenges of globalization and social inequalities. S3 are based on an Entrepreneurial Discovery Process (EDP), a participatory mechanism designed to identify regional innovation priorities. The approach builds on the Quadruple Helix model, which brings together four key actors: university, industry, government, and civil society (European Commission, 2012). S3 aim to promote technological, social, and organizational innovation, requiring multi-level governance that encourages the active participation of all stakeholders. The European Commission advocates for the creation of transnational cooperation networks to support the implementation of strategies, emphasizing the need for an effective monitoring system to evaluate the objectives and outcomes achieved (European Commission et al., 2016).
The "Quadruple Helix" emerges as an innovative concept within the European Union, expanding the understanding of innovation beyond traditional configurations. In this context, innovation is not limited to a single dimension but takes on technological, social and market forms, intersecting with issues of transformation, cohesion, growth and sustainability. It results from a complex intertwining of knowledge and practices, involving public, private, and civil society actors, even from diverse backgrounds (Marinelli E., Perianez-Forte I., 2017).
To fully grasp the importance of the Quadruple Helix, one must refer to the preceding model of the Triple Helix, which sought to facilitate interaction between government, universities and industry. This model proved effective in advanced economic contexts, where synergies between these actors enabled the creation of knowledge-based economies. However, in less developed regions, the Triple Helix revealed some limitations, as its effectiveness relied on a technological paradigm that presupposed interaction and knowledge exchange among actors, often lacking in these areas (European Committee of the Regions et al., 2016).
The need for a new model was highlighted by the studies of Elias G. Carayannis and David F.J. Campbell (2010), who proposed the inclusion of "civil society" as the fourth actor in the innovation process. Civil society, understood as the end "user" of innovation and as an active co-designer, plays a crucial role in the functioning of the Quadruple Helix. According to the European Commission, this dimension includes actors such as non-governmental organizations and consumer associations, whose involvement is essential to address contemporary social challenges.
Moreover, Carayannis and Campbell (2010) theorized the emergence of a "Quintuple Helix", which incorporates environmental and economic contexts, suggesting that innovation must also consider these aspects. The Quadruple Helix, therefore, not only broadens the concept of innovation but places it in a wider context of interaction and collaboration.
Arnkil et al. (2010) identified different configurations of the Quadruple Helix, which vary based on the active role of civil society in the innovation process. The first configuration, the "TH + User Model" sees innovation primarily driven by industries or universities, with a focus on technological innovation and scientific knowledge. The second, the "Firm-Centred Living Lab Model" involves users in innovation design, with industry as the main driver. The third configuration, the "Public Sector-Centred Living Lab Model" is governed by the public sector and aims to improve services through interaction with citizens. Finally, the "Citizen-Centred QH Model" places citizens at the forefront, with the other spheres of the Quadruple Helix supporting user-driven innovation.
To sum up, the Quadruple Helix represents an innovative and territorial approach, becoming a reference point for Research and Innovation Strategies for Smart Specialisation. Its effectiveness lies in the synergy between the different actors involved, highlighting the importance of civil society's involvement in the innovation process. The Quadruple Helix's innovation manifests in the conception of collaboration and dialogue among various actors as a critical continuum, particularly in the construction phases of S3 in European regions. In this context, civil society assumes significant theoretical responsibility, both in its relationship with local communities and in the fight against climate change, as highlighted by Roman et al. (2020).

To clarify the concept of the fourth helix, in this context the definition provided by the European Committee of the Regions et al. (2016) is adopted: it is seen as a collective entity formed by users who interact with universities, industry, and government, contributing to new innovation pathways that promote the socio-economic growth of the territory. Civil society not only expresses specific needs and provides feedback on products and services but also contributes knowledge, inventiveness and creativity. Furthermore, the interaction with other helixes is facilitated by enabling information and communication technologies, which allow for active and timely social inclusion.

S3 should materialize the Quadruple Helix through practical actions. While this process is not simple, the integration of civil society is essential to stimulate innovation that goes beyond the technological paradigm, embracing social and scientific dimensions. Carayannis and Rakhmatullin (2014) emphasize the importance of cross-sectoral, intra-sectoral, cross-regional and intra-regional learning within the Quadruple Helix, fostering interaction among different actors.

In line with the "Europe 2020" strategy of the 2014-2020 Cohesion Policy, emerging ecosystems must pursue smart, sustainable, and inclusive growth, creating value through the participation of all involved parties. This requires a specific type of interaction, referred to as "multi-level governance" where the government plays a supporting role in innovation, leveraging its economic and political capacities. According to Carayannis and Rakhmatullin (2014), the innovation system is the intersection of political, economic and knowledge systems. Through the inclusion of the fourth helix, new actors emerge as central to regional development, expanding the boundaries of knowledge to encompass fields such as art, culture and social values.

Sustainability challenges, which affect social, political, and economic dimensions at various levels, require coordinated and sustained actions. Carayannis and Rakhmatullin (2014) identify nine critical areas that require the smart use of technology, including the financial system, environmental challenges, food security, energy, education, and global political reforms. These challenges can be effectively addressed through the Quadruple Helix approach and S3s, whose flexibility allows their application in local contexts, facilitating the transnational transfer of knowledge and good practices. These tools help regions compare strategies, share best practices, and refine their innovation systems through mutual learning. The role of civil society, in this light, is not merely complementary but essential to long-term sustainability, legitimacy and responsiveness of innovation policy.

As previously mentioned, Emilia-Romagna and Catalonia were selected for this study because they represent two proactive regions in Europe in the field of S3. Both regions not only fulfilled the formal requirements but also experimented with innovative tools for stakeholder engagement and institutional learning. Moreover, they signed a cooperation agreement in 2022 specifically aimed at deepening mutual exchanges in R&I and S3 governance (Regione Emilia-Romagna, 2022), making them exemplary cases to analyse the operationalisation of the Quadruple Helix within S3.

# 3. Empirical analysis

This empirical analysis examines the implementation of Smart Specialisation Strategies (S3) in Emilia-Romagna and Catalonia across the two European programming periods 2014–2020 and 2021–2027, with particular focus on participatory governance, innovation tools and the integration of the Quadruple Helix (QH) model and Responsible Research and Innovation (RRI) principles, which refer to an inclusive approach to research and innovation. The comparative nature of this analysis sheds light on the contextual specificities that shaped each region's trajectory and adaptation to EU policy frameworks.

According to the RRI Tools project (s.d.), RRI is articulated around three main aspects: the involvement of society in R&I from the early stages, the relationships between R&I and society, and its cross-cutting

role in the Horizon 2020 program. Recently, the roles of the four helixes have undergone transformations: universities actively engage with industries, government institutions enhance innovation support services and civil society emerges as a source of social innovation. The entrepreneurial discovery process is valuable in defining strategies, as the civil society involved can engage with issues that closely affect them at the local level and contribute their knowledge based on subjective experience (European Committee of the Regions et al., 2016).

The analysis of the Research and Innovation Strategy for Smart Specialisation (S3) of Emilia-Romagna, approved by the European Commission in 2016 for the 2014-2020 period and subsequently renewed for the 2021-2027 period, presents a valuable opportunity to explore the application of S3 and the Quadruple Helix approach. This strategy stands out for its commitment to engaging civil society in a participatory and inclusive innovation process. The strategic documents were drafted following European Union recommendations, including a detailed SWOT analysis that identified strengths and weaknesses in the region's socio-economic fabric, and implemented a targeted Entrepreneurial Discovery Process (EDP).

The Emilia-Romagna region, located in northeastern Italy and home to approximately 4.4 million inhabitants, has faced significant economic challenges following the global crisis of 2008. This event had a considerable impact on the regional socio-economic landscape, with a worrying rise in unemployment. In light of this situation, it became urgent to reactivate the regional production system through strategies aimed at promoting growth and innovation. The region's strategic objective was to build a "regional innovation programming ecosystem" characterized by an integrated and dynamic network capable of attracting investments and talent while fostering innovation in both established industries and entrepreneurial renewal (Regione Emilia-Romagna et al., 2016).

In this context, Emilia-Romagna stands out for its extremely dynamic production system, the result of a long process of specialisation and knowledge accumulation, supported by strong interactions between businesses. The region's "Research and Innovation System" actively involves universities and research centers. The four main universities - Bologna, Ferrara, Parma, and Modena-Reggio Emilia - play a crucial role in promoting research and developing innovations. Alongside these institutions, nationally significant research centers such as the CNR (National Research Council) and INGV (National Institute of Geophysics and Volcanology) further enrich the scientific landscape. The "High Technology Network" coordinated by ART-ER, is a key element for regional innovation, while the creation of the "Data Valley" marks an important step toward digital and inclusive development (Regione Emilia-Romagna et al., 2016).

Despite these potentials, the 2016 strategic document highlighted a relative lack of public investment, with research and development (R&D) spending below 0.5% of GDP. This underscores the urgency of more robust financial commitments to support innovation initiatives. The analysis conducted on the Emilia-Romagna context reveals a network of actors open to innovation, but it also highlights limitations at the international, organizational, and service levels, hindering the region's ability to fully develop collaborations and exploit its innovative potential.

In the 2014-2020 period, the strategy emphasized the importance of focusing on the interaction between local actors, leveraging the region's dynamic system. The primary objective was to enhance competitiveness and job growth, allowing citizens to actively participate in the innovation process. To operationalize the S3 strategy, it was essential to define the productive sectors in which the region should specialize. Through the Entrepreneurial Discovery Process (EDP), ART-ER conducted an analysis of entrepreneurial specialisations, identifying five key sectors: Agri-food, Construction, Mechatronics and Automotive, Health Industries, and Cultural and Creative Industries. The first three sectors represent the pillars of the regional economy, while the latter two are considered high-potential sectors. To engage businesses, regional public calls were issued, alongside mapping of innovative companies and start-ups. In fact, there were created Clust-ERs, which were work laboratories of start-ups and businesses. Additionally, both citizens and businesses had the opportunity to participate in a public consultation

where they were encouraged to propose modifications or additions, through the "Emilia-Romagna Open Innovation Platform" (EROI), which is a digital platform open to people who want to participate in the innovation process. This approach helped identify the technological and organizational directions to target in order to strengthen systems and enhance regional competitiveness (Regione Emilia-Romagna et al., 2016).

The 2021-2027 S3 introduces cross-cutting priorities such as environmental sustainability, social inclusion, and quality of life, partly in response to the COVID-19 crisis. Compared to the previous cycle, it expands its thematic domains and reinforces governance through broader stakeholder participation within the QH model, with increased emphasis on open innovation and sectoral convergence. Fifteen priority thematic cross-sectoral areas have been identified, indicating a clear intent to address contemporary challenges in a multidimensional manner. The governance of the new strategy is based on the Quadruple Helix model, which promotes the active involvement of civil society, businesses, public institutions and research institutions. This approach aims to transcend traditional models of technology transfer, shifting the focus toward open and inclusive innovation processes (Regione Emilia-Romagna et al., 2021). Emilia-Romagna's new S3 represents a significant advancement towards an inclusive and dynamic governance model, effectively responding to contemporary challenges. Although the involvement of civil society and the Quadruple Helix were not explicitly mentioned in the 2016 strategy, elements suggesting greater openness and participation can be seen, particularly through the strengthened Clust-ERs and "Emilia-Romagna Open Innovation Platform" (EROI). However, gaps remain in coordination to ensure the effective and synergistic use of available resources (Regione Emilia-Romagna et al., 2021).

In contrast, Catalonia, located in northeastern Spain with a population of approximately 7.7 million spread across 947 municipalities, presents itself as an autonomous community characterized by a diversified entrepreneurial fabric and a strong industrial base. In 2014, the region experienced a period of structural change, marked by a significant loss of jobs and high social and economic costs. Nevertheless, entrepreneurial initiatives emerged, investing in innovation to improve competitiveness. Catalonia boasts a sustainable and competitive economy, supported by major research centers such as the Barcelona Supercomputing Center and the University of Barcelona (Generalitat de Catalunya, 2014).

In line with the objectives of the European Union's "Europe 2020" Strategy, the "Research and Innovation Strategy for the Smart Specialisation of Catalonia" (RIS3CAT) was developed through a SWOT analysis that identified the region's strengths and weaknesses. The strategy is structured around three main vectors: industrial tradition, focusing on key competitive sectors; quality of life, with particular attention to health and well-being; and global challenges, such as climate change, promoting a green economy. These elements form the basis for addressing the challenges of S3 in Catalonia, highlighting an integrated and innovation-oriented approach (Generalitat de Catalunya, 2014).

The strategy for the 2014-2020 period was based on four strategic objectives and four pillars of action. The first two objectives aim at modernizing the entrepreneurial fabric and creating new economic opportunities through research and innovation. The third objective seeks to position Catalonia as a European knowledge hub, while the fourth aims to improve the regional innovation system. Consequently, four pillars have been identified in relation to these objectives. The first focuses on seven leading sectors in Catalonia that can drive the region towards the growth envisioned by the "Europe 2020" Strategy. The second identifies economic opportunities in emerging sectors based on technologies and synergies between related sectors. The third pillar emphasizes cross-cutting enabling technologies, which are key tools for transforming the production system and generating new scientific, technological, and economic opportunities. The fourth pillar focuses on improving the innovation ecosystem.

The "RIS3CAT" acknowledges the importance of the Quadruple Helix, emphasizing that although the government plays a leading role, the true protagonists are the research and innovation actors. A results-

oriented governance model has been introduced, supported by a monitoring and evaluation system to adjust objectives over time. "Territorial Specialisation and Competitiveness Projects" (PECT) are initiatives promoted by RIS3CAT aimed at enhancing participation and cooperation among Quadruple Helix stakeholders. Their objective is to generate innovative and original responses to the needs and challenges of the region, leveraging the driving role of universities. The "RIS3CAT Communities" have emerged as key instruments, forming voluntary associations of companies and scientific system actors committed to incorporating R&I into productive activities (Generalitat de Catalunya, 2014).

For the 2021-2027 period, Catalonia has faced the challenges posed by the COVID-19 pandemic, integrating new global issues into the new "RIS3CAT 2030" Strategy. This new strategy aligns with the United Nations' 2030 Sustainable Development Goals and introduces a greener, more digital, resilient, and equitable socio-economic model. Emphasizing transformative and RRI, the strategy aims to create internationally exportable value chains and promotes "social innovation" in various sectors (Generalitat de Catalunya, 2022).

The strategic objectives outlined for the 2014-2020 period are considered valid and central to the new Strategy, although the latter places greater emphasis on transformative processes. Achieving this transformative character requires that the challenges are significantly relevance to local stakeholders and that the actions are effectively implemented. Participatory governance is central to the new strategy, with "shared agendas" aimed at identifying strategic problems through cross-sector cooperation. The "National Pact for the Knowledge Society" highlights the importance of targeted attention to the different territories of Catalonia, with universities, research centers and innovation laboratories playing a crucial role in disseminating knowledge.

Thus, the RIS3CAT 2030 strategy stands out for its ability to integrate innovative elements such as "shared agendas" and the concept of "RRI", consolidating the Quadruple Helix as a fundamental principle of governance. Current challenges require the practical application of these concepts, ensuring a sustainable and inclusive future for Catalonia (Generalitat de Catalunya, 2022).

The perception of the Quadruple Helix and the integration of the concept of Responsible Research and Innovation (RRI) in the S3 of Emilia-Romagna and Catalonia reveal significant differences and similarities. RRI emerges as a fundamental principle for responding to the needs of an evolving society, promoting sustainable and multidimensional innovation. Both regions have adopted distinctive approaches: RRI in Catalonia is understood as transformative innovation rooted in social labs, co-creation processes, and collaborative platforms. Unlike Emilia-Romagna, where RRI has been progressively integrated, Catalonia made it a central axis from the beginning, as evidenced by "shared agendas". In the Emilia-Romagna territory, RRI is viewed as a "transparent and interactive process" (Von Schomberg, R., 2012) articulated in four key aspects: diversity and inclusion, anticipation, openness, and adaptation to change. Instruments such as participatory governance, public engagement, living labs are fundamental in promoting a sense of collective responsibility (Regione Emilia-Romagna et al., 2021). The Catalonia region, on the other hand, has integrated RRI into its RIS3CAT 2030 Strategy, emphasizing "responsibility" and "transformation". The "shared agendas" serve as the main drivers for innovation, actively involving all Quadruple Helix actors (Generalitat de Catalunya, 2022).

In summary, while Emilia-Romagna and Catalonia share a commitment to RRI, each region develops unique approaches to integrating responsibility, inclusion, and transformation, aiming to build a sustainable and inclusive future.

In order to observe the different behaviors exhibited by the two regions, concrete actions developed are analyzed below. Within the framework of EU Cohesion Policy, Emilia-Romagna implemented the Operational Programs (ROP) are crucial for the utilization of the European Regional Development Funds (ERDF) during the periods 2014-2020 and 2021-2027. These programs focus on Research and Innovation (R&I), connecting the regional productive system with human capital and the extensive

knowledge system (Regione Emilia-Romagna, 2020). A significant development in this direction is the establishment of the network of Open Laboratories.

The Open Laboratories are based on priority axes such as research, ICT development, competitiveness of the productive system and the promotion of a low-carbon economy. The central objective is to strengthen the identity of urban areas by triggering processes of active participation from citizens and businesses, and creating new opportunities for employment and inclusion. The network includes ten laboratories distributed across various regional cities designed as innovative spaces to facilitate collaboration among the Quadruple Helix actors and contribute to the transformation of the information society (Regione Emilia-Romagna, 2020).

The Modena Laboratory, inaugurated in 2018, stands out for its commitment to research, innovation, culture, performance and creativity. This space promotes the cross-pollination of knowledge and enhances access to cultural offerings, fostering interactions among citizens, businesses and cultural institutions. Managed by a partnership between three innovation-oriented entities, the laboratory has produced significant outcomes, such as exhibitions and festivals, contributing to the dissemination of robotics and digital citizenship (Regione Emilia-Romagna et al., s.d.). However, an independent evaluation of the "POR FESR Emilia-Romagna 2014-2020" revealed the lack of a clear definition of "attractiveness" complicating the assessment of results. Furthermore, this research highlighted the role of the Open Laboratories as heterogeneous spaces that facilitate interactions among professionals, startups, and institutions, positively impacting work-life balance. Nevertheless, there is a need to develop more stable and structured relationships between the laboratories and other actors in the innovation ecosystem (Istituto per la Ricerca Sociale, 2022).

In 2022, the European Commission approved the "Emilia-Romagna Regional ERDF Program 2021-2027" and identifies four thematic challenges. In this context, the "Agende Trasformative Urbane per lo Sviluppo Sostenibile" (ATUSS) emerge as multi-level governance tools involving regional and local entities, businesses, and civil society. The ATUSS aim to promote integrated and inclusive development, addressing the gap between urban and peripheral areas (Regione Emilia-Romagna, 2023).

With a funding of 110 million Euros, fourteen ATUSS have been identified in various locations within the region, with proposals ranging from urban regeneration to cycling tourism. In 2023, the Municipality of Modena presented the first Transformative Agenda, "Modena 2050, il futuro è adesso" outlining some general objectives, including the enhancement of culture and the promotion of an inclusive city. Five key projects have been proposed, including the redevelopment of the former Estense Hospital and the strengthening of the Open Laboratory in Modena, aimed at fostering entrepreneurship and the creation of digital communities (Regione Emilia-Romagna, 2023).

To sum up, the Open Laboratories and Transformative Agendas represent crucial initiatives for the promotion of R&I in Emilia-Romagna, serving as catalysts for social and cultural innovation. However, greater integration with Quadruple Helix actors is necessary to maximize their potential and ensure a significant impact on the innovation ecosystem and the local community.

On the other hand, within the framework of the 2014-2020 programming period, Catalonia implemented several initiatives to promote social, digital, and collaborative innovation through the RIS3CAT 2020 Strategy and the CatLabs Program, launched in 2016. These efforts aim to establish a robust innovation network involving universities, research, and training institutions, with the goal of enhancing digital skills and positioning the region as an international benchmark for innovation.

A significant example of these initiatives is the Biolab Ponent project, developed in the Lleida region, which aims to transform the local economic development model. Initially launched as Biolab Baix Segre, the project focuses on Sustainable Circular Bioeconomy by leveraging local resources and promoting goods, services, and energy derived from agri-food production. Using a co-creative and systemic methodology, the project follows five stages: exploration of challenges, identification of opportunities,

combination of ideas, generation of prototypes, and implementation planning. This approach is based on the Quadruple Helix model, fostering collaboration between economic, political, social, and knowledge-based actors (Generalitat de Catalunya, 2017).

The Municipality of Alcarràs initiated a local awareness process among key stakeholders, involving neighboring municipalities and regional research agencies. Thanks to funding from the European Social Fund (ESF) and later from the European Regional Development Fund (ERDF), the project expanded its geographical scope, culminating in the creation of the Shared Agenda - a strategic document to address the socio-economic and environmental challenges of the territory (Ajuntament d'Alcarràs, 2019).

Shared Agendas were introduced in Catalonia during the transition between the RIS3CAT 2020 and RIS3CAT 2030 programming periods as a participatory governance tool to tackle territorial challenges in alignment with the Sustainable Development Goals (SDGs). These Agendas engage a wide spectrum of actors - government, research institutions, businesses, and civil society - according to the Quadruple Helix model, and are based on intersectoral cooperation (Generalitat de Catalunya, 2020). The process of developing these Agendas involves five steps: defining a common direction, constructing a shared framework, radical collaboration, solution experimentation and achieving transformative impact. Experimentation takes place through social innovation labs, which aim to develop and implement solutions tailored to the needs of local communities.

Biolab Ponent, part of the Shared Agenda for the Economic Transformation of Terres de Lleida, Pyrenees, and Aran, serves as a significant example. Through a participatory and systemic approach, the lab promotes a shared vision of the future and processes of co-participation (Generalitat de Catalunya, 2022). With dynamic governance, the Agenda has already activated over 40 actions, mobilizing more than 10 million euros (Generalitat de Catalunya, 2023).

The priority areas of the Shared Agenda include agricultural and forestry bioeconomy, digitization, sustainable energy, and urban regeneration, all aimed at enhancing territorial resources within a sustainable development context. An exemplary initiative is the "BIOHUB CAT" a space dedicated to new business models in the circular bioeconomy, contributing to the creation of qualified jobs and combating rural depopulation (Generalitat de Catalunya, 2023).

In conclusion, the Biolab Ponent project and the Shared Agendas represent an innovative and integrated approach to addressing territorial challenges in Catalonia, highlighting the importance of participatory governance and synergy among actors for the success of local initiatives within the framework of the RIS3CAT 2030 Strategy.

In Catalonia, the QH approach was integrated as early as 2014, as evidenced by the CatLabs program, which emphasizes the active participation of all sectors of society, including civil society. Conversely, Emilia-Romagna initially placed greater emphasis on businesses in the entrepreneurial discovery process, with the gradual adoption of the QH model. The creation of Open Labs during the 2014-2020 programming period in Emilia-Romagna represents an effort to involve civil society, although there is still room to increase their operational effectiveness.

In recent years, both regions have aligned their strategies, placing growing importance on the concepts of QH and RRI. This convergence is evidenced by the creation of Transformative Agendas in Emilia-Romagna and Shared Agendas in Catalonia. These agendas function as participatory and multi-level governance tools, involving all QH actors and adopting an intersectoral approach. Specifically, the Catalan Shared Agendas are central to the RIS3CAT 2030 Strategy, while the Transformative Agendas in Emilia-Romagna are integrated into the Regional Operational Program rather than directly into the S3.

Examining the practical implementations, further distinctions emerge. Both regions have established labs that serve as collaborative spaces, promoting innovation through the involvement of QH actors and aiming to foster social transformation and citizen well-being. However, the focus areas differ: Emilia-Romagna's Open Labs concentrate on ICT technologies, while Catalonia's CatLabs emphasize social,

digital and collaborative innovation.
A critical observation concerns the availability of detailed documentation on the application of QH and RRI. Emilia-Romagna appears more results-oriented, with less emphasis on explicating the processes involving QH and RRI. In contrast, Catalonia offers more comprehensive accounts of these processes, reflecting an early and sustained commitment to the active participation of all sectors of society.
Overall, both regions pursue similar goals, such as sustainable development and the improvement of quality of life, with international cooperation playing a crucial role in their progress. From the onset of the S3 introduction, Catalonia has placed significant emphasis on the active participation of all actors, particularly civil society. Emilia-Romagna has progressively incorporated participatory governance among its priorities, although its processes often feature top-down characteristics. Despite these differences, the regions are converging in a complementary manner, leveraging their respective strengths, histories and geographies to generate innovation. They are enhancing regional competitiveness, advancing digital development, promoting inclusion and proximity to citizens, addressing climate change and pursuing sustainable development, in line with the European Cohesion Policy.

# 4. Conclusions

This comparative study has explored how Emilia-Romagna and Catalonia have implemented and evolved their Smart Specialisation Strategies (S3) over the 2014-2020 and 2021-2027 programming periods, with particular attention to the application of the Quadruple Helix (QH) and Responsible Research and Innovation (RRI) frameworks. The analysis demonstrates that while both regions align with European Commission guidelines, they have interpreted and operationalized these frameworks differently, responding to distinct socio-economic challenges and territorial priorities.
While similarities emerge in the conceptualization and theorization within the analyzed documents, significant differences manifest in practical implementation. Both regions have adopted innovative approaches, including QH and RRI, as well as multilevel governance, to operationalize their S3. However, the specificities of their territorial and economic contexts have profoundly influenced the modalities and operational practices of these approaches. The analysis demonstrates that while both regions align with European Commission guidelines, they have interpreted and operationalized these frameworks differently, responding to distinct socio-economic challenges and territorial priorities.
Emilia-Romagna has progressed incrementally, capitalizing on an already dynamic productive system and established governance structures that it has maintained and utilized effectively. In contrast, Catalonia, facing partial economic decline, has adopted a systemic approach from the outset to modernize and transform traditional sectors towards competitive activities through innovation. This approach has enabled it to examine challenges from diverse perspectives, facilitating the exploration of multiple response opportunities.
These findings underscore how innovative principles can be implemented in varying ways and timelines, as each region tailors its actions to its specific context and societal needs. Both regional models offer best practices and lessons learned that can contribute to mutual improvement. The cooperation between Emilia-Romagna and Catalonia on strategic themes of sustainability and innovation exemplifies this, representing a concrete opportunity for shared progress based on mutual learning, as evidenced by their collaboration in developing monitoring platforms with the SIRIS Foundation. The role of interregional collaboration, particularly through platforms such as SIRIS, provides promising pathways for amplifying mutual learning and QH participation. SIRIS, a knowledge and policy intelligence platform, supports joint monitoring and data sharing, which could enhance transparency and transregional benchmarking. The

evidence from the Biolab Ponent in Catalonia and the Modena Open Lab in Emilia-Romagna shows that participatory labs can successfully mobilize actors and resources, though their scalability and integration into governance systems remain areas for further development.

The S3s and the associated approaches of QH and RRI have proven effective tools for growth and innovation, with replicable potential in other regions. The differences between the regions serve as catalysts for progress and development, as highlighted during the conference "Dati, policy, strategie. Il Monitoraggio S3: Emilia-Romagna e Catalogna, modelli a confronto" (2023). Representatives from both regions confirmed the synergy between their territories, which can be realized through their respective new monitoring platforms.

Despite differing methodologies and the need for further development of limited case studies, both regional experiences offer significant lessons and best practices. Key recommendations include: engaging stakeholders from the outset with a systemic and territorial vision; focusing on context-specific challenges and opportunities rather than predefined sectors; pursuing transformative and adaptive processes; leveraging existing social capital and governance structures; introducing innovative tools and communication strategies that actively involve civil society and facilitate the transition to sustainable models; and promoting the participation of all actors through laboratories, shared agendas, and bottom-up approaches.

A comparative analysis of the implementation of S3 in Emilia-Romagna and Catalonia reveals both similarities and differences in their respective approaches to regional innovation and development. Both regions have adopted the concepts of the Quadruple Helix (QH) and Responsible Research and Innovation (RRI), albeit with temporal and operational variations, following European guidelines on the entrepreneurial discovery process.

Ultimately, while both regions aim to enhance competitiveness and sustainable growth, their differing approaches act as catalysts for experimentation. The convergence of their strategies through cooperation – demonstrated, for example, during the 2023 joint conference on S3 monitoring – illustrates the growing maturity of S3 as a policy framework. Future research could explore the replicability of these regional models, particularly by analyzing the longitudinal impacts of participatory governance and RRI tools on regional development trajectories (ART-ER, et.al. (2023).

# References

Ajuntament d'Alcarràs. (2019). Pla Estratègic del Biolab Baix Segre. Pla d'acció. https://www.alcarras.cat/fitxers/pla-daccio-del-biolab-baix-segre.pdf

Arnkil R., Järvensivu A., Koski P. & Piirainen T. (2010). Exploring Quadruple Helix Outlining user-oriented innovation models, Final Report on Quadruple Helix Research for the CLIQ project, under the Interreg IVC Programme.

ART-ER, Rondella B., Fernández T., Pezzella D. & Moretti G. (2023). Dati, policy, strategie. Il Monitoraggio S3: Emilia-Romagna e Catalogna, modelli a confronto. 18° edizione di R2B Research to Business. Il salone internazionale della ricerca e delle competenze per l'innovazione. Bologna, Italia. Giugno 8-9, 2023.

Bailey, D. & Propris, L. D. (2002). The 1988 reform of the European Structural Funds: Entitlement or empowerment? Journal of European Public Policy, 9(3), 408–428. https://doi.org/10.1080/13501760210139696

Brunazzo, M. (2016). Chapter 1: The history and evolution of Cohesion policy. In Handbook on Cohesion Policy in the EU, Social and Political Science 2016, Cheltenham, UK: Edward Elgar Publishing. Consulted on 30th August 2024, da https://www.elgaronline.com/view/edcoll/9781784715663/9781784715663.00014.xml

Carayannis, E. G., & Campbell D. F. J. (2010). Triple Helix, Quadruple Helix and Quintuple Helix and how do knowledge, innovation and the environment relate to each other? A proposed framework for a trans-disciplinary analysis of sustainable development and social ecology. International Journal of Social Ecology and Sustainable Development 1: 41–69.

Carayannis, E. G., & Rakhmatullin, R. (2014). The Quadruple/Quintuple Innovation Helixes and Smart Specialisation Strategies for Sustainable and Inclusive Growth in Europe and Beyond. JRC Publications Repository. https://doi.org/10.1007/s13132-014-0185-8

Comune di Modena, Regione Emilia-Romagna, Repubblica Italiana & Unione Europea. (2023). Modena 2050, il futuro è adesso. Agenda Trasformativa per lo Sviluppo Sostenibile. https://www.comune.modena.it/novita/notizie/2023/i-nuovi-fondi-europei-2021-2027/documenti-allegati/sintesi-degli-interventi/

D'Adda, D., Iacobucci, D., Palloni, R. (2020). Relatedness in the implementation of Smart Specialisation Strategy: a first empirical assessment. Papers in Regional Science, Volume 99, Issue 3, 2020. https://doi.org/10.1111/pirs.12492

European Commission. (2010). Communication from the Commission. EUROPE 2020. A European strategy for smart, sustainable and inclusive growth. Brussels.

European Commission. (2012). Guide to Research and Innovation Strategies for Smart Specialisations (RIS 3). https://s3platform.jrc.ec.europa.eu/documents/portlet_file_entry/20125/RIS3+Guide.pdf/19fa7820-9522-3a52-fb81-6cb9115b6b9f

European Commission. (2015). 2014-2020 European structural and investment funds. https://commission.europa.eu/funding-tenders/find-funding/funding-management-mode/2014-2020-european-structural-and-investment-funds_en

European Commission. (2017). Communication from the Commission to the European Parliament, the

Council, the European Economic and Social Committee and the Committee of the Regions. Strengthening Innovation in Europe's Regions: Strategies for resilient, inclusive and sustainable growth. https://s3platform.jrc.ec.europa.eu/documents/portlet_file_entry/20125/com_2017_376_2_en.pdf/3e58fbca-d9f9-04ba-bf94-dd431ef27537

European Commission. (2022). EU Cohesion Policy: €37.3 billion for Spain to support its green transition and a fair and competitive economy. https://ec.europa.eu/commission/presscorner/detail/en/ip_22_6964

European Commission. (2022). EU Cohesion Policy: €42.7 billion for Italy to support sustainable growth, employment and modernisation while reducing regional disparities. https://ec.europa.eu/commission/presscorner/detail/en/IP_22_4562

European Commission. (s.d.). Inforegio. History of the policy. Consulted on 12nd September 2024, da https://ec.europa.eu/regional_policy/policy/what/history_en

European Commission. (s.d.). Inforegio. Priorities for 2014-2020. Consulted on 23rd August 2024, da https://ec.europa.eu/regional_policy/policy/how/priorities/2014-2020_en

European Commission. (s.d.) Smart Specialisation Platform. Consulted on 23rd August 2024, da https://s3platform.jrc.ec.europa.eu

European Commission, Directorate General for Regional and Urban Policy, Metis GmbH, ICF International. (2016). The implementation of the provisions in relation to the ex-ante conditionalities during the programming phase of the European Structural and Investment (ESI) Funds: Final report. Publications Office. https://data.europa.eu/doi/10.2776/617294

European Commission, Joint Research Centre, Przeor, M., Gianelle, C., Kyriakou, D., & Cohen, C. (2016). Implementing smart specialisation: A handbook. Publications Office. https://doi.org/10.2791/610394

European Committee of the Regions, Volpe, M., Friedl, J., Cavallini, S., & Soldi, R. (2016). Using the quadruple helix approach to accelerate the transfer of research and innovation results to regional growth. Committee of the Regions. https://doi.org/10.2863/408040

European Economic Commission. (1957). The Treaty of Rome. https://ec.europa.eu/archives/emu_history/documents/treaties/rometreaty2.pdf

European Parliament and European Council. (2013). REGULATION (EU) No 1303/2013 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 17 December 2013 laying down common provisions on the European Regional Development Fund, the European Social Fund, the Cohesion Fund, the European Agricultural Fund for Rural Development and the European Maritime and Fisheries Fund and laying down general provisions on the European Regional Development Fund, the European Social Fund, the Cohesion Fund and the European Maritime and Fisheries Fund and repealing Council Regulation (EC) No 1083/2006. Retrieved from EUR Lex. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32013R1303

Generalitat de Catalunya. (2014). RIS3CAT Research and Innovation Strategy for the Smart Specialisation of Catalonia.

Generalitat de Catalunya. (2017). CatLabs Programme.

Generalitat de Catalunya. (2018). RIS3CAT Action Plan 2015-2020.

Generalitat de Catalunya. (2020). RIS3CAT Monitoring 8. Articulating shared agendas for sustainability

and social change. A contribution from the territory to the EU debate on transitions to sustainability.

Generalitat de Catalunya. (2022). RIS3CAT 2030 Strategy for the Smart Specialisation of Catalonia 2030.

Generalitat de Catalunya. (2022). Transformative innovation labs and shared agendas. https://fonseuropeus.gencat.cat/web/.content/ris3cat/documents/angles/18-laboratoris-innovacio-transformativa-en.pdf

Generalitat de Catalunya. (2023). RIS3CAT Shared Agendas as platforms for synergies. https://fonseuropeus.gencat.cat/web/.content/ris3cat/documents/angles/ris3cat-agendes-compartides-plataforma-sinergies-en.pdf

Istituto per la Ricerca Sociale & Nomisma. (2022). Servizio di Valutazione Indipendente del POR FESR Emilia-Romagna 2014-2020. Rapporto di valutazione tematica: Asse VI - Città Attrattive e Partecipate". https://fesr.regione.emilia-romagna.it/por-fesr/valutazione

Marinelli E., Perianez-Forte I. (2017) Smart Specialisation at work: The entrepreneurial discovery as a continuous process, Publications Office of the European Union, Luxembourg, 2017, ISBN 978-92-79-74377-1, doi:10.2760/514714, JRC108571.

Regione Emilia-Romagna. (2020). POR Emilia-Romagna FESR.

Regione Emilia-Romagna. (2022). Programma Regionale Emilia-Romagna FESR 2021-2027. https://fesr.regione.emilia-romagna.it/erdf/documents/programma-regionale-fesr-2021-2027.pdf

Regione Emilia-Romagna. (2022). Sostenibilità e trasformazione digitale, a Barcellona la firma dell'Accordo fra Emilia-Romagna e Catalogna. https://www.regione.emilia-romagna.it/notizie/2022/luglio/sostenibilita-e-trasformazione-digitale-a-barcellona-la-firma-dell2019accordo-fra-emilia-romagna-e-catalogna

Regione Emilia-Romagna. (2023). Sviluppo sostenibile e territorio. La Regione Emilia-Romagna presenta le Agende trasformative urbane per lo sviluppo sostenibile (ATUSS): 110 milioni di euro di fondi europei per cambiare il profilo delle città, più verdi e digitali. Enti locali protagonisti. A Modena il primo accordo presentato: 5 progetti e un investimento superiore ai 20 milioni di euro. Bonaccini: "L'Emilia-Romagna sa fare gioco di squadra". Emilia-Romagna Notizie. Consulted on 23rd August 2024, da https://notizie.regione.emilia-romagna.it/comunicati/2023/aprile/sviluppo-sostenibile-e-territorio-la-regione-emilia-romagna-presenta-le-agende-trasformative-urbane-per-lo-sviluppo-sostenibile-atuss-110-milioni-di-euro-di-fondi-europei-per-cambiare-il-profilo-delle-citta-piu-verdi-e-digitali-enti-locali-protagonisti-a

Regione Emilia-Romagna, ART-ER, Repubblica Italiana & Unione Europea. (2021). Strategia di ricerca e innovazione per la specializzazione intelligente 2021-2027.

Regione Emilia-Romagna, Laboratori Aperti Emilia-Romagna. (s.d.). Laboratorio aperto di Modena. Consulted on 30th August 2024, https://www.laboratoriaperti.it/modena

Regione Emilia-Romagna, Repubblica Italiana & Unione Europea. (2016). Research and innovation strategy for Smart Specialisation. Strategia di Ricerca e Innovazione per la Specializzazione Intelligente.

Roman, M., Varga, H., Cvijanovic, V., & Reid, A. (2020). Quadruple Helix Models for Sustainable Regional Innovation: Engaging and Facilitating Civil Society Participation. Economies, 8(2), 48. http://dx.doi.org/10.3390/economies8020048

RRI Tools Project. (s.d.). Informazioni su RRI - RRI Tools. Consulted on 29th August 2024, da https://rri-tools.eu/it/informazioni-su-rri

Von Schomberg, R. (2012). Prospects for Technology Assessment in a Framework of Responsible Research and Innovation. SSRN Electronic Journal. https://doi.org/10.2139/ssrn.2439112

Wassenberg, B. & European Committee of the Regions. (2020). The History of the Committee of the Regions (1994-2019): 25 years of cities and regions furthering European integration. Publications Office. https://data.europa.eu/doi/10.2860/501