EMERGENCE AND EVOLUTION OF RESEARCH, TECHNOLOGY ORGANIZATIONS (RTOS) IN THE BASQUE COUNTRY. A SYSTEMIC AND EVOLUTIONARY PERSPECTIVE

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The valorisation of knowledge remains one of the central challenges for modern economies and is particularly pressing in the European Union (EU). As Mario Draghi recently stated, "the problem is not that Europe lacks ideas or ambitions, but rather translating innovation into commercialisation." Closing this innovation gap remains a priority for the EU and many of its Member States.

One of the main barriers lies in the limited absorptive capacity of much of the business sector. As defined by Cohen and Levinthal (1990), absorptive capacity is a firm's ability to recognise, assimilate, and apply external knowledge. While policies increasingly promote interaction between firms and knowledge producers, many companies–especially SMEs– struggle to understand and incorporate scientific and technological advances, limiting the impact of such incentives.

In many regions, this gap is being addressed through knowledge intermediaries that connect science and industry. Research and Technology Organisations (RTOs) are a key example. Positioned between academic research and industrial application, RTOs facilitate knowledge transfer, co-develop technology, and help firms build innovation capacity (EARTO, 2024).

Definitions of RTOs vary widely, but this paper adopts the one proposed by EARTO, which describes them as non-profit organisations dedicated to producing, combining, and bridging diverse forms of knowledge to support public and industrial partners. Examples include Fraunhofer In-

stitutes (Germany), TNO (Netherlands), VTT (Finland), Kosetsushi (Japan), and Tecnalia (Spain), where they are commonly referred to as Technology Centres.

Because innovation systems are embedded in historical trajectories, they are highly context-specific. Transferring successful models across regions often fails (Fagerberg, 2017). Inspired by the success of RTOs, several EU countries created new ones in the 1990s and 2000s, hoping to replicate their effects. Yet, uneven innovation performance across regions suggests that outcomes depend on more than institutional design.

The Basque Country provides a compelling case. Sustained public policy, dense institutional networks, and strong industry linkages have enabled the region to strengthen firm-level innovation. At the heart of this strategy is the Basque Network of Science, Technology and Innovation (BNSTI), which includes over 21 research-performing organisations and Technology Centres.

This paper analyses the origins and evolution of Basque RTOs and their contributions to the regional innovation system across successive STI policy phases. It offers a context-sensitive and longitudinal perspective that complements existing studies, which often overlook the specific institutional dynamics behind the effectiveness of RTOs. The Basque case suggests that such effectiveness depends not on replication, but on alignment with local industrial structures and policy frameworks.

LITERATURE REVIEW

The transition from linear to systemic models of innovation has profoundly shaped how knowledge creation and diffusion are conceptualised. The linear model envisions innovation as a unidirectional sequence from research to market. In contrast, the systems of innovation perspective highlights interactive learning, tacit knowledge, and institutional coordination as central elements of technological progress (Fagerberg, 1989; Lundvall, 2010; Edquist, Eriksson & Sjögren, 2002). Within this framework, innovation systems consist of organisations (e.g., firms, universities) and institutions (norms, rules) that co-evolve and interact (Edquist, 2011; Cooke, 2008). Regional Innovation Systems (RIS) extend this view by stressing proximity, historical paths, and multilevel governance in shaping innovation dynamics (Olazaran, Albizu & Otero, 2009; Cooke, Uranga & Etxebarria, 1998; Otero et al., 2014).

In response, regional innovation policies are increasingly tailored to territorial conditions rather than following uniform models (Tödtling & Trippl, 2005). Scholars have stressed the need for empirical insights into how these policies evolve over time and are shaped by political, institutional, and socio-economic contexts (Flanagan & Uyarra, 2016; Borrás & Jordana, 2016).

Traditional models emphasised the triple helix –government, universities, and industry– as the drivers of innovation (Etzkowitz & Klofsten, 2005). However, building meaningful collaborations between these actors often requires support from intermediary organisations. These intermediaries –variously termed interface institutions (Lundvall, 2010), hybrid organisations (Etzkowitz & Leydesdorff, 2000), or fourth pillar actors (Simon & Marquès, 2012)– are essential for facilitating connectivity and knowledge exchange (Nelson & Rosenberg, 1993).

Among them, Research and Technology Organisations (RTOs) stand out for their capacity to co-create knowledge, provide technological services, and support firm-level innovation, particularly among SMEs (EARTO, 2024; Kilpatrick & Wilson, 2013). Their roles vary significantly by region, sector, and policy context (Charles & Ciampi Stancova, 2015; Larrue & Strauka, 2022). While increasingly recognised for their importance, RTOs are still often treated generically, limiting understanding of their specific contributions (Landry et al., 2013; Arnold, Clark & Javorka, 2010).

Some studies highlight RTOs as knowledge producers (Barge-Gil & Modrego, 2011; Baviera-Puig et al., 2012), while others underscore their intermediary role in enabling innovation among firms with limited internal capacity (Steen & Nauta, 2020; Taverdet-

Popiolek, 2021). However, most literature focuses on isolated case studies or theoretical reflections, with little systemic or historical analysis (Del Campo et al., 2023; Stezano, 2018).

Technology Centres, as a prevalent type of RTO, have received particular attention due to their role in fostering innovation in regions with a dense SME base (Mas-Verdú, 2007; Baviera-Puig et al., 2013). Their ability to bridge the gap between scientific research and industrial application is especially valuable for smaller firms, helping to overcome collaboration barriers and build absorptive capacity (Barge-Gil, Santamaría & Modrego, 2011; Albors-Garrigós, Rincon-Diaz & Igartua-Lopez, 2014; Hervas-Oliver et al., 2012).

Understanding the relevance of these intermediaries also requires placing them within the broader framework of science, technology, and innovation (STI) policy. Over the past decades, STI policy has evolved around two contrasting rationales: market failure and system failure. The former justified public funding for basic research due to firms' limited incentives to invest in non-appropriable knowledge (Elg & Leijten, 2010). The latter, grounded in systemic models, recognises the importance of institutional coordination, absorptive capacity, and learning-by-doing (Freeman, 1995; Lundvall, 1992).

This shift has reframed the role of intermediaries such as RTOs–not merely as service providers, but as systemic actors who support coordination, knowledge transfer, and firm-level capability building. Their contribution spans all stages of the innovation process and has become essential in contexts where institutional fragmentation or capability gaps inhibit innovation diffusion (Fagerberg, 2017; Jensen et al., 2007; Comin et al., 2019).

The Basque Country is often cited as a successful case of transformation from a declining industrial region to a competitive innovation system. It pioneered cluster policies (Navarro, 2010; Parrilli et al., 2010), led smart specialization strategy (S3) design (Valdaliso et al., 2014; Aranguren, Morgan & Wilson, 2023), and developed a stable multilevel STI governance structure (Magro & Wilson, 2013; Navarro et al., 2014). Political continuity and fiscal autonomy have supported a long-term, consensus-based innovation strategy (Holl & Rama, 2016; Aranguren et al., 2023).

Within this system, the Basque Network of Science, Technology and Innovation (BNSTI) plays a central role. Technology Centres, as part of this network, are crucial in translating research into industrial competitiveness (OECD, 2011). While several studies acknowledge their role (Olazaran et al., 2009; Morgan, 2016; Iturrioz-Landart et al., 2021), few offer a systematic analysis of their evolving contributions. Existing research tends to group RTOs within broad categories or focus on static case studies (Barge-Gil & Modrego, 2011; Alcalde-Heras et al., 2023).

This study contributes to filling that gap by examining the historical evolution of Basque RTOs and their intermediary functions. It adopts a systemic and evolutionary lens to explore how these organisations have adapted to successive policy phases, enhancing both regional and firm-level competitiveness.

METHODOLOGY

This paper adopts a case study methodology (Yin, 2006) to examine the evolving role of Research and Technology Organisations (RTOs) within the Basque regional innovation system. This approach is well suited to studying complex, context-dependent phenomena, enabling both empirical insight and theoretical development.

Drawing on a cognitive-distance perspective, the study conceptualises RTOs as systemic intermediaries that help bridge the gap between basic science and industrial application. This theoretical lens guides a historical-institutional analysis of successive STI policy phases and the changing role of RTOs within them.

The analysis combines qualitative and quantitative evidence. On the qualitative side, we examine strategic STI plans, poli-

cy evaluations, and other grey literature to identify milestones in the design and implementation of Basque innovation policy. On the quantitative side, we use descriptive indicators–drawn from Eurostat, the Spanish Statistical Office (INE), the Basque Statistical Office (Eustat), the Regional Innovation Scoreboard (RIS), and the Science and Technology Information System (SICTI)–to track R&D investment, innovation outcomes, and firm-level performance over time. This allows for comparison between the Basque Country and other Spanish and European regions.

The study follows a narrative approach (Garud et al., 2010), tracing how RTOs have contributed to knowledge generation, diffusion, and capability building, and how they have responded to shifting policy rationales and industrial demands. This integrated methodological design enables a comprehensive understanding of how RTOs have become structural components of the Basque innovation ecosystem.

RESULTS

This section examines the emergence and institutional consolidation of the Basque innovation system through a historical and systemic lens, with particular emphasis on the evolving role of Research and Technology Organisations (RTOs) in enabling regional transformation. The analysis begins by outlining the economic and industrial foundations of the Basque Country, followed by a periodisation of STI policy into six distinct phases. It then explores the contribution of RTOs to knowledge valorisation, firm-level innovation, internationalisation, and capability development, drawing on both qualitative evidence and comparative quantitative indicators.

With a population of 2.2 million and a territory of just over 7,200 km^2, the Basque Country is a medium-sized European region with consistently high levels of socioeconomic development. It ranks among the top Spanish regions in GDP per capita, productivity, and innovation intensity, supported by a robust industrial base and growing specialisation in advanced sectors. This resilience is the result of a long-term policy strategy in which innovation has played a central role. Within this trajectory, RTOs have become key institutional actors, bridging science and industry and supporting the diffusion of innovation across the regional economy.

Historical evolution of the Basque STI system

The development of the Basque innovation system can be understood as a relatively recent co-evolution of policy frameworks, institutional infrastructures, and the strong industrial component of its economy (Barrutia and Echebarria, 2011). A first phase, prior to the 1980s, was characterised by the absence of a formal STI policy and the existence of informal initiatives rooted in industrial associations and cooperative structures. Despite scarce central government funding for R&D, the Basque Government, empowered by its fiscal autonomy, launched its own policy initiatives to support industrial technological upgrading. This marked the beginning of a regional strategy that would gain traction over the following decades (Moso & Olazaran, 2002).

In the 1980s, the first formal phase of Basque STI policy saw the creation of Technology Centres, often starting as small applied research units and gradually professionalising with public co-funding. These centres, such as Ikerlan, Labein, Inasmet, Tekniker and Ceit, were instrumental in providing technological services, assisting SMEs with quality certifications, and developing applied knowledge (Moso & Olazaran, 2002). During this phase, a balance between generic and contracted research was promoted (Olazaran & Lavía, 2000). The foundation of the Society for Industrial Reconversion (SPRI), a public agency to support business development and innovation, consolidated this phase of policy, anchored in a strong public-private cooperation logic.

During the 1990s, policy evolved towards a cluster-based approach. STI instruments were increasingly shaped by the needs of industrial clusters, and RTOs became key enablers of collective innovation projects.

This period also saw the formal establishment of the Basque Technology Network, in 1997, which brought together different actors under a common framework to facilitate knowledge transfer and coordination. RTOs extended their missions and capabilities during this phase, moving beyond technical services to engage in strategic cooperation with firms and policymakers.

A third phase, beginning in the early 2000s, introduced new institutional actors with a stronger scientific profile, such as the Basque Excellence Research Centres (BERCs) and the Cooperative Research Centres (CICs). These institutions aimed to bridge the gap between the scientific system and the productive sector, with RTOs playing a central role as intermediaries. STI policy was structured around strategic plans with five-year horizons (Aghion, David, & Foray, 2009), and RTOs increasingly functioned as brokers of innovation, mediators in collaborative projects, and leaders of strategic foresight exercises.

Between 2011 and 2020, STI policy was shaped by the Smart Specialisation Strategy (S3), which identified key technological priorities for the region. The consolidation of the system led to the merging of eight Technology Centres into Tecnalia, which became the largest RTO in Spain. The Basque Research and Technology Alliance (BRTA) was created in 2019 to further coordinate RTO activity and reinforce their strategic alignment with regional goals. This period also saw the institutionalisation of the Elkartek and Hazitek programmes, which supported collaborative R&D projects between firms, RTOs and universities, reinforcing the central role of RTOs in the innovation ecosystem.

The most recent phase, corresponding to the 2021–2030 horizon, builds on the STIP 2030 strategy. RTOs are positioned as key agents for the region's green, digital, and inclusive transitions, with responsibilities in areas such as applied research, sustainability, industrial decarbonisation, and talent development. Their contribution is now understood not only in terms of knowledge transfer but as central actors in building the region's capacity to respond to technological and societal challenges.

The evolving role of RTOs

Throughout these phases, the role of RTOs has evolved substantially. Initially created to provide basic technological services, they have progressively become enablers of firm-level innovation, internationalisation, and systemic learning. They have contributed to strengthening the regional knowledge base through the development of applied research capabilities, testing infrastructure, and support for firms in adopting new technologies. Their proximity to SMEs has allowed them to act as key partners in innovation processes, especially for firms with limited internal R&D capacities.

RTOs have also supported firms in aligning their technological trajectories with market demands, helping to move innovations from concept to application. In parallel, RTOs have facilitated the Basque Country's integration into European innovation frameworks. Their leadership in EU R&D programmes is well documented. In successive Framework Programmes, they have consistently accounted for the majority of Basque participation and funding returns. For instance, in Horizon 2020, they secured 46% of the regional funding received. This international engagement has been reinforced by their support to firms in meeting EU standards and certification processes, contributing to increased competitiveness and access to global value chains.

Their contribution to capacity building has also been significant. RTOs support the development of absorptive capacities within firms by tailoring their interventions to different modes of innovation–whether science-based (STI) or practice-based (DUI). They also play a key role in training human capital, generating high-quality employment, and retaining talent. The presence of RTOs has fostered cross-sectoral collaboration and helped develop innovation capabilities in strategic areas such as advanced manufacturing, energy transition, and biosciences.

Empirical indicators of RTO impact

Understanding the role of Research and Technology Organisations (RTOs) in Spain requires situating them within the broader architecture of the national knowledge

transfer system. In this system, different types of R&D&I-performing institutions contribute to the transfer of knowledge and technology through a variety of mechanisms–such as collaborative projects, contract research, and licensing–each with distinct institutional orientations, client bases, and degrees of market proximity.

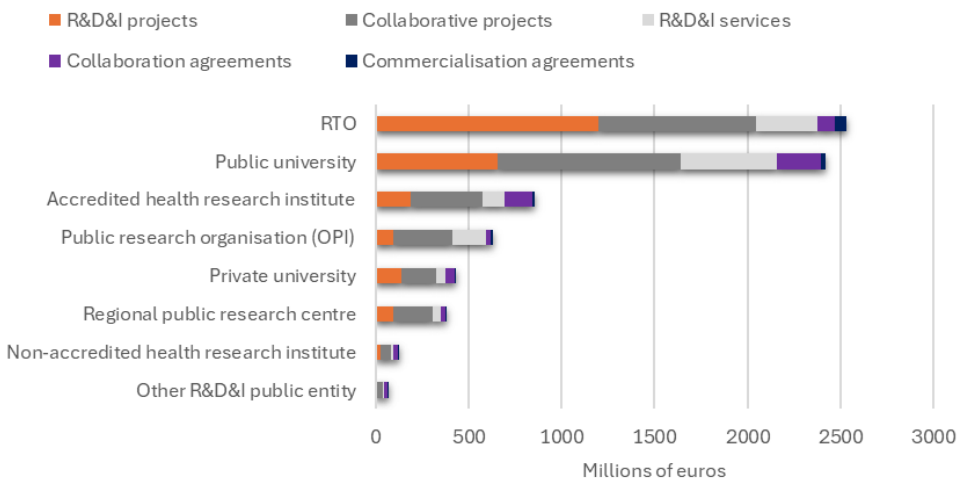
Figure 1 displays income generated through knowledge transfer activities by organisation between 2019 and 2022. The data reveal a clear functional differentiation across institution types. RTOs stand out as the leading actors in total transfer income, surpassing public universities and other research institutions. They dominate in R&D&I projects and services, but also maintain a strong presence in collaborative projects and, to a lesser extent, in commercialisation agreements. This underscores their role as organisations geared toward applied research and technological development in close connection with firms and industry needs.

Unlike universities–which tend to collaborate with firms that already have internal R&D capabilities–RTOs work extensively with firms that would otherwise struggle to access or absorb scientific and technological knowledge. Their ability to act as institutional intermediaries enables them to reduce the distance between innovation supply (from research) and demand (from firms), especially in sectors with lower innovation intensity. In this sense, RTOs contribute not only to the sophistication of advanced industrial actors, but also to the broadening of innovation participation, helping to mobilise a more diverse segment of the productive fabric.

This pattern is particularly visible in the case of Technology Centres, which are a major component of the Spanish RTO landscape. Their activities range from contract research and technical services to collaborative R&D, making them essential vehicles for both technology co-development and knowledge valorisation. Their position at the intersection of scientific production and industrial application allows them to operate across multiple Technology Readiness Levels (TRLs), a capability not always present in other research organisations.

This national-level evidence provides a valuable reference point for analysing regional dynamics. In particular, it highlights why the role of RTOs cannot be understood

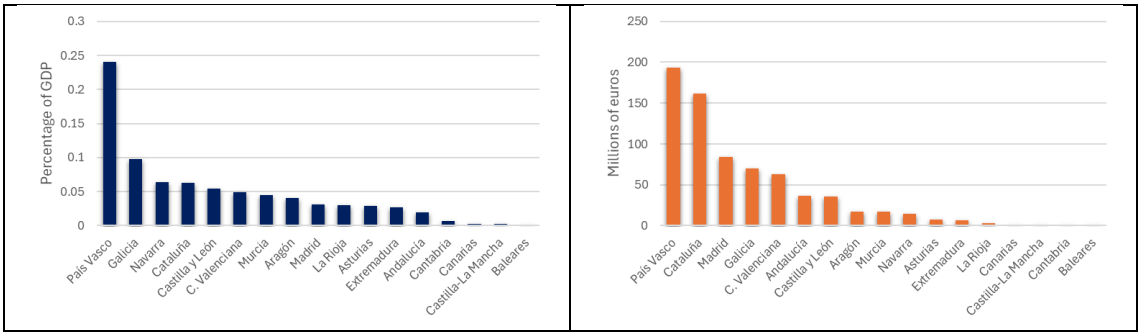
FIGURE 1
TECHNOLOGY AND KNOWLEDGE TRANSFER INCOME IN SPAIN (2019–2022)



Source: Own elaboration based on data from the Ministry of Science, Innovation and Universities of Spain.

Note: Note: R&D&I projects refer to direct contracts with public or private entities. Collaborative projects are funded through competitive calls involving multiple partners. R&D&I services include technical or scientific support provided to third parties. Collaboration agreements cover sponsored chairs, industrial PhDs, patronage, and other formal partnerships. Commercialisation agreements refer to licensing or exploitation of intellectual property rights.

FIGURE 2
THE BASQUE COUNTRY'S LEADERSHIP IN R&D&I CONTRACTS



Source: Own elaboration based on data from the Ministry of Science, Innovation and Universities of Spain.

in isolation from their institutional context and from the types of firms and territories with which they interact. These insights lay the groundwork for examining specific regional trajectories–most notably that of the Basque Country, where a dense and mature network of RTOs has become a cornerstone of its innovation policy.

While national-level data highlights the division of labour across different types of research institutions, a more granular, regional analysis focusing on a specific transfer mechanism–R&D&I contracts–reveals critical differences in how innovation ecosystems operate in practice. These contracts, which directly link public research institutions with firms, represent one of the most tangible instruments of knowledge valorisation. They are particularly important for firms that may lack the in-house resources to independently engage in R&D, as they provide access to external expertise, infrastructure, and tailored innovation services.

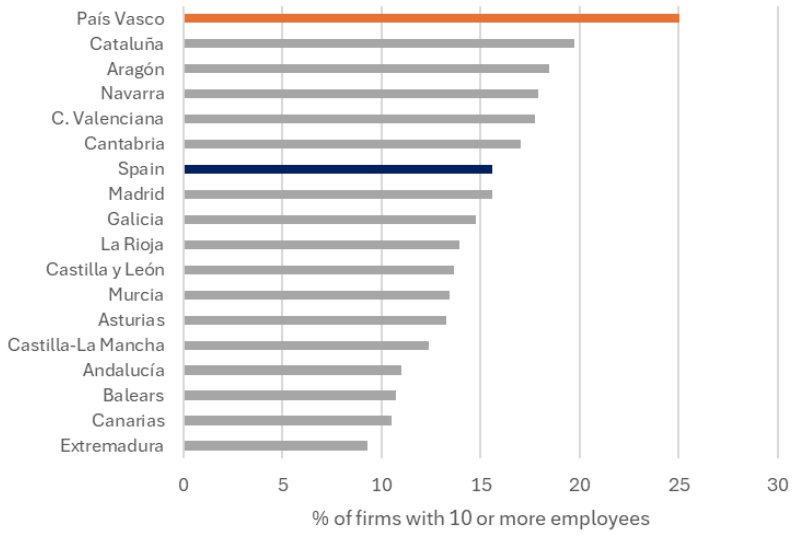
In this context, the Basque Country emerges as a clear outlier (see Figure 2). It leads all Spanish regions in total income from R&D&I contracts, surpassing €200 million–well ahead of regions such as Catalonia and Madrid, despite their significantly larger economies. When this income is measured as a share of GDP, the Basque Country's intensity more than doubles the national average, confirming the systemic nature of these collaborative arrangements. This performance is not merely the result of an active industrial base, but rather reflects a deliberate and long-standing policy effort to build an integrated innovation system in which knowledge producers and firms are closely aligned.

A key driver of this outcome has been the sustained support for Technology Centres and other RTOs acting as intermediaries. These organisations have structured innovation demand through accessible, applied research services that reduce the risks and costs of innovation for a wide array of firms. As a result, R&D&I contracts in the Basque Country have become not only a funding channel, but a core pillar of innovation inclusiveness–enabling more firms to participate in the knowledge economy.

The effects of this institutional architecture are also evident in firm-level innovation data. As shown in Figure 3, the Basque Country leads all Spanish regions in the percentage of firms (with 10 or more employees) engaged in innovation activities, with approximately 25% reporting such engagement. This is well above the national average of 15% and significantly higher than the levels observed in other advanced regions.

This pattern reinforces the idea that innovation in the Basque Country is not concentrated in a handful of elite firms or sectors, but rather embedded across the productive fabric. The institutional density and continuity of its innovation system–underpinned by targeted instruments like R&D&I contracts and supported by a mature network of intermediaries–have lowered the entry barriers for firms and institutionalised collaborative innovation practices.

FIGURE 3
INNOVATION ENGAGEMENT AMONG FIRMS IN THE BASQUE COUNTRY



Source: Own elaboration based on data from the Spanish National Statistics Institute (INE).

The Basque experience illustrates how a regional innovation system can evolve to become not only competitive, but also structurally inclusive, ensuring that a wider share of the business community can benefit from and contribute to innovation. This systemic capability is what sets the Basque model apart–and what makes it particularly relevant as a reference in broader discussions on knowledge transfer and innovation policy effectiveness.

One of the most compelling indicators of the inclusiveness of the Basque innovation system is the evolution of firm size distribution among R&D-performing companies. As shown in Figure 4, the past two decades have witnessed a significant structural transformation. In 2001, small firms with fewer than 20 employees accounted for just over one-third (36%) of all firms conducting R&D in the region. By 2011, this figure had jumped dramatically to 68%, and although it slightly declined in the following decade, small firms still made up the majority (58%) of R&D-active firms in 2022.

This trajectory marks a qualitative leap in the integration of small enterprises into the innovation ecosystem. Unlike larger firms, which often have in-house R&D departments and established routines for managing innovation, small firms typically face substantial barriers to engaging in R&D activities, including financial constraints, limited human resources, and low absorptive capacity. The growing presence of small firms in the R&D landscape of the Basque Country is therefore not merely a numerical change–it signals a deep transformation in the functioning of the regional system, one that has enabled a broader segment of the productive fabric to participate in innovation.

This shift can be largely attributed to the dense network of intermediary institutions, especially Technology Centres, which have played a central role in lowering the threshold for small firms to access research capabilities and develop innovative projects. Through tailored support, collaborative projects, and contract-based R&D, these intermediaries have helped embed innovation in firms that would otherwise remain disconnected from the knowledge economy.

In essence, the data reflect a system that no longer concentrates innovation in a few large actors, but rather promotes the distributed participation of firms of all sizes, with a notable expansion of small-firm engagement. This structural change has not

only strengthened the competitiveness of individual firms but has also made the entire regional economy more dynamic, resilient, and innovation-driven.

The indicators discussed throughout this section clearly illustrate the unique profile of the Basque Country within the Spanish innovation landscape. However, more conventional metrics also confirm the systemic relevance of RTOs in the region. The Basque Country has the highest share of private R&D funding in Spain, and one of the highest in Europe, with over 60% of total R&D expenditure financed by firms. Business-led R&D execution is equally dominant, accounting for 77% of regional R&D activity, compared to just 16% executed by universities. These figures position the Basque innovation system closer to global leaders such as Germany and Japan than to the Spanish average. In the European Regional Innovation Scoreboard, the Basque Country performs 9.8% above the EU average and 23% above the national average–leading all Spanish regions in this composite indicator.

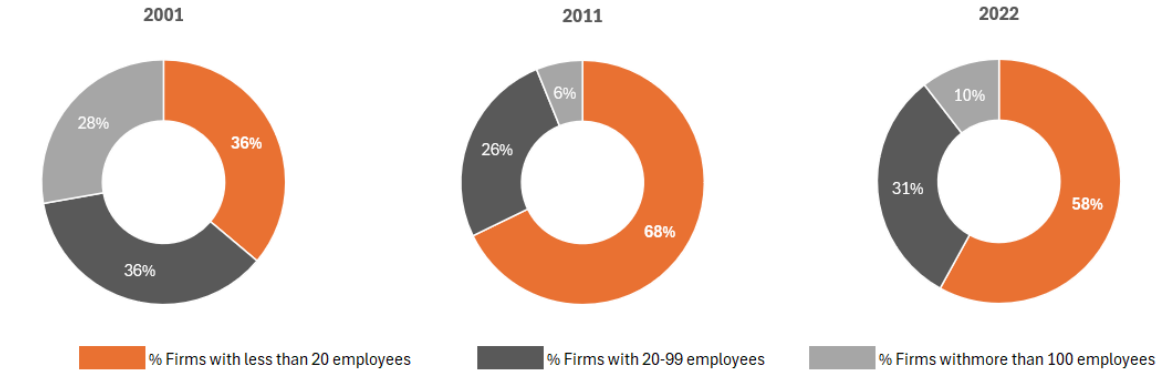
Taken together, these results suggest that the success of the Basque innovation system cannot be explained by isolated policy measures or the performance of individual actors. Rather, it reflects the cumulative effects of a territorially grounded, systemic innovation strategy, in which RTOs have played a pivotal role. By activating both the supply and demand sides of knowledge flows, and by enabling firms–particularly SMEs–to access, adapt, and apply scientific and technological advances, RTOs have become structural agents of innovation. Their ability to evolve in line with shifting policy rationales and industrial priorities helps explain their enduring relevance over the past four decades.

CONCLUDING REMARKS

This paper has analysed the historical evolution and institutional embedding of Research and Technology Organisations (RTOs) in the Basque Country, showing how their progressive integration into regional innovation policy has enabled a more inclusive and dynamic innovation system. The co-evolution of RTOs and industrial restructuring has not only strengthened the regional knowledge base but has also facilitated the sustained participation of SMEs in innovation activities–traditionally a challenge in less research-intensive economies.

While the Basque case is deeply shaped by its institutional and industrial context, it provides generalisable insights. Above all, it highlights that the effectiveness of RTOs is not inherent to their organisational model, but contingent on the broader policy architecture in which they are embedded. Replicating the Basque experience elsewhere requires careful adaptation to local capabilities, governance arrangements, and industrial structures.

FIGURE 4
A STRUCTURAL SHIFT: THE GROWING ROLE OF SMALL FIRMS IN R&D ACTIVITY



Source: Own elaboration based on data from Eustat.

From a policy perspective, the findings underscore the need to prioritise intermediary organisations in innovation strategies, particularly those capable of bridging scientific production with firm-level application. Effective innovation policy must avoid overly generic classifications of intermediaries and instead support diverse RTOs with tailored missions and flexible governance. Long-term public support, integration into international networks, and alignment with regional priorities are all essential conditions for impact.

That said, important challenges remain. The role of universities in the Basque innovation system remains limited compared to their potential as engines of interdisciplinary knowledge and problem-oriented research. Moreover, despite strong participation in EU programmes, the overall international visibility of the Basque innovation system remains modest. Addressing these gaps will be crucial to sustain the region's trajectory in an increasingly globalised and mission-oriented innovation landscape.

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