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FINAL REPORT

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WP 4 – Research, Technological Development and Innovation

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List of abbreviations

CF	Cohesion Fund
COSME	Competitiveness of Enterprises and Small and Medium-sized Enterprises
CP	Cooperation Programme(s)
CRII	Coronavirus Response Investment Initiative
DG REGIO	Directorate-General Regional and Urban Policy
DG RTD	Directorate-General for Research and Innovation
EAFRD	European Agricultural Funds for Rural Development
EC	European Commission
ERDF	European Regional Development Fund
ESF	European Social Fund
ESIF	European Structural and Investment Funds
ESFRI	European Strategy Forum on Research Infrastructures
EU	European Union
FoI	Field(s) of Intervention
H2020	Horizon 2020
ICT	Information and Communication Technology
IPR	Intellectual Property Rights
LIFE	Programme for Environment and Climate Action
MA/ MAs	Managing Authority/ Managing Authorities
MS	Member State(s)
NGO	Non-governmental organisation
OP/ OPs	Operational Programme/Operational Programmes
PI/ PIs	Policy instrument/ Policy instruments
R&D	Research and Development
RDI	Research, Development and Innovation
REACT-EU	Recovery Assistance for Cohesion and the Territories of Europe
RIS	Regional Innovation Scoreboard
RTD	Research and Technological Development
RTDI	Research, Technological Development, and Innovation
S3	Smart Specialisation Strategy
SME(s)	Small and Medium-Sized Enterprise(s)
TO	Thematic Objective
ToR	Terms of References
ToC	Theory of Change
TRL	Technology Readiness Level
TTOs	Technology Transfer Offices

List of abbreviations (Countries)

AT	Austria
BE	Belgium
BG	Bulgaria
CZ	Czechia
DE	Germany
DK	Denmark
EE	Estonia
FI	Finland
GR	Greece
IE	Ireland
IT	Italy
LT	Lithuania
LV	Latvia
MT	Malta
NL	The Netherlands
PL	Poland
PT	Portugal
RO	Romania
SI	Slovenia
SK	Slovakia
UK	The United Kingdom

Glossary

Inputs	Financial, human, material and information resources used to produce outputs through activities and accomplish outcomes. This includes ERDF funding as well as how this funding was allocated.
Activities/ projects	Actions taken or work performed through which inputs are mobilized to produce outputs. Depending on the instrument, these may refer to calls for projects, or to projects implemented by beneficiaries of the allocated funding.
Outputs	Direct products or services stemming from the activities. They should be generated immediately upon the delivery of ERDF sponsored activities (the shortest-term results of the policy instruments being analysed). The generation of outputs is directly dependent on those who implement activities.
Immediate outcomes (during project)	Changes which are expected to occur once one or more outputs have been achieved. They are short-term outcomes. They can be changes in capacity, such as an increase in knowledge, awareness, skills, or abilities among intermediaries and/or beneficiaries.
Intermediate outcomes (after project)	Changes which are expected to occur once one or more immediate outcomes have been achieved. They are medium-term outcomes that are usually achieved at the end of or after the project. Their appearance is only partially controlled by the stakeholders in charge of implementing activities i.e. other factors come into play and may drive or challenge the generation of outcomes. These outcomes are generally achieved one to three years after the delivery of ERDF sponsored activities. While some outcomes may have been generated during the 2014-2020 period, others may have appeared after.
Outcomes at systemic level	More systemic and macro-level changes in competitiveness at the regional and/or country level. The intervention can only contribute to these changes, as part of a causal package of interventions.
Casual pathways	Uninterrupted chains of assumptions linking the intervention with their consequences on capacity, attitude, or behaviour of stakeholders towards policy goals. Pathways can work in parallel or as alternatives. They can be triggered by different activities, different modes of implementation, or different reactions of stakeholders to the policy inputs.
Preconditions	Conditions the policy maker assumes are in place and will remain in place during the lifetime of the policy instrument that have been identified (by the policy maker or by the evaluator) as being key to ensuring the success of the policy instrument. Policy makers may not always be aware of these, so the evaluator must draw from his expertise as well as the literature review to identify them. As opposed to supporting factors or risks / threats, pre-conditions are of a more static nature, which means that they are not expected to change throughout the course of implementation of the instrument. If they do change, they will generally weaken or alter the foundation upon which the instrument is built. In most cases, assumed pre-conditions will directly relate to factors which originally made the policy instrument relevant and well-adjusted to the local context. The policy maker should have verified their existence either though preliminary studies or through the selection procedures put in place to distribute financial support.

Unintended effects	Results which were observed and took place as a result of the policy intervention, which were not part of the intended goals of the policy maker. They can be positive or negative.
Needs (barriers)	Problems and factors impeding to achieve the policy instrument's specific goals (e.g. internationalisation), to show what the ERDF policy instrument is tackling and what it is not. They should be considered for the assessment of Relevance.
Enablers	Activities, events, or situations which can be expected to take place or exist during the implementation of the policy instrument, and which may contribute to the achievement of the policy instrument's expected results. They are not however directly linked to the policy instrument. Instead, they are carried out or exist out independently of the policy instrument, and in many cases, will not be the direct responsibility of the policy maker. As such, supporting factors are exogenous to the policy instrument. This may include other elements of the identified RTD policy mix deemed to directly influence the achievement of the same intended effect of the ERDF policy instrument being assessed. The policy maker may or may not have identified these at the outset of the policy instrument, so they may or may not be directly reflected in the design of the instrument. As such, the evaluator will have to rely on their own knowledge as well as the literature review to identify the most important ones. The absence of a supporting factors can be considered to be an inhibitor.
Barriers/risks	Events that may happen and conditions that may arise during the course of implementation of the policy instrument that may potentially impact the performance (i.e. achievement of expected results) of the instrument. As opposed to supporting factors, barriers and risks are by nature, negative. Their appearance will only lead to a negative effect if not mitigated correctly. Risks are events that could happen that will make things go wrong. While risks can be formulated as the absence of a supporting factor (i.e. the supporting factor did not happen), it is better to separate these two to the extent possible. The same applies to preconditions. Risks however negatively influence or weaken key supporting factors and assumed pre-conditions, which may in turn impact the ToC of the instrument.
Mechanisms	A combination of events, processes, conditions, factors of different nature (institutional, socio-economic, political, behavioural) leading from the initial state before the instrument is launched, to the subsequent one that is observed through this study.
EU 14+ UK/ /EU13	EU14+UK includes Member States that have joined the EU before 2004. These are Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden and UK. EU13 includes Member States that have joined the EU since 2004. These are Bulgaria, Croatia, Cyprus, Czechia, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia, and Slovenia.
Trans-formational activities	Activities with the potential for contributing to systemic change.
Upstream and downstream synergies.	Upstream synergies refer to using ERDF to fund actions that build R&I capacities needed to compete in Horizon 2020, while downstream synergies are those that seek to leverage the ERDF to fund actions that capitalize on already implemented Horizon 2020 projects.

Abstract

This report presents the ex-post evaluation of investments in Research, Technological Development and Innovation (RTDI) funded by the European Regional Development Fund (ERDF) during the 2014-2020 programming period. The evaluation employs a multi-level approach, examining country, Operational Programme, instrument, and project levels, and utilises a combination of qualitative and quantitative methods influenced by theory-based impact evaluation.

During this period, the ERDF programmes allocated a total of EUR 59 billion to support RTDI, primarily via non-repayable grants to sole beneficiaries with a predominant focus on promoting research activities within businesses and fostering science-industry collaborative projects. The direction of ERDF support was largely guided by regional and national Smart Specialisation Strategies (S3s), which targeted specific priority sectors. The ERDF played a crucial role in advancing knowledge production and enhancing regional collaborations between science and industry, contributing positively to technological progress in the EU.

However, the effectiveness of this support was contingent upon its strategic alignment with national and regional RTDI frameworks. The evaluation findings also revealed limited upstream synergies at the project level and limited downstream synergies between the ERDF and the H2020 Framework Programme, along with challenges related to research infrastructure projects, despite the overall smooth disbursement of ERDF grants.

Executive summary

RTDI actors were confronted with considerable obstacles and an evolving landscape of challenges, necessitating a tailored approach to support.

Building on the 2007-2013 period and the Lisbon Agenda, the European Regional Development Fund (ERDF) support for RTDI remained a key element of the 2014-2020 programming period. RTDI actors across the EU regions continued to encounter obstacles that impeded their performance, including limited access to finance, networks, human capital, and institutional constraints, as well as reliance on external markets. Private R&D investments and industry-science relations, technology transfer and spinoffs were among the principal weaknesses affecting the regional innovation systems in 2014, followed by weaknesses related to the commercialisation of innovations and public R&D investments. Regional disparities continued due to varying territorial contexts, including differences in infrastructure quality, skills availability, and complex regulatory environments, resulting in uneven research and innovation (R&I) outcomes and potential development traps.

The period between 2014 and 2020 was characterised by two significant economic events: the recovery from the 2008-2009 financial crisis and the emergence of a novel crisis triggered by the outbreak of the COVID-19 pandemic in 2020. During this period, societal challenges, including the digital and green transitions, necessitated the adaptation and redefinition of innovation policies. Economic development strategies gained more prominence during the planning and implementation of the operational programmes. This change was driven by the need to enhance overall competitiveness, partly due to the reduction in public resources. The approach prioritised endogenous development and a "place-based" strategy, which emphasised the significance of local contexts and distinctive regional strengths in fostering innovation. Concepts such as Smart Specialisation Strategies (S3) played a pivotal role, leveraging existing regional assets to uncover new opportunities, with the objective of improving public funding outcomes and securing long-term competitive advantages.

The ERDF programmes allocated EUR 59 billion to support RTDI in the 2014-2020 period.

The ERDF made a significant contribution to the development of the EU research and innovation landscape during the period under review. Its main role has been to strengthen research, technological development and innovation, in particular by improving R&I infrastructure and promoting excellence in this field. It also facilitated the creation of poles of excellence and encouraged business investment in R&I. It also sought to create links and synergies between the various actors involved in RTDI. The ERDF was designed to tailor its support to the specific needs and challenges of local regions and territories, with the aim of reducing disparities and improving their performance in terms of innovation, productivity and competitiveness.

During the 2014-2020 period, the ERDF allocated EUR 40 billion to enhance the performance of Europe’s RTDI actors. Combined with national co-financing, this allocation amounted to a total support of EUR 59 billion, representing a significant increase compared to the previous programming period. The distribution of ERDF support for RTDI was concentrated on a limited number of Operational

Programmes (OPs), with 85% of total eligible expenditure concentrated in 71 out of 229 OPs. A total of 14 OPs across 12 Member States were allocated half of the planned ERDF RTDI budget, with less developed regions receiving 50% of the total planned expenditure. The ERDF also was a primary source of funding for RTDI in EU13 countries. In a vast majority of cases, absorption rates were positive or above 90% by the end of 2023.

ERDF supported primarily sole beneficiaries through non-repayable grants, with a particular focus on research activities in businesses and science-industry collaborative projects.

Eight types of ERDF policy instruments to strengthen RTDI over the period 2014-2020 were identified for the purpose of the evaluation. These policy instruments included investments in physical infrastructure (such as the construction, upgrade, and modernisation of facilities, as well as the purchase of equipment for testing and validation), funding of RTDI projects (ranging from early stage to applied research), and soft support to create a RTDI culture (such as the promotion of exchanges between research centres, universities, and enterprises, along with investments in capacity building). Of the eight policy instruments identified, the provision of funding for RTDI projects was the most frequently utilised. In comparison, infrastructure investments and soft support were employed to a lesser extent. The largest share of expenditure (approximately 39%) was allocated to research activities in businesses, which remain a core target group of ERDF support. Collaborative science-industry projects represented the second-largest policy instrument by expenditure (nearly 20%).

In less developed regions, support was directed towards measures that directly benefited RTDI in enterprises. Transition regions allocated more resources to infrastructure investments for research, while more developed regions focused on technology transfer and science–industry collaborative projects. Almost 75% of the operations were distributed to sole beneficiaries, primarily enterprises (40%). The majority of RTDI support (over 90% of total expenditure) was provided in the form of non-repayable grants. Only 32 Operational Programmes mobilised financial instruments for EUR 1.7 billion by the end of 2023 and were mainly used to provide finance to enterprises (SMEs).

Regional and national S3s were used to thematically direct ERDF support for RTDI towards selected priority sectors to a significant extent.

Smart Specialisation Strategies (S3) were a central strategic framework for targeting ERDF RTDI investments within regions. The evaluation confirmed that the directionality inherent in the S3 paradigm (i.e., the selection of priority areas) has enabled MAs to channel ERDF funding towards pre-identified innovation goals (incl. so-called “transformational activities” of the S3 paradigm). During the 2014-2020 period, around 64% of ERDF RTDI operations were found to be thematically aligned with the S3 Priority Areas. Regional variations were identified, whereby transition and less developed regions demonstrated greater thematic alignment. The majority of ERDF RTDI operations aligned with S3 were concentrated in specific thematic areas, including ICT and Industry 4.0, Health and Life Sciences, and Agrifood and Bioeconomy. The introduction of the S3 framework facilitated the direction of support in a way that was conducive to success, with the most effective Managing Authorities aligning investments with the regional economic and technological profiles. While regional S3s functioned effectively as a strategic framework for targeting investments, their success was contingent upon the appropriate application of the prioritisation logic.

However, there is still room for improvement in the design of the S3s, particularly in terms of their breadth, depth, and selection of thematic priorities. Additionally, there is potential to enhance the design of S3-related calls. In an effort to ensure that the funds are used to the fullest, these calls tend to be broad and consequently undermine the prioritization logic of the S3.

Both upstream synergies on the project level and downstream synergies between ERDF and H2020 Framework Programme were limited…

The evaluation found great coherence between ERDF and Horizon 2020. At the ERDF programme level, complementarities between Horizon 2020 and ERDF policy instruments supporting research activities in universities were observed in 83% of OPs. Similarly, complementarities between ERDF policy instruments for science-industry collaborative RDI projects and infrastructure investments for research were noted in 73% and 64% of OPs, respectively. Additionally, the evaluation found that approximately 10% of ERDF RTDI beneficiaries also received Horizon 2020 funding. The majority of dual beneficiaries were located in more developed regions (71.4%) and EU14 countries (79.3%). In relation to upstream synergies, 17% of ERDF projects undertaken by these beneficiaries were directly related to building R&I capacity, indicating that there is still untapped potential for upstream synergies between ERDF and Horizon 2020. In terms of downstream synergies, the study identified 840 innovations supported by ERDF funding, representing 10.7% of the total number of innovations included in the Innovation Radar as of June 2024. Of these, around half are still in the exploratory phase, and only 1.2% are business-ready, suggesting a modest outcome in terms of innovation scale. This suggests that while ERDF funding has contributed to downstream synergies by building on previous EU-supported initiatives, these synergies were present to a limited extent. There was a lack of systematic pursuit of upstream and downstream synergies between ERDF and Horizon projects. The main obstacles were misconceptions about the compatibility of the two programmes, differences in their scope and objectives, and the administrative burden of managing both funding streams simultaneously.

…as well as the use of financial instruments to support RTDI.

By the end of 2023, only 32 out of 229 Operational Programmes had mobilised financial instruments, with a total investment of EUR 1.7 billion. Financial instruments were mainly used to finance enterprises (SMEs), and were used to indirectly support technology transfer, research activities in enterprises and business investment to support the uptake of innovation. Grants were the predominant mode of delivery in a context where the implementation of financial instruments was difficult (initially low interest rates and subsequently the COVID-19 pandemic). Despite the implementation difficulties, financial instruments have significant potential to support the knowledge valorisation phase. Consequently, the next evaluation should give appropriate attention to the issue of finance throughout the innovation life cycle.

The disbursement of grant-based ERDF support for RTDI proceeded smoothly, although some challenges were encountered

During the 2014-2020 programming period, significant efforts were made to improve ERDF support efficiency by addressing issues from the previous period, such as State Aid regulations, through initiatives like the COMP-REGIO State Aid action plan, which aimed to strengthen administrative capacity and clarify legislation. Despite a relatively high average completion rate of 85% for seven out of

in the context of research infrastructure projects.

eight policy instruments, infrastructure projects encountered delays due to the impact of the COVID-19 pandemic and the war in Ukraine. The evaluation found that having experienced Managing Authorities and beneficiaries had a positive impact on project outcomes, while inexperience led to complications and delays. Contextual factors, such as well-defined long-term strategies and qualified human capital, were crucial for successful implementation, although issues like public procurement rules and limited flexibility for project modifications posed barriers.

ERDF played a substantial role in advancing knowledge production...

The ERDF investments in RTDI were instrumental in generating and disseminating new knowledge. This is evidenced by more than 138,000 scientific publications in reputable journals that acknowledge the ERDF's role in their production during the 2014-2020 period. Of these publications, almost 79,000 were the result of activities undertaken by beneficiaries of ERDF-funded RTDI projects. A greater proportion of these publications were concentrated in the EU14 (74%) and associated with ERDF RTDI beneficiaries in more developed regions (57%), followed by less developed regions (34%) or regions in transition (9%).

The majority of identified publications addressed topics related to science, technology, engineering, and mathematics (STEM). There was no significant variation in these topics across the different regions (EU14/EU13 and Cohesion Regions), suggesting a strong focus on disciplines that contribute directly to scientific and/or technological advancement. The identified publications were primarily associated with science-industry collaboration, university and research centre activities, and research infrastructure investment that produced a significant number of publications across all Cohesion regions. However, the majority of publications from business-related research activities originated from more developed countries.

…and in stimulating regional collaborations between science and industry.

ERDF RTDI support facilitated knowledge sharing and the formation of regional partnerships, primarily through science-industry collaborative RTDI projects, which represent the second largest RTDI policy instrument. According to the monitoring indicators, by the end of 2022 ERDF instruments supported more than 75,500 enterprises in collaboration with research institutions, exceeding the target value by 115%. The majority of publications by ERDF RTDI beneficiaries between 2016 and 2023 (60,000) were from science-industry collaborative RDI projects, regardless of the type of Cohesion Region.

ERDF positively contributed to the technological advancement of EU

The ERDF has made a significant contribution to the technological advancement of EU regions, with over 7,000 registered patents that build upon the knowledge generated by the ERDF RTDI support. The micro-level data collected for this evaluation demonstrated that, on a per capita basis, the highest number of these patents that extend the knowledge generated by the ERDF RTDI support were observed in Western Europe (especially in Portugal and the Netherlands), the Nordic countries (especially Denmark and Finland) as well as Estonia. Almost 50% of these patent registrations were related to the broad domain of "human necessities", encompassing a diverse range of technologies that have a direct impact on people's daily lives. Conversely, 45% of

these patent applications were directly related to STEM fields, including chemistry, metallurgy, physics and electricity.

The success of ERDF support was contingent upon its strategic alignment with national and regional RTDI frameworks.

The results of the ERDF-supported policy instruments for RTDI are very positive. The success of RTDI support was contingent upon a transparent, long-term strategy at both regional and beneficiary levels, with effective integration of developed infrastructure into strategic plans being of paramount importance. The evaluation emphasises the importance of regional and national alignment, the creation of synergies between funding sources, and the use of a variety of funding instruments to optimise resources. However, the effectiveness of ERDF-supported measures has been hindered by complex administrative procedures, staff shortages, and delays caused by the impact of the COVID-19 pandemic.

ERDF facilitated strategic planning and the long-term commitment of RTDI resources across all examined EU territories.

The ERDF has enabled MAs to formulate strategic plans that extend beyond the boundaries of electoral cycles, thereby enabling them to commit RTDI resources on a long-term basis. MAs in less developed regions identified the scale of EU support as the most valuable aspect, noting that projects of this scale would not have been possible without it. The added value of the ERDF was particularly evident in regions lacking fiscal resources, where it was often the main source of funding. This was also the case where high co-financing rates were required, such as for infrastructure projects in EU13 regions. While the ERDF enabled strategic planning and encouraged cooperation, there was little evidence that local policymakers used this support to implement innovative policy practices, such as experimental approaches or stakeholder involvement.

It is not yet clear to what extent ERDF-supported RTDI instruments have contributed to more systemic effects, such as improving regional competitiveness and fostering convergence. This uncertainty is not only due to the presence of multiple external factors and the fact that some effects can only materialise in the longer term. Systemic effects were also constrained by the limited synergies established across different instruments and funding opportunities at regional, national, and EU levels.

The key lessons highlight the necessity to drive directionality via S3, increase synergistic RTDI funding across all EU regions, foster collaboration and ensure adequate human capital and skills.

The evaluation underlines the need for systemic transformation and more targeted ERDF support for RTDI, which needs to be achieved by reinforcing the principles of S3. The evidence shows that the S3 paradigm, in particular its emphasis on priority areas, has effectively guided MAs in directing ERDF funding towards pre-identified innovation goals, or "transformational activities", i.e., activities with the potential for contributing to systemic change. To further enhance effectiveness, this approach should be combined with increased R&D investments across all regions and strategic policy reforms to reduce the EU's R&D intensity gap with its main competitors. It is also essential to further strengthen the coordination and alignment of various RTDI funding sources. This could be achieved in the regions, for instance, through centralised management within specialised agencies and/or the establishment of dedicated structures to oversee central EU programmes such as Horizon Europe, while avoiding the duplication of national structures.

Further strengthening collaboration between RTDI stakeholders across the EU is also crucial for boosting Europe's competitiveness

and technological progress, with the I3 and other recent initiatives of the 2021-2027 period offering promising solutions. Key future considerations include strengthening and promoting existing networks and platforms, enhancing technology transfer and intellectual property management through better resourced Technology Transfer Offices, and diversifying collaborative formats. It is also essential that future policies focus on retaining and attracting talent. Initiatives such as the Harnessing Talent Platform should be enhanced, as should public-private partnerships and the possibility of combining funding from ERDF, ESF, and where possible Horizon Europe, for the development of skills for RTDI, industrial transition and entrepreneurship.

Résumé exécutif

Les RTDI acteurs ont été confrontés à des obstacles considérables et à un environnement en constante évolution, ce qui a nécessité une approche sur mesure en matière de soutien.

Dans le prolongement de la période 2007-2013 et de l'agenda de Lisbonne, le soutien du Fonds européen de développement régional (FEDER) à la RDTI est resté un élément clé de la période de programmation 2014-2020. Les acteurs de la RDTI dans les régions de l'UE ont continué à se heurter à des obstacles qui ont entravé leurs performances, notamment un accès limité au financement, aux réseaux et au capital humain, des contraintes institutionnelles, ainsi que la dépendance à l'égard des marchés extérieurs. Les investissements privés dans la R&D, les relations entre l'industrie et la science, le transfert de technologies et les retombées ont figuré parmi les principales faiblesses affectant les systèmes d'innovation régionaux en 2014, suivies par les faiblesses liées à la commercialisation des innovations et aux investissements publics dans la R&D. Les disparités régionales ont persisté en raison de la diversité des contextes territoriaux, notamment des différences en matière de qualité des infrastructures, de disponibilité des compétences et de complexité des environnements réglementaires, ce qui a entraîné des résultats inégaux en matière de recherche et d'innovation (R&I) et des pièges potentiels pour le développement.

La période comprise entre 2014 et 2020 a été marquée par deux événements économiques majeurs : la reprise après la crise financière de 2008-2009 et l'émergence d'une nouvelle crise déclenchée par la pandémie de COVID-19 en 2020. Au cours de cette période, les défis sociétaux, notamment les transitions numérique et écologique, ont nécessité l'adaptation et la redéfinition des politiques d'innovation. Les stratégies de développement économique ont pris davantage d'importance lors de la planification et de la mise en œuvre des programmes opérationnels. Ce changement a été motivé par la nécessité de renforcer la compétitivité globale, en partie en raison de la réduction des ressources publiques. La nouvelle approche a donné la priorité au développement endogène et à une stratégie « axée sur le territoire », qui mettait l'accent sur l'importance des contextes locaux et des atouts régionaux distinctifs pour favoriser l'innovation. Des concepts tels que les stratégies de spécialisation intelligente (S3) ont joué un rôle central, en tirant parti des atouts régionaux existants pour découvrir de nouvelles opportunités, dans le but d'améliorer les résultats du financement public et de garantir des avantages concurrentiels à long terme.

Les programmes du FEDER ont attribué 59 billions d'euros pour soutenir la RTDI au cours de la période 2014-2020.

Le FEDER a apporté une contribution significative au développement du paysage européen de la recherche et de l'innovation au cours de la période considérée. Son rôle principal a consisté à renforcer la recherche, le développement technologique et l'innovation, notamment en améliorant les infrastructures de R&I et en promouvant l'excellence dans ce domaine. Il a également facilité la création de pôles d'excellence et encouragé les investissements des entreprises dans la R&I. Il s'est également efforcé de créer des liens et des synergies entre les différents acteurs impliqués dans la RDTI. Le FEDER a été conçu pour adapter son soutien aux besoins et aux défis spécifiques des régions et des territoires locaux, dans le but de réduire les disparités

et d'améliorer leurs performances en matière d'innovation, de productivité et de compétitivité.

Au cours de la période 2014-2020, le FEDER a attribué 40 billions d'euros pour améliorer les performances des acteurs européens de la RDT&I. Combinée au cofinancement national, cette allocation a représenté un soutien total de 59 billions d'euros, soit une augmentation significative par rapport à la période de programmation précédente. La répartition du soutien du FEDER en faveur de la RDTI s'est concentrée sur un nombre limité de programmes opérationnels (PO), 85 % des dépenses totales éligibles étant concentrées dans 71 des 229 PO. Au total, 14 PO dans 12 États membres ont reçu la moitié du budget prévu par le FEDER pour la RDTI, les régions moins développées recevant 50 % des dépenses totales prévues. Le FEDER a également été une source principale de financement pour la RDTI dans les pays de l'UE-13. Dans la grande majorité des cas, les taux d'absorption étaient positifs ou supérieurs à 90 % à la fin de 2023.

Le FEDER a principalement soutenu des bénéficiaires uniques par le biais de subventions non remboursables, en mettant particulièrement l'accent sur les activités de recherche dans les entreprises et les projets de collaboration entre la science et l'industrie.

Huit types d'instruments politiques du FEDER visant à renforcer la RDTI au cours de la période 2014-2020 ont été identifiés aux fins de l'évaluation. Ces instruments politiques comprenaient des investissements dans les infrastructures physiques (tels que la construction, la mise à niveau et la modernisation d'installations, ainsi que l'achat d'équipements pour les essais et la validation), le financement de projets de RDTI (allant de la recherche précoce à la recherche appliquée) et un soutien non financier visant à créer une culture de la RDTI (telle que la promotion des échanges entre les centres de recherche, les universités et les entreprises, ainsi que des investissements dans le renforcement des capacités). Parmi les huit instruments politiques recensés, le financement de projets de RDTI était le plus fréquemment utilisé. En comparaison, les investissements dans les infrastructures et le soutien non financier ont été moins utilisés. La plus grande partie des dépenses (environ 39 %) a été allouée aux activités de recherche dans les entreprises, qui restent un groupe cible essentiel du soutien du FEDER. Les projets collaboratifs entre la science et l'industrie représentaient le deuxième instrument politique en termes de dépenses (près de 20 %).

Dans les régions moins développées, l'aide a été orientée vers des mesures qui ont directement profité à la RDT&I dans les entreprises. Les régions en transition ont alloué davantage de ressources aux investissements dans les infrastructures de recherche, tandis que les régions plus développées se sont concentrées sur le transfert de technologies et les projets de collaboration entre la science et l'industrie. Près de 75 % des opérations ont été réparties entre des bénéficiaires uniques, principalement des entreprises (40 %). La majeure partie du soutien à la RDTI (plus de 90 % des dépenses totales) a été fournie sous forme de subventions non remboursables. Seuls 32 programmes opérationnels ont mobilisé des instruments financiers pour un montant de 1,7 billion d'euros à la fin de 2023, qui ont principalement servi à financer des entreprises (PME).

Les S3 régionales et nationales ont

Les stratégies de spécialisation intelligente (S3) constituaient un cadre stratégique central pour cibler les investissements du FEDER

été utilisées dans une large mesure pour orienter thématiquement le soutien du FEDER en matière de RTDI vers certains secteurs prioritaires.

en matière de RDTI dans les régions. L'évaluation a confirmé que la directionnalité inhérente au paradigme S3 (c'est-à-dire la sélection de domaines prioritaires) a permis aux autorités de gestion d'orienter les financements du FEDER vers des objectifs d'innovation préidentifiés (y compris les « activités transformationnelles » du paradigme S3). Au cours de la période 2014-2020, environ 64 % des opérations du FEDER en matière de RDTI ont été jugées conformes aux domaines prioritaires de la stratégie S3 sur le plan thématique. Des variations régionales ont été constatées, les régions en transition et les régions moins développées affichant une plus grande conformité thématique. La majorité des opérations du FEDER alignées sur la stratégie S3 se concentraient dans des domaines thématiques spécifiques, notamment les TIC et l'industrie 4.0, la santé et les sciences de la vie, ainsi que l'agroalimentaire et la bioéconomie. L'introduction du cadre S3 a facilité l'orientation du soutien de manière à favoriser la réussite, les autorités de gestion les plus efficaces alignant les investissements sur les profils économiques et technologiques régionaux. Si les S3 régionaux ont fonctionné efficacement en tant que cadre stratégique pour cibler les investissements, leur succès dépendait toutefois de l'application appropriée de la logique de hiérarchisation des priorités. Toutefois, la conception des S3 peut encore être améliorée, notamment en termes d'étendue, de profondeur et de sélection des priorités thématiques. De plus, il est possible d'améliorer la conception des appels liés à la S3. Afin de garantir une utilisation optimale des fonds, ces appels ont tendance à être très généraux, ce qui nuit à la logique de hiérarchisation de la S3.

Les synergies en amont au niveau du projet et les synergies en aval entre le FEDER et le programme-cadre H2020 ont été limitées...

L'évaluation a révélé une grande cohérence entre le FEDER et Horizon 2020. Au niveau des programmes du FEDER, des complémentarités entre Horizon 2020 et les instruments politiques du FEDER soutenant les activités de recherche dans les universités ont été observées dans 83 % des PO. De même, des complémentarités entre les instruments politiques du FEDER pour les projets de RDI collaboratifs entre la science et l'industrie et les investissements dans les infrastructures de recherche ont été constatées dans respectivement 73 % et 64 % des PO. En outre, l'évaluation a révélé qu'environ 10 % des bénéficiaires du FEDER RTDI ont également reçu un financement au titre d'Horizon 2020. La majorité des bénéficiaires doubles étaient situés dans des régions plus développées (71,4 %) et dans les pays de l'UE-14 (79,3 %). En ce qui concerne les synergies en amont, 17 % des projets FEDER entrepris par ces bénéficiaires étaient directement liés au renforcement des capacités de R&I, ce qui indique qu'il existe encore un potentiel inexploité de synergies en amont entre le FEDER et Horizon 2020. En termes de synergies en aval, l'étude a recensé 840 innovations soutenues par des fonds FEDER, soit 10,7 % du nombre total d'innovations répertoriées dans l'Innovation Radar en juin 2024. Parmi celles-ci, environ la moitié sont encore en phase exploratoire et seulement 1,2 % sont prêtes à être commercialisées, ce qui suggère un résultat modeste en termes d'échelle d'innovation. Cela suggère que si le financement du FEDER a contribué à des synergies en aval en s'appuyant sur des initiatives précédentes soutenues par l'UE, ces synergies ont été limitées. Il y avait un manque de recherche systématique de

synergies en amont et en aval entre les projets du FEDER et ceux du programme-cadre de recherche et d'innovation de l'UE. Les principaux obstacles étaient des idées fausses sur la compatibilité des deux programmes, des différences dans leur champ d'application et leurs objectifs, ainsi que la charge administrative liée à la gestion simultanée des deux sources de financement.

… ainsi que l'utilisation d'instruments financiers pour soutenir la RTDI.

À la fin de 2023, seuls 32 des 229 programmes opérationnels avaient mobilisé des instruments financiers, pour un investissement total de 1,7 billion d'euros. Les instruments financiers ont principalement servi à financer des entreprises (PME) et ont été utilisés pour soutenir indirectement le transfert de technologies, les activités de recherche dans les entreprises et les investissements des entreprises afin de favoriser l'adoption de l'innovation. Les subventions ont été le principal mode de mise en œuvre dans un contexte où la mise en œuvre des instruments financiers était difficile (taux d'intérêt initialement bas, puis pandémie de COVID-19). Malgré les difficultés de mise en œuvre, les instruments financiers présentent un potentiel important pour soutenir la phase de valorisation des connaissances. Par conséquent, la prochaine évaluation devrait accorder une attention appropriée à la question du financement tout au long du cycle de vie de l'innovation.

Le versement des aides du FEDER sous forme de subventions pour la RD&I s'est déroulé sans heurts, même si certains problèmes ont été rencontrés dans le cadre des projets d'infrastructures de recherche.

Au cours de la période de programmation 2014-2020, des efforts importants ont été déployés pour améliorer l'efficacité du soutien du FEDER en traitant les problèmes de la période précédente, tels que la réglementation en matière d'aides d'État, grâce à des initiatives telles que le plan d'action COMP-REGIO en matière d'aides d'État, qui visait à renforcer les capacités administratives et à clarifier la législation. Malgré un taux de réalisation moyen relativement élevé de 85 % pour sept des huit instruments politiques, les projets d'infrastructure ont pris du retard en raison de l'impact de la pandémie de COVID-19 et de la guerre en Ukraine. L'évaluation a montré que l'expérience des autorités de gestion et des bénéficiaires avait un impact positif sur les résultats des projets, tandis que le manque d'expérience entraînait des complications et des retards. Des facteurs contextuels, tels que des stratégies à long terme bien définies et un capital humain qualifié, ont été essentiels à la réussite de la mise en œuvre, même si des questions telles que les règles relatives aux marchés publics et la flexibilité limitée pour les modifications de projets ont constitué des obstacles.

Le FEDER a joué un rôle important dans la promotion de la production de connaissances...

Les investissements du FEDER dans la RDTI ont joué un rôle déterminant dans la production et la diffusion de nouvelles connaissances. En témoignent plus de 138 000 publications scientifiques dans des revues réputées qui reconnaissent le rôle du FEDER dans leur production au cours de la période 2014-2020. Parmi ces publications, près de 79 000 sont le résultat d'activités menées par des bénéficiaires de projets de RDT&I financés par le FEDER. Une grande partie de ces publications étaient concentrées dans l'UE-14 (74 %) et associées à des bénéficiaires de l'ERDF RTDI dans des régions plus développées (57 %), suivies par des régions moins développées (34 %) ou des régions en transition (9 %).

La majorité des publications identifiées traitaient de sujets liés aux sciences, à la technologie, à l'ingénierie et aux mathématiques

(STEM). Il n'y avait pas de variation significative dans ces sujets entre les différentes régions (UE14/UE13 et régions de cohésion), ce qui suggère une forte concentration sur les disciplines qui contribuent directement au progrès scientifique et/ou technologique. Les publications identifiées étaient principalement associées à la collaboration entre la science et l'industrie, aux activités des universités et des centres de recherche, ainsi qu'aux investissements dans les infrastructures de recherche, qui ont donné lieu à un nombre important de publications dans toutes les régions de cohésion. Cependant, la majorité des publications issues d'activités de recherche liées aux entreprises provenaient de pays plus développés.

…et en stimulant les collaborations régionales entre la science et l'industrie.

Le soutien du FEDER en matière de RDTI a facilité le partage des connaissances et la formation de partenariats régionaux, principalement par le biais de projets de RDTI collaboratifs entre le monde scientifique et l'industrie, qui constituent le deuxième instrument politique le plus important en matière de RDTI. Selon les indicateurs de suivi, à la fin de 2022, les instruments du FEDER avaient soutenu plus de 75 500 entreprises en collaboration avec des instituts de recherche, dépassant ainsi l'objectif fixé de 115 %. La majorité des publications des bénéficiaires du FEDER RTDI entre 2016 et 2023 (60 000) provenaient de projets de RDI collaboratifs entre la science et l'industrie, quel que soit le type de région de cohésion.

Le FEDER a contribué positivement au progrès technologique de l'UE.

Le FEDER a apporté une contribution significative au progrès technologique des régions de l'UE, avec plus de 7 000 brevets enregistrés qui s'appuient sur les connaissances générées par le soutien du FEDER en matière de RDTI. Les données microéconomiques collectées pour cette évaluation ont montré que, par habitant, le plus grand nombre de ces brevets qui prolongent les connaissances générées par le soutien du FEDER a été observé en Europe occidentale (en particulier au Portugal et aux Pays-Bas), dans les pays nordiques (en particulier au Danemark et en Finlande) ainsi qu'en Estonie. Près de 50 % de ces brevets enregistrés concernaient le vaste domaine des « besoins humains », qui englobe un large éventail de technologies ayant un impact direct sur la vie quotidienne des citoyens. À l'inverse, 45 % de ces demandes de brevet étaient directement liées aux domaines des sciences, des technologies, de l'ingénierie et des mathématiques (STEM), notamment la chimie, la métallurgie, la physique et l'électricité.

Le succès du soutien du FEDER dépendait de son alignement stratégique sur les cadres nationaux et régionaux de RTDI.

Les résultats des instruments politiques soutenus par le FEDER en faveur de la RDTI sont très positifs. Le succès du soutien à la RDTI dépendait d'une stratégie transparente et à long terme tant au niveau régional qu'au niveau des bénéficiaires, l'intégration efficace des infrastructures développées dans les plans stratégiques revêtant une importance capitale. L'évaluation souligne l'importance de l'alignement régional et national, de la création de synergies entre les sources de financement et de l'utilisation d'une variété d'instruments de financement afin d'optimiser les ressources. Cependant, l'efficacité des mesures soutenues par le FEDER a été entravée par des procédures administratives complexes, des pénuries de personnel et des retards causés par l'impact de la pandémie de COVID-19.

Le FEDER a facilité la planification stratégique et l'engagement à long terme des ressources RTDI dans tous les territoires de l'UE examinés.

Le FEDER a permis aux autorités de gestion d'élaborer des plans stratégiques qui dépassent les limites des cycles électoraux, leur permettant ainsi d'engager des ressources RTDI à long terme. Les autorités de gestion des régions moins développées ont identifié l'ampleur du soutien de l'UE comme l'aspect le plus précieux, soulignant que des projets de cette envergure n'auraient pas été possibles sans lui. La valeur ajoutée du FEDER était particulièrement évidente dans les régions dépourvues de ressources fiscales, où il constituait souvent la principale source de financement. C'était également le cas lorsque des taux de cofinancement élevés étaient requis, comme pour les projets d'infrastructure dans les régions de l'UE-13. Si le FEDER a permis une planification stratégique et encouragé la coopération, rien n'indique que les décideurs politiques locaux aient utilisé ce soutien pour mettre en œuvre des pratiques politiques innovantes, telles que des approches expérimentales ou la participation des parties prenantes.

On ne sait pas encore clairement dans quelle mesure les instruments de RDTI soutenus par le FEDER ont contribué à des effets plus systémiques, tels que l'amélioration de la compétitivité régionale et la promotion de la convergence. Cette incertitude n'est pas seulement due à la présence de multiples facteurs externes et au fait que certains effets ne peuvent se concrétiser qu'à plus long terme. Les effets systémiques ont également été limités par les synergies restreintes établies entre les différents instruments et possibilités de financement aux niveaux régional, national et européen.

Les principaux enseignements soulignent la nécessité de définir une orientation claire via le S3, d'accroître les synergies entre les financements RTDI dans toutes les régions de l'UE, d'encourager la collaboration et de garantir un capital humain et des compétences adéquats.

L'évaluation souligne la nécessité d'une transformation systémique et d'une plus grande orientation dans le soutien futur du FEDER à la RDTI, qui doit être réalisée en renforçant les principes des S3. Les données montrent que le paradigme S3, en particulier l'accent mis sur les domaines prioritaires, a efficacement guidé les autorités de gestion dans l'orientation des fonds du FEDER vers des objectifs d'innovation préidentifiés, ou « activités transformationnelles ». Afin d'améliorer encore son efficacité, cette approche devrait être combinée à une augmentation des investissements en R&D dans toutes les régions et à des réformes politiques stratégiques visant à réduire l'écart entre l'UE et ses principaux concurrents en matière d'intensité de R&D. Il est également essentiel de renforcer davantage la coordination et l'alignement des différentes sources de financement de la RDTI. Cela pourrait être réalisé dans les régions, par exemple, grâce à une gestion centralisée au sein d'agences spécialisées et/ou à la mise en place de structures dédiées chargées de superviser les programmes centraux de l'UE tels qu'Horizon Europe, tout en évitant la duplication des structures nationales.

Il est également essentiel de renforcer davantage la collaboration entre les acteurs de la RDT&I dans toute l'UE afin de stimuler la compétitivité et le progrès technologique de l'Europe. L'initiative I3 et d'autres initiatives récentes pour la période 2021-2027 offrent des solutions prometteuses à cet égard. Les principales considérations pour l'avenir comprennent le renforcement et la promotion des réseaux et des plateformes existants, l'amélioration du transfert de technologies et de la gestion de la propriété intellectuelle grâce à

des bureaux de transfert de technologie mieux dotés en ressources, et la diversification des formats de collaboration. Il est également essentiel que les politiques futures se concentrent sur la rétention et l'attraction des talents. Il convient de renforcer les initiatives telles que la plateforme « Harnessing Talent », ainsi que les partenariats public-privé et la possibilité de combiner les financements du FEDER, du FSE et, si possible, d'Horizon Europe, pour le développement des compétences en matière de RDTI, de transition industrielle et d'entrepreneuriat.

Zusammenfassung

Die Akteure im Bereich Forschung, technologische Entwicklung und Innovation (FTEI) sahen sich mit erheblichen Hindernissen und einer sich wandelnden, herausfordernden Landschaft konfrontiert, die einen maßgeschneiderten Ansatz zur Unterstützung erforderlich machte.

Aufbauend auf der Förderperiode 2007-2013 und der Lissabon-Strategie blieb die Unterstützung des Europäischen Fonds für regionale Entwicklung (EFRE) für FTEI ein Schlüsselelement des Programmplanungszeitraums 2014-2020. FTEI-Akteure in den EU-Regionen sahen sich weiterhin mit Hindernissen konfrontiert, die ihre Leistungsfähigkeit beeinträchtigten, darunter begrenzter Zugang zu Finanzmitteln, Netzwerken, Fachkräften, institutionelle Beschränkungen sowie die Abhängigkeit von externen Märkten. Private FTEI-Investitionen und Beziehungen zwischen Industrie und Wissenschaft, Technologietransfer und Ausgründungen gehörten 2014 zu den größten Schwachstellen der regionalen Innovationssysteme, gefolgt von Schwächen im Zusammenhang mit der Vermarktung von Innovationen und öffentlichen FTEI-Investitionen. Aufgrund unterschiedlicher territorialer Gegebenheiten, darunter Unterschiede in der Qualität der Infrastruktur, der Verfügbarkeit von Fachkräften und komplexen regulatorischen Rahmenbedingungen, bestanden weiterhin regionale Disparitäten, die zu ungleichen Forschungs- und Innovationsergebnissen und potenziellen Entwicklungsfallen führten.

Der Zeitraum zwischen 2014 und 2020 war durch zwei bedeutende wirtschaftliche Ereignisse geprägt: die Erholung von der Finanzkrise 2008–2009 und das Auftreten einer neuen Krise, ausgelöst durch den Ausbruch der COVID-19-Pandemie im Jahr 2020. In diesem Zeitraum erforderten gesellschaftliche Herausforderungen, darunter die digitale und die grüne Wende, eine Anpassung und Neudefinition der Innovationspolitik. Strategien zur wirtschaftlichen Entwicklung gewannen bei der Planung und Umsetzung der operationellen Programme an Bedeutung. Diese Veränderung wurde durch die Notwendigkeit vorangetrieben, die allgemeine Wettbewerbsfähigkeit zu verbessern, was zum Teil auf die Verringerung der öffentlichen Mittel zurückzuführen war. Der neue Ansatz priorisierte die endogene Entwicklung und eine „ortsbezogene" Strategie, die die Bedeutung lokaler Kontexte und spezifischer regionaler Stärken für die Förderung von Innovation hervorhob. Konzepte wie die Strategien für intelligente Spezialisierung (S3) spielten eine zentrale Rolle, indem sie bestehende regionale Ressourcen nutzten, um neue Möglichkeiten zu erschließen, mit dem Ziel, die Ergebnisse der öffentlichen Finanzierung zu verbessern und langfristige Wettbewerbsvorteile zu sichern.

Die Programme des EFRE stellten im Zeitraum 2014-2020

Der EFRE leistete im Berichtszeitraum einen wesentlichen Beitrag zur Entwicklung der Forschungs-

59 Mrd. EUR zur Unterstützung von FTEI bereit.

und Innovationslandschaft der EU. Seine Hauptaufgabe bestand darin, FTEI zu stärken, insbesondere durch die Verbesserung der FTEI-Infrastruktur und die Förderung von Exzellenz in diesem Bereich. Außerdem hat er die Schaffung von Exzellenzzentren erleichtert und Unternehmensinvestitionen in FTEI gefördert. Darüber hinaus hat er versucht, Verbindungen und Synergien zwischen den verschiedenen Akteuren im Bereich FTEI herzustellen. Der EFRE wurde so konzipiert, dass er seine Unterstützung auf die spezifischen Bedürfnisse und Herausforderungen der lokalen Regionen und Gebiete zuschneidet, mit dem Ziel, Ungleichheiten zu verringern und ihre Leistung in Bezug auf Innovation, Produktivität und Wettbewerbsfähigkeit zu verbessern.

Im Zeitraum 2014-2020 stellte der EFRE 40 Mrd. EUR zur Verfügung, um die Leistungsfähigkeit der europäischen FTEI-Akteure zu verbessern. Zusammen mit der nationalen Kofinanzierung belief sich diese Zuweisung auf insgesamt 59 Mrd. EUR, was einen deutlichen Anstieg gegenüber dem vorangegangenen Programmplanungszeitraum darstellt. Die Verteilung der EFRE-Fördermittel für FTEI konzentrierte sich auf eine begrenzte Anzahl von Operationellen Programmen (OPs), wobei 85 % der gesamten förderfähigen Ausgaben auf 71 von 229 OPs entfielen. Insgesamt 14 OPs in 12 Mitgliedstaaten erhielten die Hälfte des geplanten EFRE-Mittel für FTEI, wobei weniger entwickelte Regionen 50 % der geplanten Gesamtausgaben erhielten. Der EFRE war auch eine wichtige Finanzierungsquelle für FTEI in den EU-13-Mitgliedstaaten. In den allermeisten Fällen waren die Absorptionsraten bis Ende 2023 positiv oder lagen über 90 %.

Der EFRE unterstützte in erster Linie Einzelbegünstigte durch nicht rückzahlbare Zuschüsse, wobei der Schwerpunkt auf Forschungsaktivitäten in Unternehmen und Kooperationsprojekten zwischen Wissenschaft und Industrie lag.

Für die Zwecke der Evaluierung wurden acht Arten von EFRE-Politikinstrumenten zur Stärkung von FTEI im Zeitraum 2014-2020 identifiziert. Zu diesen Politikinstrumenten gehörten Investitionen in die physische Infrastruktur (wie der Bau, die Aufrüstung und die Modernisierung von Einrichtungen sowie die Anschaffung von Ausrüstung für Tests und Validierungen), die Finanzierung von FTEI-Projekten (von der Frühphase bis zur angewandten Forschung) und weiche Unterstützung zur Schaffung einer FTEI-Kultur (wie die Förderung des Austauschs zwischen Forschungszentren, Universitäten und Unternehmen sowie Investitionen in den Kapazitätsaufbau). Von den acht identifizierten Politikinstrumenten wurde die Bereitstellung von Finanzmitteln für FTEI-Projekte am häufigsten genutzt. Im Vergleich dazu wurden Infrastrukturinvestitionen und weiche Unterstützung in geringerem Umfang eingesetzt. Der größte Teil der Ausgaben (ca. 39 %) entfiel auf Forschungsaktivitäten in Unternehmen, die nach wie vor eine Kernzielgruppe der EFRE-Förderung sind. Kooperationsprojekte zwischen

Wissenschaft und Industrie stellten mit fast 20 % das zweitgrößte Politikinstrument nach Ausgabenvolumen dar.

In weniger entwickelten Regionen wurde die Unterstützung auf Maßnahmen ausgerichtet, die direkt der FTEI in Unternehmen zugutekamen. Übergangsregionen stellten mehr Mittel für Infrastrukturinvestitionen im FTEI-Bereich bereit, während sich weiter entwickelte Regionen auf Technologietransfer und Kooperationsprojekte zwischen Wissenschaft und Industrie konzentrierten. Fast 75 % der Maßnahmen wurden an einzelne Begünstigte verteilt, vor allem an Unternehmen (40 %). Der Großteil der FTEI-Förderung (über 90 % der Gesamtausgaben) wurde in Form von nicht rückzahlbaren Zuschüssen gewährt. Nur 32 OPs mobilisierten bis Ende 2023 Finanzinstrumente in Höhe von 1,7 Mrd. EUR, die hauptsächlich zur Finanzierung von Unternehmen (KMU) verwendet wurden.

Regionale und nationale Strategien für intelligente Spezialisierung wurden in erheblichem Umfang genutzt, um die EFRE-Förderung für FTEI thematisch auf ausgewählte vorrangige Sektoren auszurichten.

Strategien für intelligente Spezialisierung (S3) waren ein zentraler strategischer Rahmen für die Ausrichtung der EFRE-Investitionen im Bereich Forschung, technologische Entwicklung und Innovation (FTEI) innerhalb der Regionen. Die Bewertung bestätigte, dass die dem S3-Paradigma innewohnende Ausrichtung (d. h. die Auswahl vorrangiger Bereiche) es den Verwaltungsbehörden ermöglicht hat, EFRE-Mittel auf vorab festgelegte Innovationsziele (einschließlich der sogenannten „transformativen Aktivitäten“ des S3-Paradigmas) zu konzentrieren. Im Zeitraum 2014-2020 standen rund 64 % der EFRE-FTEI-Maßnahmen thematisch im Einklang mit den S3-Prioritätsbereichen. Es wurden regionale Unterschiede festgestellt, wobei Übergangsregionen und weniger entwickelte Regionen eine größere thematische Übereinstimmung aufwiesen. Die meisten EFRE-Maßnahmen im Bereich FTEI, die mit der S3-Strategie in Einklang standen, konzentrierten sich auf bestimmte Themenbereiche, darunter Informations- und Kommunikationstechnologien (IKT) und Industrie 4.0, Gesundheit und Biowissenschaften sowie Agrar- und Ernährungswirtschaft und Bioökonomie. Die Einführung des S3-Rahmens erleichterte die Ausrichtung der Förderung in einer Weise, die zum Erfolg beitrug, wobei die effektivsten Verwaltungsbehörden die Investitionen auf die regionalen wirtschaftlichen und technologischen Profile abstimmten. Die regionalen S3 fungierten zwar effektiv als strategischer Rahmen für die Ausrichtung der Investitionen, ihr Erfolg hing jedoch von der angemessenen Anwendung der Priorisierungslogik ab. Allerdings gibt es noch Verbesserungsbedarf bei der Gestaltung der S3, insbesondere hinsichtlich ihrer Breite, Tiefe und Auswahl der thematischen Prioritäten. Darüber hinaus besteht Potenzial zur Verbesserung der

Gestaltung von S3-bezogenen Förderaufrufen. Um sicherzustellen, dass die Mittel optimal ausgeschöpft werden, sind diese Förderaufrufe in der Regel sehr allgemein gehalten, was letztlich der Priorisierungslogik der S3 zuwiderläuft.

Sowohl die vorgelagerten Synergien auf Projektebene als auch die nachgelagerten Synergien zwischen dem EFRE und dem Rahmenprogramm Horizont 2020 waren begrenzt...

Die Bewertung ergab eine hohe Kohärenz zwischen dem EFRE und Horizont 2020. Auf Ebene der EFRE-Programme wurden in 83 % der operationellen Programme Komplementaritäten zwischen den politischen Instrumenten von Horizont 2020 und dem EFRE zur Förderung von Forschungsaktivitäten an Hochschulen festgestellt. Ebenso wurden in 73 % bzw. 64 % der operationellen Programme Komplementaritäten zwischen den politischen Instrumenten des EFRE für gemeinsame F&E&I-Projekte von Wissenschaft und Industrie und Infrastrukturinvestitionen für die Forschung festgestellt. Darüber hinaus die Evaluierung ergab, dass etwa 10 % der EFRE-RTDI-Begünstigten auch Mittel aus Horizont 2020 erhielten. Die Mehrheit der doppelten Begünstigten befand sich in stärker entwickelten Regionen (71,4 %) und EU-14-Mitgliedstaaten (79,3 %). In Bezug auf vorgelagerte Synergien standen 17 % der von diesen Begünstigten durchgeführten EFRE-Projekte in direktem Zusammenhang mit dem Aufbau von FTEI-Kapazitäten, was darauf hindeutet, dass es noch ungenutztes Potenzial für vorgelagerte Synergien zwischen dem EFRE und Horizont 2020 gibt. Im Hinblick auf nachgelagerte Synergien identifizierte die Studie 840 durch EFRE-Mittel geförderte Innovationen, was 10,7 % der Gesamtzahl der im Innovationsradar bis Juni 2024 erfassten Innovationen entspricht. Davon befindet sich etwa die Hälfte noch in der Explorationsphase, und nur 1,2 % sind marktreif, was auf ein bescheidenes Ergebnis in Bezug auf den Innovationsumfang hindeutet. Dies deutet darauf hin, dass die EFRE-Förderung zwar durch den Aufbau auf früheren EU-geförderten Initiativen zu nachgelagerten Synergien beigetragen hat, diese Synergien jedoch nur in begrenztem Umfang vorhanden waren. Es fehlte an einer systematischen Verfolgung von vorgelagerten und nachgelagerten Synergien zwischen EFRE-Projekten und Projekten des Forschungs- und Innovationsrahmenprogramms. Die Haupthindernisse waren Missverständnisse hinsichtlich der Kompatibilität der beiden Programme, Unterschiede in ihrem Umfang und ihren Zielen sowie der Verwaltungsaufwand für die gleichzeitige Verwaltung beider Finanzierungsströme.

…sowie den Einsatz von Finanzinstrumenten zur Unterstützung von FTEI.

Bis Ende 2023 hatten nur 32 von 229 OPs Finanzinstrumente mit einer Gesamtinvestition von 1,7 Mrd. EUR mobilisiert. Finanzinstrumente wurden hauptsächlich zur Finanzierung von Unternehmen (KMU) eingesetzt und dienten der indirekten Unterstützung von Technologietransfer, Forschungsaktivitäten in Unternehmen und

Unternehmensinvestitionen zur Förderung der Innovationsaufnahme. In einem Umfeld, in dem die Umsetzung von Finanzinstrumenten schwierig war (zunächst niedrige Zinssätze und anschließend die COVID-19-Pandemie), waren Zuschüsse die vorherrschende Form der Bereitstellung. Trotz der Schwierigkeiten bei der Umsetzung haben Finanzinstrumente ein erhebliches Potenzial zur Unterstützung der Phase der Wissensverwertung. Daher sollte die nächste Bewertung der Frage der Finanzierung während des gesamten Innovationslebenszyklus angemessene Aufmerksamkeit widmen.

Die Auszahlung der Zuschüsse aus dem EFRE für FTEI verlief reibungslos, obwohl im Zusammenhang mit Forschungsinfrastrukturprojekten einige Herausforderungen zu bewältigen waren.

Während des Programmplanungszeitraums 2014-2020 wurden erhebliche Anstrengungen unternommen, um die Effizienz der EFRE-Förderung zu verbessern, indem Probleme aus dem vorangegangenen Zeitraum, wie beispielsweise die Vorschriften für staatliche Beihilfen, durch Initiativen wie den Aktionsplan COMP-REGIO für staatliche Beihilfen angegangen wurden, der darauf abzielte, die Verwaltungskapazitäten zu stärken und die Rechtsvorschriften zu präzisieren. Trotz einer relativ hohen durchschnittlichen Abschlussquote von 85 % bei sieben von acht politischen Instrumenten kam es bei Infrastrukturprojekten aufgrund der Auswirkungen der COVID-19-Pandemie und des Krieges in der Ukraine zu Verzögerungen. Die Bewertung ergab, dass erfahrene Verwaltungsbehörden und Begünstigte sich positiv auf die Projektergebnisse auswirkten, während Unerfahrenheit zu Komplikationen und Verzögerungen führte. Kontextfaktoren wie klar definierte langfristige Strategien und verfügbare Fachkräfte waren für eine erfolgreiche Umsetzung von entscheidender Bedeutung, obwohl Probleme wie Vorschriften für die Vergabe öffentlicher Aufträge und begrenzte Flexibilität bei Projektänderungen Hindernisse darstellten.

Der EFRE spielte eine wesentliche Rolle bei der Förderung der Wissensproduktion...

Die EFRE-Investitionen in FTEI trugen maßgeblich zur Generierung und Verbreitung neuen Wissens bei. Dies belegen mehr als 138.000 wissenschaftliche Veröffentlichungen in renommierten Fachzeitschriften, in denen die Rolle des EFRE bei ihrer Entstehung im Zeitraum 2014-2020 gewürdigt wird. Fast 79.000 dieser Veröffentlichungen sind das Ergebnis von Aktivitäten, die von Begünstigten von aus dem EFRE finanzierten FTEI-Projekten durchgeführt wurden. Ein größerer Teil dieser Veröffentlichungen konzentrierte sich auf die EU-14 (74 %) und stand im Zusammenhang mit EFRE-FTEI-Begünstigten in stärker entwickelten Regionen (57 %), gefolgt von weniger entwickelten Regionen (34 %) oder Regionen im Übergang (9 %).

Die meisten der identifizierten Veröffentlichungen befassten sich mit Themen aus dem Bereich der Mathematik, Informatik, Naturwissenschaft und Technik (MINT). Bei diesen Themen gab es keine signifikanten Unterschiede zwischen den verschiedenen Regionen,

was auf eine starke Konzentration auf Disziplinen hindeutet, die direkt zum wissenschaftlichen und/oder technologischen Fortschritt beitragen. Die identifizierten Veröffentlichungen standen in erster Linie im Zusammenhang mit der Zusammenarbeit zwischen Wissenschaft und Industrie, Aktivitäten von Universitäten und Forschungszentren sowie Investitionen in Forschungsinfrastrukturen, die zu einer erheblichen Anzahl von Veröffentlichungen in allen Regionen führten. Die Mehrheit der Veröffentlichungen aus wirtschaftsbezogenen Forschungsaktivitäten stammte jedoch aus stärker entwickelten Ländern.

…und bei der Förderung regionaler Kooperationen zwischen Wissenschaft und Industrie.

Die Unterstützung durch den EFRE im FTEI-Bereich erleichterte den Wissensaustausch und die Bildung regionaler Partnerschaften, vor allem durch FTEI-Projekte, die auf der Zusammenarbeit zwischen Wissenschaft und Industrie basieren und das zweitgrößte FTEI-Politikinstrument darstellen. Den Indikatoren aus dem Monitoring zufolge wurden bis Ende 2022 mehr als 75.500 Unternehmen in Zusammenarbeit mit Forschungseinrichtungen durch EFRE-Instrumente unterstützt, womit der Zielwert um 115 % übertroffen wurde. Die meisten Veröffentlichungen der Begünstigten von EFRE-FTEI-Fördermitteln zwischen 2016 und 2023 (60.000) stammten aus FTEI-Kooperationsprojekten zwischen Wissenschaft und Industrie, unabhängig von der Art der Region.

Der EFRE hat positiv zum technologischen Fortschritt der EU beigetragen.

Der EFRE hat mit über 7.000 registrierten Patenten, die auf dem durch die EFRE-Förderung im Bereich FTEI generierten Wissen aufbauen, einen bedeutenden Beitrag zum technologischen Fortschritt der EU-Regionen geleistet. Die für diese Evaluierung erhobenen Daten auf Mikroebene zeigten, dass pro Kopf die meisten dieser Patente, die auf durch die EFRE-Förderung im Bereich FTEI generiertes Wissen zurückzuführen sind, in Westeuropa (insbesondere in Portugal und den Niederlanden), Nordeuropa (insbesondere Dänemark und Finnland) sowie Estland zu verzeichnen waren. Fast 50 % dieser Patentanmeldungen bezogen sich auf den breiten Bereich der „menschlichen Grundbedürfnisse“, der eine Vielzahl von Technologien umfasst, die einen direkten Einfluss auf das tägliche Leben der Menschen haben. Umgekehrt standen 45 % dieser Patentanmeldungen in direktem Zusammenhang mit MINT-Bereichen, darunter Chemie, Metallurgie, Physik und Elektrizität.

Der Erfolg der EFRE-Förderung hing von ihrer strategischen Ausrichtung auf nationale und regionale FTEI-Rahmenbedingungen ab.

Die Ergebnisse der vom EFRE unterstützten Politikinstrumente für FTEI sind sehr positiv. Der Erfolg der FTEI-Förderung hing von einer transparenten, langfristigen Strategie sowohl auf regionaler als auch auf Ebene der Begünstigten ab, wobei die effektive Integration der entwickelten Infrastruktur in strategische Pläne von größter Bedeutung war. Die Evaluierung unterstreicht die Bedeutung der regionalen und

nationalen Abstimmung, der Schaffung von Synergien zwischen den Finanzierungsquellen und des Einsatzes einer Vielzahl von Finanzierungsinstrumenten zur Optimierung der Ressourcen. Die Wirksamkeit der EFRE-unterstützten Maßnahmen wurde jedoch durch komplexe Verwaltungsverfahren, Personalmangel und Verzögerungen aufgrund der Auswirkungen der COVID-19-Pandemie beeinträchtigt.

Der EFRE erleichterte die strategische Planung und die langfristige Bindung von FTEI-Mitteln in allen untersuchten EU-Gebieten.

Der EFRE ermöglichte es den Verwaltungsbehörden, strategische Pläne zu formulieren, die über die Grenzen von Wahlzyklen hinausgehen, und so FTEI-Mittel langfristig zu binden. Die Verwaltungsbehörden in weniger entwickelten Regionen bezeichneten den Umfang der EU-Unterstützung als den wertvollsten Aspekt und wiesen darauf hin, dass Projekte dieser Größenordnung ohne diese Unterstützung nicht möglich gewesen wären. Der Mehrwert des EFRE war besonders deutlich in Regionen mit knappen finanziellen Mitteln, wo er oft die wichtigste Finanzierungsquelle darstellte. Dies war auch der Fall, wenn hohe Kofinanzierungssätze erforderlich waren, beispielsweise für Infrastrukturprojekte in den EU-13-Regionen. Der EFRE ermöglichte zwar eine strategische Planung und förderte die Zusammenarbeit, es gab jedoch kaum Anhaltspunkte dafür, dass lokale Entscheidungsträger/-innen diese Unterstützung für die Umsetzung innovativer politischer Maßnahmen wie experimenteller Ansätze oder der Einbeziehung von Anspruchsgruppen nutzten.

Es ist noch nicht klar, inwieweit die vom EFRE unterstützten FTEI-Instrumente zu systemischen Effekten wie der Verbesserung der regionalen Wettbewerbsfähigkeit und der Förderung der Konvergenz beigetragen haben. Diese Unsicherheit ist nicht nur auf das Vorhandensein mehrerer externer Faktoren und die Tatsache zurückzuführen, dass einige Effekte erst langfristig sichtbar werden. Systemische Effekte wurden auch durch die begrenzten Synergien zwischen verschiedenen Instrumenten und Fördermöglichkeiten auf regionaler, nationaler und EU-Ebene eingeschränkt.

Die wichtigsten Erkenntnisse unterstreichen die Notwendigkeit, die Ausrichtung über S3 voranzutreiben, die synergetische RTDI-Finanzierung in allen EU-Regionen zu erhöhen, die Zusammenarbeit zu fördern und für ausreichende Fachkräfte und Kompetenzen zu sorgen.

Die Bewertung unterstreicht die Notwendigkeit einer systemischen Transformation und einer stärkeren Ausrichtung der künftigen EFRE-Förderung für FTEI, die durch die Stärkung der S3-Grundsätze erreicht werden muss. Die Ergebnisse zeigen, dass das S3-Paradigma, insbesondere seine Konzentration auf vorrangige Bereiche, die Verwaltungsbehörden wirksam dabei unterstützt hat, die EFRE-Mittel auf vorab festgelegte Innovationsziele oder „transformative Aktivitäten“ auszurichten. Um die Wirksamkeit weiter zu verbessern, sollte dieser Ansatz mit erhöhten FTEI-Investitionen in allen Regionen und strategischen politischen Reformen kombiniert werden, um die Lücke der FTEI-Intensität der EU gegenüber ihren Hauptkonkurrenten zu verringern.

Es ist auch von entscheidender Bedeutung, die Koordinierung und Angleichung. Erreicht werden könnte dies in den Regionen beispielsweise durch eine zentralisierte Verwaltung innerhalb spezialisierter Agenturen und/oder die Einrichtung spezieller Strukturen zur Überwachung zentraler EU-Programme wie „Horizont Europa“, wobei Doppelungen nationaler Strukturen vermieden werden sollten.

Die weitere Stärkung der Zusammenarbeit der FTEI-Akteure in der gesamten EU ist ebenfalls von entscheidender Bedeutung für die Steigerung der Wettbewerbsfähigkeit und des technologischen Fortschritts Europas, wobei die Initiative „Interregional Innovation Investments (I3)“ und andere aktuelle Initiativen für den Zeitraum 2021-2027 vielversprechende Lösungen bieten. Zu den wichtigsten Überlegungen für die Zukunft gehören die Stärkung und Förderung bestehender Netzwerke und Plattformen, die Verbesserung des Technologietransfers und des Managements geistigen Eigentums durch besser ausgestattete Technology Transfer Offices sowie die Diversifizierung der Kooperationsformate. Außerdem ist es von entscheidender Bedeutung, dass künftige politische Maßnahmen darauf ausgerichtet sind, Talente zu halten und anzuziehen. Initiativen wie die Plattform „Harnessing Talent“ sollten ebenso ausgebaut werden wie öffentlich-private Partnerschaften und die Möglichkeit, Mittel aus dem EFRE, dem ESF und, soweit möglich, aus dem Programm „Horizont Europa“ für die Entwicklung von Kompetenzen in den Bereichen Forschung, technologische Entwicklung und Innovation, industrieller Wandel und Unternehmertum zu kombinieren.

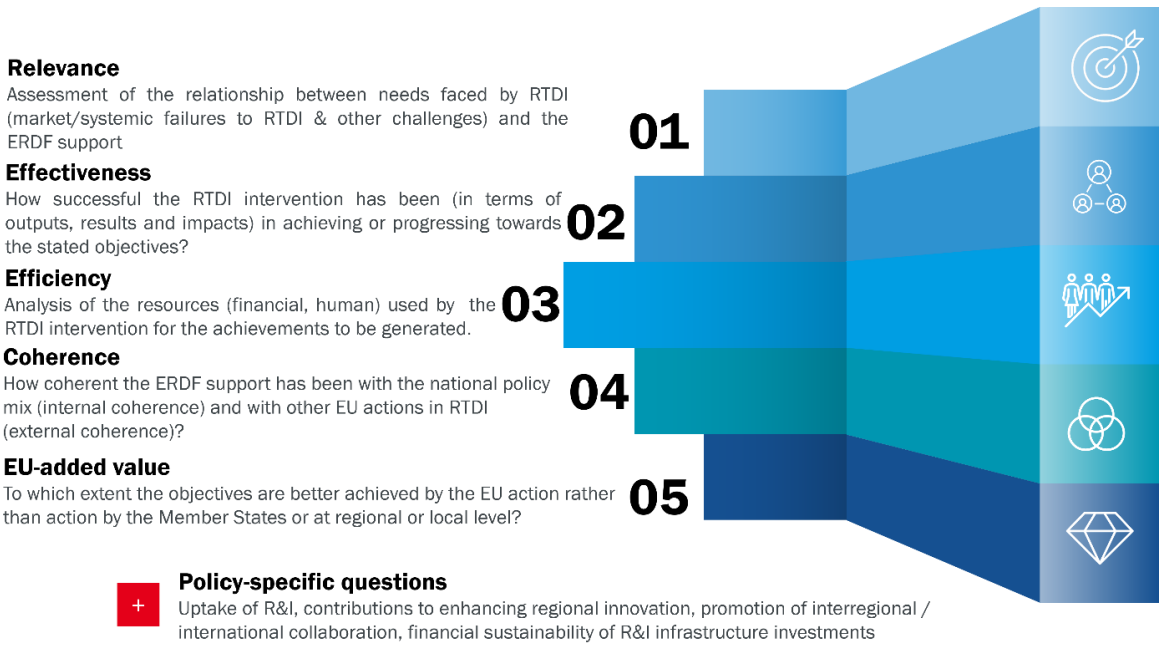
1. Introduction

1.1. Objective and scope of the study

The "**Ex post evaluation of Cohesion Policy programmes 2014-2020 financed by the ERDF: Work package 4 – Research, Technological Development and Innovation**" is part of a comprehensive exercise of ex-post evaluations of European Regional Development Fund (ERDF) and Cohesion Fund (CF) initiated by the European Commission - DG REGIO in 2022. It takes place in the context of the Commission's efforts to fulfil commitments in terms of transparency and accountability and to foster evidence-based and result-oriented policymaking.

The evaluation is designed to provide a robust evidence base on the effects of ERDF support for Research, Technological Development and Innovation (RTDI) over the period 2014-2020. Unless explicitly stated otherwise, only regions in the EU27 Member States are included in the analysis. In alignment with the European Commission's Better Regulation Guidelines, the study assesses the **relevance, effectiveness, efficiency, coherence with other policies and EU-added value** of RTDI support measures co-financed by the ERDF for the period 2014-2020 (**Error! Reference source not found.**). The full list of evaluation questions is provided in Annex I. Furthermore, it identifies the linkages and synergies with the S3 strategy, as well as the success factors and good practices that have an impact on growth, sustainability, and job creation in different socio-economic contexts. The outcome of the evaluation study is of strategic importance for the future orientation of Cohesion Policy in the long-term budget of the EU, the Multiannual Financial Framework, in particular for the post-27 period.

Figure 1. Evaluation criteria and policy-specific questions



Source: Prognos / CSIL / Visionary Analytics (2024). The full list by Terms of Reference is in Annex I.

In contrast to previous evaluations, which primarily focused on programmes, **this evaluation examines specific policy instruments mobilised by the national and regional programmes.** This approach allows us to gain deeper insight into the mechanisms through which these instruments operate, identifying their relevance, effectiveness, efficiency, coherence, and EU added value. By doing so, it is possible to

better gauge how these instruments contribute to the achievement of overarching objectives and the overall success of the programmes they support.

The ERDF funding supporting RTDI is categorised into eleven Fields of Intervention (FoIs)[1], as shown in the figure below. However, the classification of spending across FoIs by Managing Authorities is somewhat discretionary and may be subject to various interpretations. This is in accordance with the recommendations set out in the "Report on the clustering of operations and beneficiaries" prepared in the context of Work Package 2 – Preparatory Study.[2] In response, the evaluation team has examined all of the funded operations included in the database assembled during the Preparatory Study[3] and categorised them into a coherent set of policy instruments.[4] This typology transcends the mere administrative classification of expenditures and instead identifies **policy instruments** that are **defined as a consistent set of activities towards a policy goal**, i.e., addressing the same market/systemic failures and challenges and having the same expected impact(s). To be considered a coherent policy instrument, it must be internally coherent, but also sufficiently broad to encompass interventions across EU regions and Member States. It is assumed that the same policy instrument can be delivered in different ways (e.g., through direct support to final beneficiaries – universities, research centres, enterprises – or through an intermediary organisation), or via different forms of finance.[5] In the context of RTDI, **the type of final beneficiaries** (i.e., universities/research centres vs. enterprises) are a crucial factor in differentiating among policy instruments, as it is often linked to the expected outcomes.

Figure 2. 11 Fields of Interventions (FoIs) in the scope of the evaluation

Source: Prognos / CSIL / Visionary Analytics (2024).

[1] The Field of Intervention is one of the categories of intervention according to which ERDF, ESF and Cohesion Fund operations should be classified by the Managing Authority, as specified in Article 8 of the Regulation (EU) No 215/2014. For ERDF operations, it identifies the type of investment involved. The Regulation identifies a total of 123 distinct Fields of Intervention, but not all fields can be used in the context of ERDF operations. The latter can be categorised in the fields 1-101, 102-121 (only in the case they fall under the European territorial cooperation (ETC) goal and 121-123 in the case of Technical Assistance operations. The other categories listed in Annex I of the aforementioned Regulation, according to which operations are to be classified, are the Form of Finance, the Territory Type, the Territorial Delivery Mechanism, the Thematic Objective, the Economic Activity and the Location.

[2] See https://ec.europa.eu/regional_policy/sources/policy/evaluations/ec/2014-2020/wp2_report_on_clustering_final.pdf

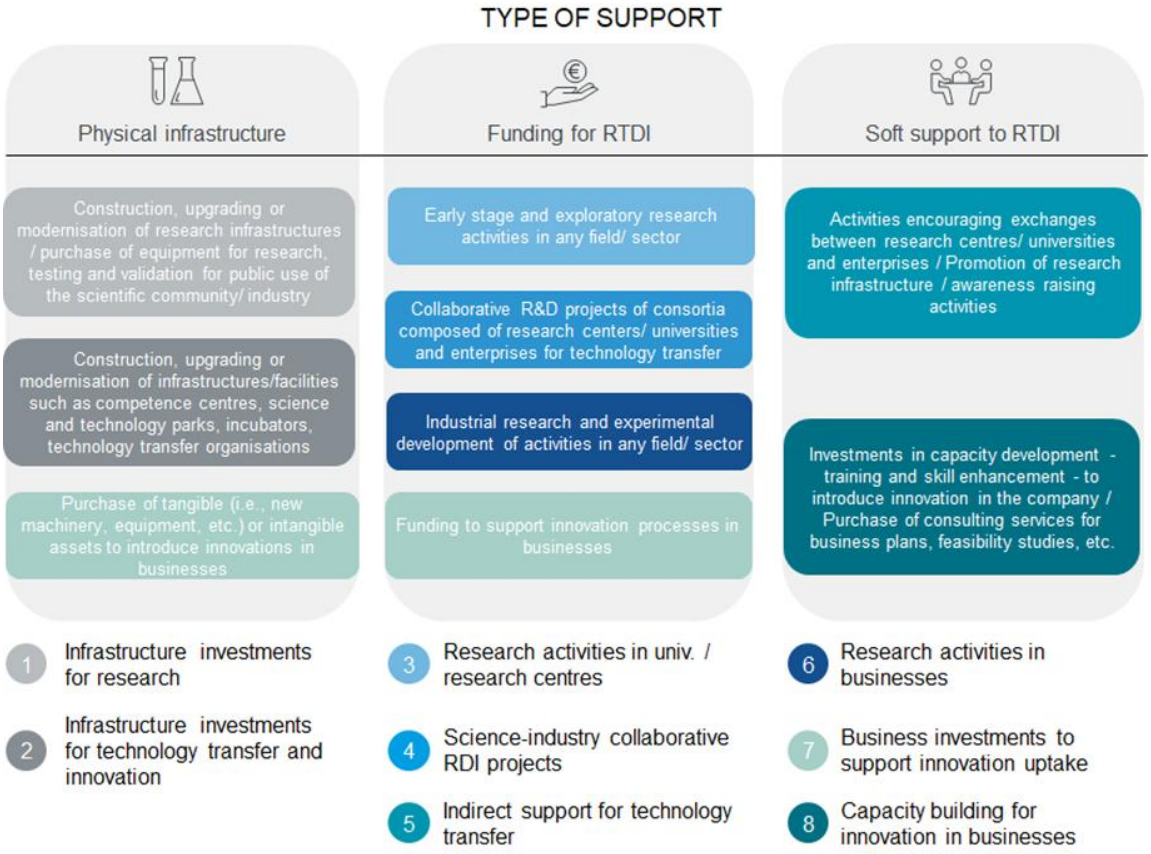
[3] The database covers 215 national and regional programmes co-financed by ERDF and/or CF and 73 programmes for territorial cooperations co-financed during the 2014-2020 period, across the 11 Thematic Objectives, with a cut-off date that ranges from the end of December 2020 for most programmes to July 2021. A more detailed description of the database is provided in the "Report on the Single Database" and the "Cohesion Open Data story presenting the "Single database" on 2014-2020 operations monitoring".

[4] See Annex III for more details on the methodology applied to categorise operations into policy instruments.

[5] The mode of delivery and the form of finance were not considered as main criteria to discriminate across policy instruments, also due to a small share of financial instruments.

The taxonomy developed in this report comprises eight specific policy instruments (PIs), each one associated with a particular Theory of Change (ToC). The identified policy instruments encompass three categories of support: support for the development or modernisation of physical infrastructure, funding for research, technology development or innovation activities, and soft support. The taxonomy is illustrated in the figure below.

Figure 3. Taxonomy of ERDF policy instruments for RTDI support 2014-2020



Source: Prognos / CSIL / Visionary Analytics (2024).

The total value of expenditure planned to support RTDI in the 2014-2020 programming period (in the above mentioned 11 FoIs) as of the end of 2023 amounts to **EUR 59 billion, of which EUR 40 billion is covered by ERDF resources**.[6] The largest proportion (38.58%) of this expenditure was allocated to supporting research activities within businesses, including both SMEs and large companies (PI6). Collaborative projects involving universities or research organisations and businesses (PI4) represented the second-largest policy instrument by expenditure (19.72%). Infrastructure investments for research (PI1) made up 13.12% of the total expenditure. In total, projects falling under the aforementioned policy instruments accounted for 72% of the total expenditure in 2020.

[6] Figures based on ESIF 2014-2020 categorisation ERDF-ESF-CF planned vs implemented considering the variable "Planned_Total_Amount_(Notional)" and "EU_amount_planned" and the year 2023.

1.2. Methodology

1.2.1. Theory-based impact evaluation

The proposed methodological approach stems from the ambition to build a theory-based impact evaluation in the specific context of RTDI activities. In particular, the role of the "theory" behind the supported interventions (i.e. the overall rationale and expected preconditions. enablers and risks) was the starting point informing all the evaluation activities, from the literature review to the projects and beneficiary mapping until the case studies and the quantitative analysis. In this way, the study sought to go beyond the mere assessment of what had occurred (i.e., the direct effects of the ERDF support for RTDI) and attempted to provide answers regarding the underlying causes and mechanisms that led to the observed effects.

For the assessment of the degree of effectiveness of selected policy instruments, the evaluation employed a **Theory-based Impact Evaluation (TBIE) approach**.[7] This entailed initially reconstructing the Theory of Change (ToC) underlying the public intervention, whether at the programme or policy instrument level. This process involved identifying the articulated set of assumptions regarding how, why, when, for whom, to what extent, and under what conditions an intervention would lead or contribute to expected or unexpected, desired or undesired results within a given context. Subsequently, the initial theory, reflecting the intentions and expectations (both explicit and implicit) of policymakers and programme designers, was subjected to empirical testing to determine whether the ex-ante rationale for the implementation details of the different support measures held true. The evaluation also aimed to identify any unanticipated mechanisms through which the interventions achieved positive or negative unexpected results and to ascertain whether the policy instrument causally determined or at least contributed to the actual results.

1.2.2. Mixed methods analytical approach

In order to answer the different evaluation questions and properly apply the theory-based impact evaluation approach, the evaluation study collected and analysed both qualitative and quantitative data. On the one hand, qualitative evidence is necessary to outline, for instance, the rationales of EU policy interventions in the programming documents. On the other hand, quantitative evidence is used to provide robust evidence to address the evaluation questions. Given the complex and ambitious nature of this evaluation and the diversity of effects expected by the various policy instruments and by the same policy instrument used in different contexts, **mixed methods and triangulation of data sources were used to perform the analysis of the findings**. This evaluation was guided by a set of **evaluation questions** corresponding to several evaluation criteria (see ANNEX I). Over a period of 18 months, the study employed a number of different methodological tools to collect and analyse a variety of evidence in both a qualitative and a quantitative form. Specifically, the evaluation draws from the following tools for data collection and tools for data analysis:

Tools for data collection:

- A **documentary analysis** was carried out on programming and implementation documents with the objective of achieving a comprehensive understanding of the rationales underlying the programmes and the variety of policy instruments utilised in different contexts. The review of the aforementioned documents was conducted with regard to **a sample of 57 ERDF programmes**, representing 82% of the total

[7] Currently, theory-based evaluation is cited among the preferred tools for conducting impact analysis in the monitoring and evaluation guidelines for the European Structural and Investment Funds by the European Commission (see European Commission 2013a). See Stern et al. (2012) and Stern (2015) for more details on this methodological approach.

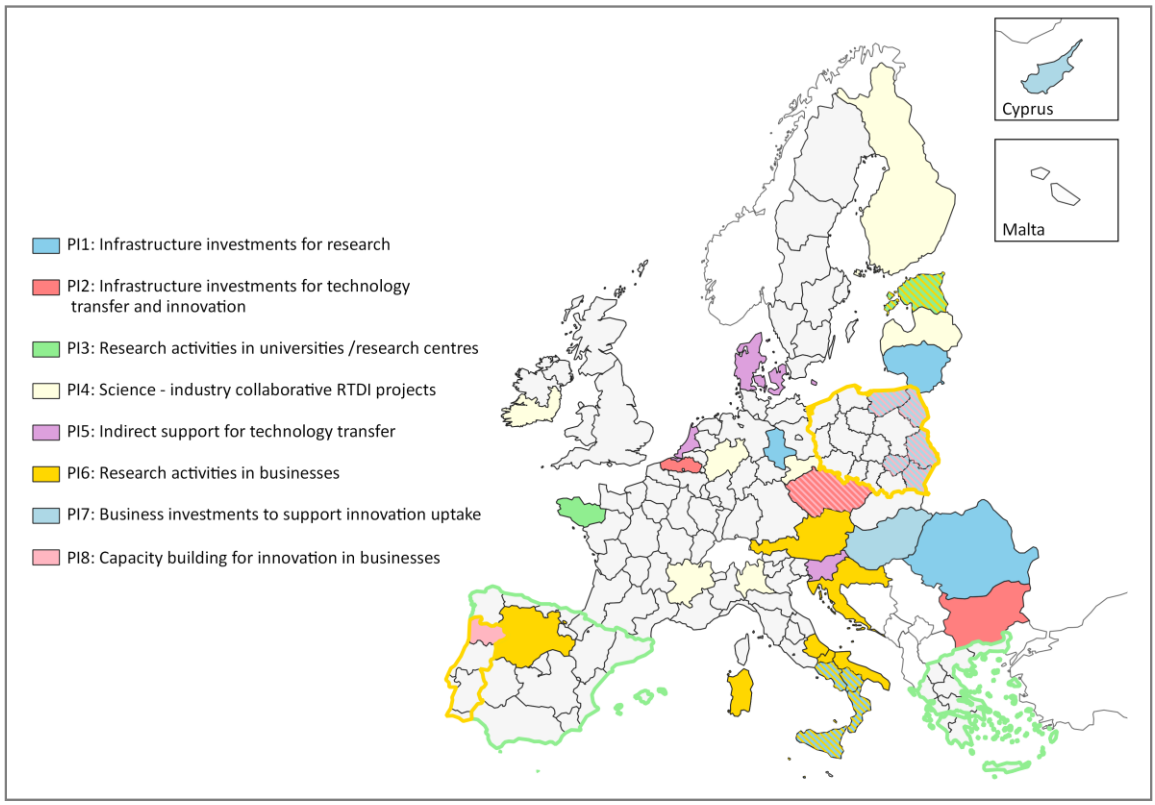
expenditure and 84% of the total EU contribution to RTDI interventions during the 2014-2020 period. The programmes in question spanned all Member States and the United Kingdom, thereby ensuring a robust geographical representation across national, multiregional, or regional programmes. These encompassed more developed, less developed, and transition regions. Furthermore, project calls, guidelines for applications and other documents were reviewed when conducting the in-depth analysis of selected examples of policy instruments.

- An **extensive literature review** was conducted to develop a robust evaluation framework and build upon previous research and evaluations, including those conducted at the regional and Member State levels. A **total of 350 documents** were examined to assess the extent and manner in which public support, including ERDF, can enhance research and innovation. The insights from the literature review were integrated into all evaluation deliverables, ranging from the First Intermediate Report to the policy instrument case studies.

Eight case studies were conducted at the regional and Member State (MS) levels to test theories about the implemented policy instruments. The aim was to collect evidence on observed outputs, outcomes, and the conditions for their materialisation. The examination extended to 34 specific interventions across 23 Member States (see the coverage of case studies in

- Figure 4.). Primary evidence was collected through **283 semi-structured interviews** with stakeholders from a diverse range of backgrounds. Beneficiaries were the focus of 185 interviews, representing 65% of the total.

Figure 4. Map of selected case studies and policy instruments



Source: Prognos / CSIL / Visionary Analytics (2024). Note: Shaded regions indicate that the regions are covered in multiple case studies.

- A **cross-case analysis of financial instruments** that sheds light on the various reasons for using financial instruments in support of RTDI.
- **A stakeholder seminar** was held in Brussels on 23 April 2024, with 173 participants in attendance, including 56 on-site attendees and 117 online participants. The seminar was conducted in a hybrid format, with representatives from the European Commission, Managing Authorities, academic and country experts, and other relevant parties present. The objective of the seminar was to discuss the preliminary evidence collected by the study, with the aim of providing an initial summary and interpretation of the body of evidence collected.

Tools for data analysis:

- **Descriptive statistical analysis** of data on operations and beneficiaries for ERDF support to RTDI was performed to provide an accurate description of where ERDF expenditure was allocated.[8]
- **Novel quantitative explorations, utilising artificial intelligence (AI)**, were employed to analyse a multitude of datasets to gain new insights into the outcomes and early impacts of the ERDF RTDI support. A more detailed description of these can be found in the Box below and Annex IV.

Box 1. Novel AI-based explorations

Word embedding is a technique employed in the field of natural language processing, whereby terms are transformed into a vector representation that encodes the meaning of the word. Terms that are close to each other in vector spaces are expected to have a similar meaning. **This approach was used in the study to assess the alignment of RTDI investments made under the ERDF 2014-2020 with the respective Smart Specialisation Strategies.**

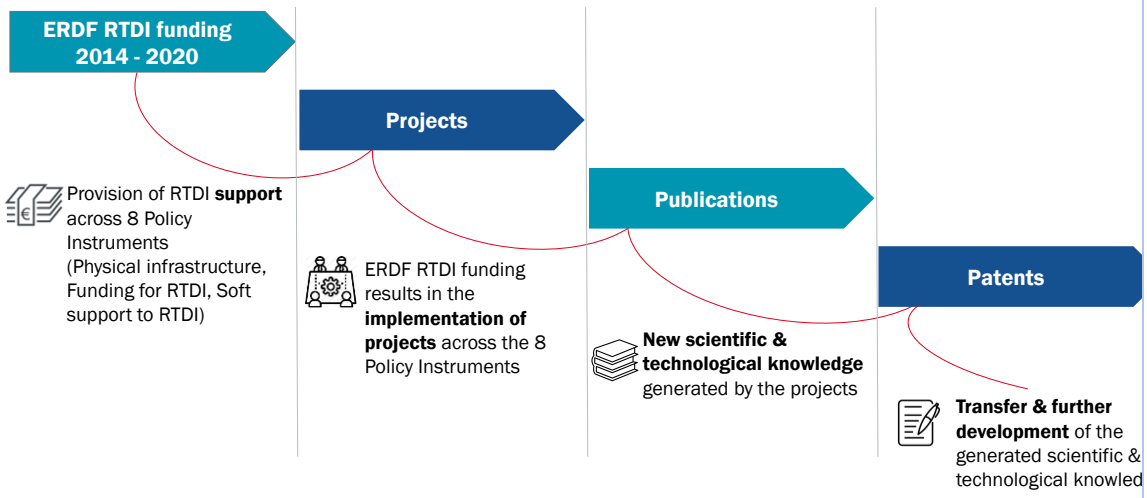
Approximate String Matching is an algorithmic approach that enables the identification of strings that are similar but not identical. This technique was employed for a novel assessment of funding synergies, downstream and upstream effects. More specifically, **this technique was applied to link beneficiaries of ERDF RTDI support 2014-2020 with beneficiaries of H2020 funding and innovative projects supported by various funding sources indicated by the Innovation Radar.**

Large Language Models (LLMs) are a type of AI-based algorithm. They are based on machine learning techniques and are trained on large amounts of data. As such, LLMs can also be understood as a condensed knowledge repository that is based on a large variety of sources (websites, publications, news articles, etc.). A novel exercise was carried out through the application of LLM in a multi-step approach to identify publications linked to the ERDF RTDI support between 2014 and 2020 (including their scientific impact) and to further trace these publications to patents. **This approach allowed for the tracing of knowledge generated by the ERDF RTDI support from projects over publications to patents (see** also **Figure 5.)**. This state-of-the-art approach identified (both unstructured and structured) references in the patents to non-patent literature. As a result, the extent to which the ERDF RTDI support in the 2014-2020 programming period has led to the generation and dissemination of knowledge and the uptake of innovation can be traced.

[8] Data on ERDF operations and beneficiaries was collected under Work Package 2 – Preparatory Study and presented in the Report on the Single Database (Deliverables 2+ 3).

As an additional exercise, a novel impact tracing approach based on a LLM was applied that allows to **find traces of the funded ERDF RTDI projects online** and calculate the probability that the ERDF RTDI projects were used in products.

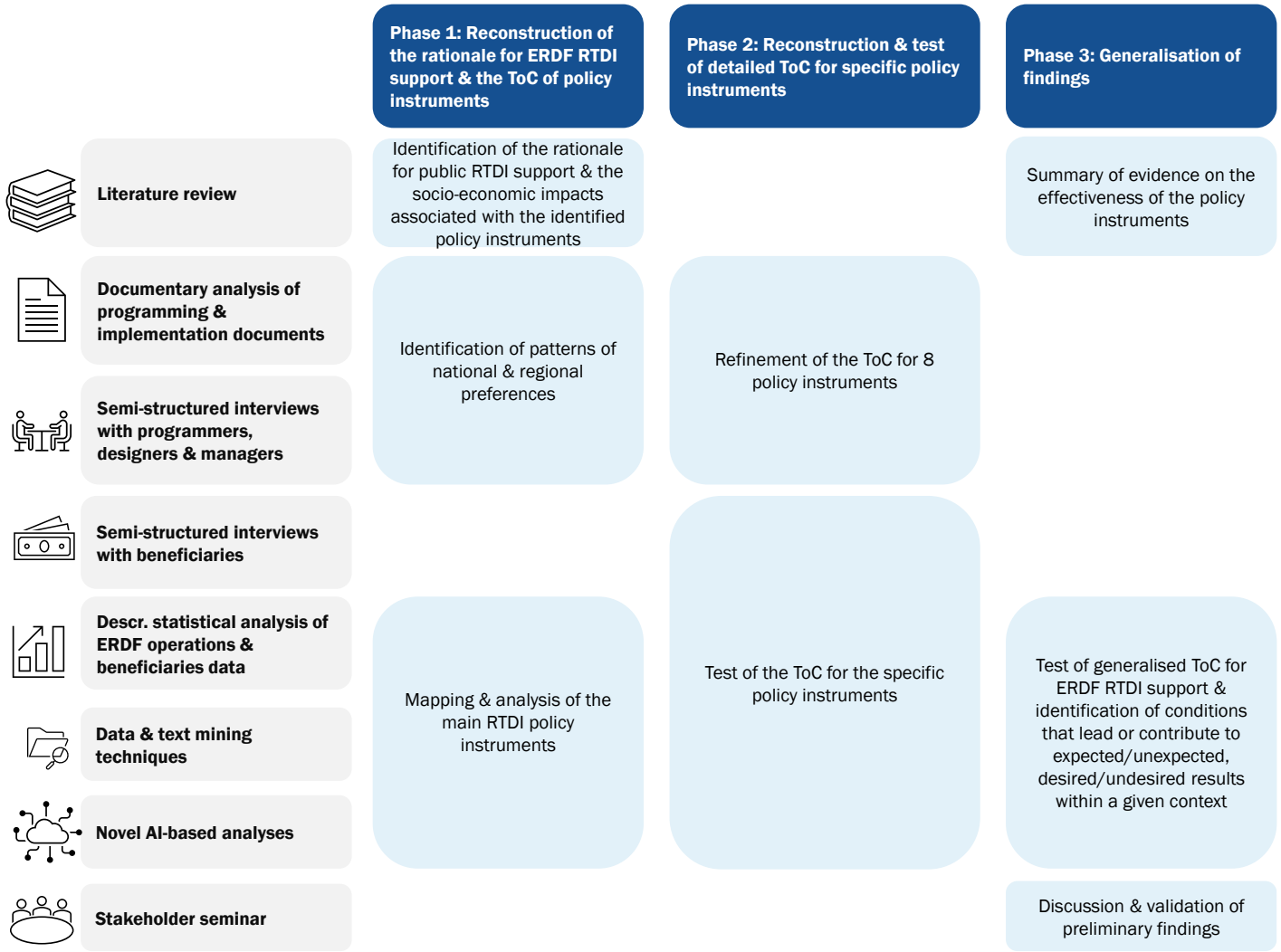
Figure 5. Schematic overview of tracing knowledge generated by the ERDF RTDI support from projects to patents



Source: Prognos / CSIL / Visionary Analytics (2024).

The combination of different methods was instrumental in collecting a comprehensive set of evidence. Figure 6. shows an overview of the methodological framework and how it was used to triangulate and generalize the findings from the different data sources and analyses. As indicated in the figure, the **process of triangulation is essential for deepening the understanding of the theory of policy support for RTDI by combining multiple perspectives, theories, and data sources; validating /corroborating findings by cross-checking data collected through different methods and from different sources**; and reducing bias that may be intrinsic to specific methodological approaches. The interconnection of the different evidence generated in this study was built at a sequential level, building on the evidence gained from the previous step and expanding in the directions indicated by the evaluation questions. While some analysis methods were selected because of their appropriateness in answering some of the evaluation questions (case studies, cross-case analysis), others were necessary as a starting point for further analysis (mapping of projects and beneficiaries, literature review, analysis of OP strategies). The overall logic went from a general overview to the specific assessment of individual cases, then expanded to a more general level.

Figure 6. Overview of the methodological framework



Source: Prognos / CSIL / Visionary Analytics (2024).

1.2.3. Methodological robustness and limitations

This section will examine the methodological robustness of the study, discussing the strengths that lend credibility to the findings and the limitations that must be considered when interpreting the results. The methodological design of this evaluation displays a number of notable strengths:

- **Comprehensive evaluation coverage**. This approach ensures a comprehensive understanding of the relevance, coherence, effectiveness, efficiency and EU added value of ERDF funding for RTDI across various contexts and regions. The case studies on all RTDI policy instruments were based on insights from 34 in-depth country investigations across 23 Member States. Total eligible costs of OPs included in the case studies amount to more than EUR 43 billion (57%) with eligible costs of EUR 33 billion (61%). The same policy instrument was analysed across at least three different Member States, as shown in the figure above. The selection was made to allow comparison of the same policy instrument implemented across different contexts, in terms of size, geographical location, level of development, and other relevant context characteristics
- **Depth of the evaluation**. The case studies gathered and analysed a vast array of data and information, encompassing not only the broader context and programmes but also specific calls and documents associated with the analysed policy instruments. This meticulous approach enabled the evaluation team to delve deeply into the design, implementation, and effects of individual policy instruments, thus refining their comprehension of the intervention logic, resulting effects, and, particularly, causal relationships. This depth of analysis is crucial as it provides a comprehensive understanding of the complexities involved, yielding insights into the nuanced mechanisms driving the observed outcomes and enhancing the robustness of the evaluation findings.
- **Systematic assessment approach.** A consistent methodological approach and reporting framework were employed for the analysis of all programmes and for each case study of a policy instrument. While some flexibility was permitted in order to accommodate variations in data availability and the specificities of the policy instruments under evaluation, the standardised framework ensured that the main findings could be read, understood, and compared horizontally across different programmes and policy instruments in a consistent, comparable, and thorough manner.

Despite the substantial quantity of data and evidence gathered through the evaluation process, several limitations remain. Among the most noteworthy limitations are the following:

- **Time lag of effects**. The staggered start of policy instruments resulted in the observation of impacts at different times, particularly pronounced for those launched late in the programming period. The limited number of completed operations posed a challenge to the representativeness of measured effects. Furthermore, in cases where operations were only recently completed, assessing beneficiary performance two to three years after ERDF support was not feasible.
- **Uneven data availability and/ or poor quality of some beneficiary data (duplication or missing data).** Variations in data availability on beneficiaries led to reliance on different types of evidence across case studies. Because of this, it was not always possible to carry out robust quantitative causal analyses of effectiveness or to assess the heterogeneity of effects across contexts and types of beneficiaries. Mitigation strategies included triangulation of evidence from existing evaluations, implementation reports and other studies, and supplementing primary data gathered from interviews with stakeholders. Attention was paid to ensuring that

all relevant voices were heard, from programme managers to implementing bodies, business associations, as well as cases of beneficiary RTDI actors.

- **The difficulty of assessing the regional impact of the policy instruments in question.** The lack of ex-post programme evaluations in some regions and weaknesses of the monitoring indicators hindered the full assessment of the impact of the policy instrument on the regional innovation ecosystem.

Despite these limitations, the triangulation of data sources and extensive discussions with country experts, external academic experts, and stakeholders enabled the team to gather robust conclusions for most evaluation questions. Some open questions remain; they are discussed in the last chapter of the report.

1.3. Structure of the report

The report is organised as follows:

- **Chapter 1** outlines the objectives, evaluation questions, scope and methodology of the evaluation;
- **Chapter 2** delves into the policy issues and the underlying theories guiding these interventions;
- **Chapter 3** examines the policy instruments supported by ERDF during the period, analysing the types of interventions, expenditure patterns, policy mixes, and how framework conditions such as ex-ante conditionalities and horizontal principles were considered;
- **Chapter 4** discusses the main evaluation findings;
- **Chapter 5** applies the Better Regulation criteria to assess the evaluation findings and considers horizontal issues across different policy instruments;
- **Chapter 6** discusses lessons learned and policy implications from the evaluation study.

A set of **Annexes** complements this report:

- Annex I presents in detail the Evaluation Matrix and specific judgment criteria;
- Annex II lists the sample of 57 Operational Programmes within the scope of this study;
- Annex III shows the taxonomy of policy instruments that were used in this study;
- Annex IV gives detailed descriptions of the Methodology of the different data analysis tools and approaches of this evaluation study;
- Annex V: presents a detailed analysis of ERDF expenditure across the policy instruments;
- Annex VI provides a synthesis of the assessment by each of the policy instruments in the scope of this study;
- Annex VII is presented as self-standing document accompanying this report, containing 28 Country fiches.
- Annex VIII contains the financial instruments cross-case analysis and is presented as self-standing document accompanying this report.
- Annex IX includes the list of bibliographical references used in this report.

2. Rationale and policy context

This chapter examines the underlying reasons and strategic framework that drive public support for RTDI investments, with a particular focus on the role of the Cohesion Policy. Section 2.1 examines the general and specific rationales for public intervention in RTDI, emphasising the importance of these investments for fostering innovation, economic growth and regional development. Furthermore, it analyses the targeted support provided by the Cohesion Policy, outlining the ERDF priorities and the synergies with other RTDI funding programmes during the 2014-2020 period.

Section 2.2 presents a simplified Theory of Change, illustrating the intended outcomes of RTDI support under the ERDF 2014-2020. This framework helps to identify the pathways through which RTDI investments are expected to generate the desired impacts on regional innovation ecosystems. Finally, Section 2.3 provides a baseline assessment of the performance of regional innovation ecosystems across the EU as of 2014. This assessment provides a foundation for evaluating the progress and effectiveness of RTDI support measures implemented under the Cohesion Policy.

The key messages gathered from this chapter are listed in the box below.

KEY TAKEAWAYS

- **The traditional market failure rationale for public policy intervention in RTDI is complemented by the systemic failure approach and transformative change**. This approach highlights deficiencies in innovation systems, such as institutional failures, capability failures, and network failures. Government intervention is required to enhance the diversity of learning mechanisms, promote experimentation, and improve the functional performance of innovation systems. Furthermore, innovation policies are increasingly geared towards addressing major societal challenges, such as climate change, through a mission-oriented approach. This involves creating new markets and fostering transformative change via experimentation, demand articulation, and policy coordination.
- At the beginning of the programming period, the Regional Innovation Scoreboard 2016 identified **a heterogeneous performance of innovation ecosystems across the EU**, while noting that innovation performance was converging across Member States. The majority of Innovation Leaders were primarily located in northern and western Europe (DK, FI, SE, DE), while Modest Innovators were predominantly situated in eastern Europe (BG, LV, RO). **Private R&D investments and industry-science relations, technology transfer and spinoffs were among the principal weaknesses** affecting the regional innovation systems in 2014, followed by weaknesses related to the commercialisation of innovations and public R&D investments.
- During the 2014-2020 programming period, **ERDF investments in RTDI were crucial for smart and sustainable growth, facilitating recovery from economic crises by unlocking new growth potential**, enhancing innovation, productivity, and competitiveness. In addition, there was a shift from a mainly redistributive logic to a development logic, led by generalized conditions of shrinking public resources and by the need to achieve overall spatial efficiency and competitiveness, mainly advocating endogenous development as well as **"place-based" approach**. The place-based approach under Cohesion Policy highlighted the importance of local contexts and unique regional characteristics for fostering innovation. Policies like Smart Specialisation focus on leveraging existing regional strengths to identify new opportunities, aiming for a higher success rate of public funding and long-term competitive advantage.

- **The ERDF's funding strategy during the 2014-2020 programming period** focused on enhancing research and innovation infrastructure and capacities, promoting centres of competence, encouraging business investment in innovation, and fostering synergies between enterprises, R&D centres, and higher education. This comprehensive approach aimed to establish regional innovation hubs, drive high-impact research, and align academic efforts with industry needs to boost competitiveness and regional development across the EU.
- **A simplified Theory of Change for ERDF support in the field of RTDI**, presented in this section, illustrates how the ERDF RTDI intervention influenced the sequence of immediate, intermediate, and ultimate outcomes, as well as highlights the underlying factors that shaped these outcomes. The ToC also indicates some **broader contextual factors (preconditions, enablers, risks)** that contribute to the achievement of the desired outcomes and long-term policy goals, e.g., the maturity of the innovation system, institutional and governance capacity, and the combination of complementary measures within the RTDI policy mix.

2.1. Rationale of public support for RTDI investments and the role of the Cohesion Policy

2.1.1. General rationale for public support to RTDI

The crucial role of public R&D funding in stimulating economic growth is long substantiated in the literature. **Public policy intervention in RTDI is traditionally justified using the market failure rationale**. This neoclassical welfare economics approach assumes that private firms under-invest in R&D as they cannot sufficiently appropriate the benefits of their investments due to knowledge spillovers. Therefore, government support is essential to encourage private R&D to reach a socially desirable level.[9] The inability of the market to secure necessary long-term investments due to uncertainty, spillovers, and externalities, among other factors, further justifies government intervention.[10]

The main argument supporting intervention is based on appropriation asymmetries. As knowledge is a public good and a major input for innovation, the benefits it generates can be used by multiple actors, not just the creator. Because private returns from investing in knowledge are lower than public returns, there is a disincentive to optimal knowledge production. Therefore, public policy is needed to support knowledge production in public organisations, provide financial support for innovation activities in firms and start-ups, and help protect intellectual property to incentivise private knowledge production and exploitation.[11]

However, the market failure rationale for public policy intervention is not comprehensive enough, according to existing literature. It fails to consider the role of wider non-market agents, interactions, and institutions in the innovation process.[12] Therefore, a more general **systemic failure argument** is used alongside the market failure

[9] Edler, J., Cunningham, P., and Gök, A. (Eds.). (2016). Handbook of innovation policy impact. Edward Elgar Publishing.

[10] Arrow, K. J., and Nerlove, M. (1962). Optimal advertising policy under dynamic conditions. Economica, 129-142; Romer, P. M. (1990). Endogenous technological change. Journal of political Economy, 98(5, Part 2), pp.71-102.

[11] Edler, J., Cunningham, P., and Gök, A. (Eds.). (2016). Handbook of innovation policy impact. Edward Elgar Publishing.

[12] Bleda, M., and Del Rio, P. (2013). The market failure and the systemic failure rationales in technological innovation systems. Research policy, 42(5), pp. 1039-1052.

approach to justify government intervention.[13] This argument is based on the innovation system approach, which identifies deficiencies in innovation systems as the basis for policy intervention.[14] According to Metcalfe[15], if a system's functional performance to create and use innovation at a socially desirable rate is limited by factors like legal and financial conditions (sometimes referred to as institutional failure), inadequate capabilities (capabilities' failure), or insufficient exchange and cooperation (interaction or network failure), then policy intervention is needed to support those system functions that do not perform to a sufficient level.

The systemic failure approach also emphasises the variety of learning processes. Innovation is driven by the diversity of firms, in terms of behaviour, knowledge and ability to learn. The focus of the policymaker becomes enhancing the diversity of learning mechanisms and promoting variety and experimentation, rather than focusing on individual research projects. The scope for government action is broadened to become as much an issue of institutional design, interconnectivity, and the ability of firms (and other innovation system actors) to learn, as it is a question of subsidy.

In the last decade or so, system failure interventions have been influenced by the increased need to support innovation that addresses major societal challenges ('grand societal challenges', such as climate change). The need to respond to these challenges has emphasized the role of demand in challenge-based approaches to innovation policy.[16] The issue of **transformative change** that can be unleashed through experimentation, demand articulation and policy coordination led to the introduction of the **mission-oriented approach** to innovation policy. It highlights, on the one hand, the crucial policy distinction between subsidies and investments in the area of research and innovation and, on the other hand, the particular role that large societal challenges could play in Europe co-creating new (local and global) markets.[17] The successful implementation of these public missions will depend on the establishment of their appropriate design and governance, including the appropriate level of R&D expenditures, development of cooperation in R&D activity and the right choices of policy measures that should be used to boost innovations through missions.[18]

When considering targets for support, the marginal benefit of supporting SMEs is thought to be higher than the marginal benefit of supporting larger companies. Also, helping exporting companies (and thus creating more jobs) and catching up of regions/economies are complementary rationales. The above rationale is also addressed by cooperative or demand-side programmes, albeit as a secondary objective. However, these measures tend to focus, respectively, on objectives such as collaboration with a university or mission orientation and the support of societal missions through increasing R&D expenditure. [19]

The recent theories of innovation have pointed out that R&D is only one element, albeit important, of the innovation process. The commercial success of discovery and its translation in improved growth and productivity levels depend on a complex set of interrelated factors, both internal and external to the firm (organisational, institutional,

[13] Edler, J., and Fagerberg, J. (2017) Innovation policy: what, why, and how. Oxford Review of Economic Policy, Volume 33, Issue 1.

[14] Woolthuis, R. K., Lankhuizen, M., and Gilsing, V. (2005). A system failure framework for innovation policy design. Technovation, 25(6), pp. 609-619.

[15] Metcalfe, J.S. (2002). Knowledge of growth and the growth of knowledge, Journal of Evolutionary Economics, 12, pp.3-15.

[16] Boon, W., and J. Edler. (2018). Demand, Challenges, and Innovation. Making Sense of new Trends in Innovation Policy. Science and Public Policy 45(4), pp. 435–447.

[17] European Commission (2017). The economic rationale for public research & innovation funding and its impact.

[18] European Commission (2018). ESIR Memorandum II: Implementing EU Missions. Luxembourg: Publications Office of the European Union.

[19] Edler, J., Cunningham, P., and Gök, A. (Eds.). (2016). Handbook of innovation policy impact. Edward Elgar Publishing.

economic, etc.). If for some reason these are not in place or do not perform effectively, the firm will face difficulties in capitalising on its R&D efforts. Public investment in RDI thus requires a mix of direct instruments and market-based incentives (a policy mix), as no single mechanism can provide a full range of incentives.

2.1.2. Rationale to support RTDI within Cohesion Policy

Cohesion Policy represents a fundamental pillar of the EU policy, intending to achieve structural change by fostering balanced and sustainable development across its Member States and regions. **Following the 2007-2013 period and the Lisbon agenda, the continued provision of RTDI support played a key role in the 2014-2020 programming period**, with a particular focus on smart and sustainable growth. To facilitate a sustainable recovery from the economic crisis, it was necessary to implement actions and investments that would enable countries and regions to unlock new growth potential and to enhance their performance in terms of innovation, productivity and competitiveness. In this context, the Europe 2020 strategy aimed to develop an economy based on knowledge and innovation.[20] Consequently, the ERDF Regulation defined strengthening research, technological development and innovation as one of the eleven high-level thematic objectives.

Article 176 of the Treaty on the Functioning of the European Union (TFEU) delineates the fundamental objective of the European Regional Development Fund (ERDF). Its primary aim is to address significant regional disparities within the European Union by providing targeted support to regions lagging in development and aiding the transformation of declining industrial areas. The typical rationale of the Cohesion policies is mainly based on the need to compensate lagging regions for the absence of some preconditions for growth – particularly in the areas of infrastructure, accessibility, education and healthcare – and to counterbalance the virtuous circles of agglomeration economies and increasing returns benefitting other "core" areas.[21] In addition, the 2014-2020 period saw a shift from a mainly redistributive logic to a development logic[22], led by generalized conditions of shrinking public resources and by the need to achieve overall spatial efficiency and competitiveness, mainly advocating endogenous development, continuous innovation and a growth perspective as well as "place-based" approach.

The place-based dimension of innovation ecosystems emphasises the importance of local contexts for making innovation flourish – meaning that every place-based innovation ecosystem is to a certain extent unique. Place-based is a term reflecting efforts towards urban or regional economic transformation that exceeds the eventual effects of national or even EU-level strategies. As a concept, place-based is born to empower a bottom-up approach that seeks (and targets in its objective function as it were) benefits for the concerned region, through a strategy emanating from it and exploiting niches and new engagements for its resources.[23] The suggestion of policy design driven by the needs and based on the specificities of each territory is in line with relatively new policy concepts like

[20] Europe 2020 Strategy - Publications Office of the EU (europa.eu).

[21] Fernandez, J. (2011). Why location matters: The terms of a debate. In: OECD (ed) Regional outlook 2011. Paris, pp. 167–174.

[22] Camagni, R. and Capello R. (2013). Regional innovation patterns and the EU regional policy reform: Towards smart innovation policies. Growth and Change, 44 (2013), pp. 355-389.

[23] Rissola, G. and Haberleithner, J. (2020). Place-Based Innovation Ecosystems. A case-study comparative analysis, EUR 30231 EN, Publications Office of the European Union, Luxembourg, JRC120695.

constructing regional advantage[24], platform policies[25], place-based development[26] and Smart Specialisation[27].

The influential Barca Report to the European Commission[28] promoted a place-based regional policy founded on place specificities and territorial assets, designed transparently and inclusively by local actors with the support of external institutional and economic actors (multilevel governance) and subject to precise "conditionalities" imposed by the Union to prevent local rent-seeking and monopolistic practices. For the Cohesion Policy period 2014-2020, the European Commission had set ex-ante conditionalities, the compliance with which provided a framework for the approval of the ERDF Operational Programmes. The development of a "national and regional research and innovation strategy for **Smart Specialisation**" constituted such a conditionality (ex-ante conditionality 1.1).[29] Consequently, Smart Specialisation has been introduced as a strategic approach in the ERDF context. From a policy perspective, the rationale and expectations towards Smart Specialisation are clear: rather than identifying (global) megatrends and focusing public investments into these areas ("me-too strategies"), Smart Specialisation requires to identify endogenous innovation capacities, focus on higher value creation activities, and benchmark this in the global context. "Specialisation" is not about making regions more specialised but about leveraging existing strengths to identify new opportunity areas for investment. The goal is to achieve a higher success rate of public funding and build-up of long(er) term competitive advantage.

The role of Smart Specialisation in the implementation of RTDI funding under Cohesion Policy 2014-2020 is further elaborated on in Section Investments in Smart Specialisation Strategies under Cohesion Policy 2014-2020.

2.1.3. ERDF priorities in the RTDI over the period 2014-2020 and synergies with other RTDI funding programmes

ERDF RTDI priorities in the 2014-2020 period

The ERDF funding architecture included Thematic Objective 1 and its two investment priorities (1a and 1b), which were dedicated to strengthening RTDI. This can be further divided into four specific priorities, as presented in the figure below.

[24] Asheim, B.T., Boschma, R, and Cooke P. (2011). Constructing Regional Advantage: Platform Policies Based on Related Variety and Differentiated Knowledge Bases. Regional Studies, 45 (7), pp. 893-904.

[25] Cooke, P., DeLaurentis, C., MacNeill, S., and Collinge S. (Eds.) (2010). Platform of innovation: Dynamics of new industrial knowledge flows. Edward Elgar, Cheltenham

[26] Barca, F. (2009). An agenda for a reformed cohesion policy. Independent Report prepared at the request of Danuta Hübner, Commissioner for Regional Policy, by Fabrizio Barca. EC – DG REGIO, April. Available online.

[27] Foray, D., David, P., and B. Hall (2009). Smart specialisation - The Concept. Knowledge Economists Policy Brief no. 9, pp. 1-5. Available online.

[28] Barca, F. (2009). An agenda for a reformed cohesion policy. Independent Report prepared at the request of Danuta Hübner, Commissioner for Regional Policy, by Fabrizio Barca. EC – DG REGIO, April. Available online.

[29] European Commission (2012). Research and Innovation Strategies for Smart Specialisation. Cohesion Policy 2014-2020.

Figure 7. ERDF investment priorities in the RTDI over the period 2014-2020

Source: Prognos / CSIL / Visionary Analytics (2024).

During the 2014-2020 programming period, the enhancement of research and innovation infrastructure and capacities was one of the key ERDF priorities. Investments were strategically directed towards the development and improvement of R&I infrastructure, to ensure that regions across the EU had access to cutting-edge facilities and technologies. This encompassed considerable financial support for cutting-edge laboratories, advanced research facilities, and technological platforms intended to facilitate high-level scientific research and innovation activities. These investments were designed to cultivate R&I excellence by providing researchers and innovators with the requisite tools and environments to conduct pioneering work. By enhancing infrastructure, the ERDF sought to establish innovation hubs that could attract top talent, facilitate high-impact research, and promote regional competitiveness.

Another crucial objective of the ERDF was the promotion of centres of competence. The fund provided support for the establishment and enhancement of these centres, with a particular focus on those of European interest. These centres aimed to concentrate expertise, resources, and activities in specific fields of research and innovation, aiming for high standards of excellence and global competitiveness. By focusing on centres of competence, the ERDF sought to create specialised hubs that could drive advancements in key areas of scientific and technological research, contributing significantly to the overall innovation landscape in Europe.

In addition, **the ERDF placed a significant emphasis on encouraging business investment in innovation and research** by providing support for a broad spectrum of activities, including product and service development, technology transfer, social innovation, eco-innovation, public service applications, demand stimulation, networking, clusters, and open innovation through Smart Specialisation. This support is intended to enable businesses to bring new and improved products to market, thereby enhancing their competitiveness.

The ERDF's strategy also involved developing links and synergies between enterprises, R&D centres, and the higher education sector. To this end, it facilitated the development of networks, clusters, and synergies that could effectively bridge the gap between research and practical application. By fostering close partnerships, the ERDF aimed to align academic research with industry needs, establishing an ecosystem conducive to the testing, refinement, and efficient market introduction of innovations.

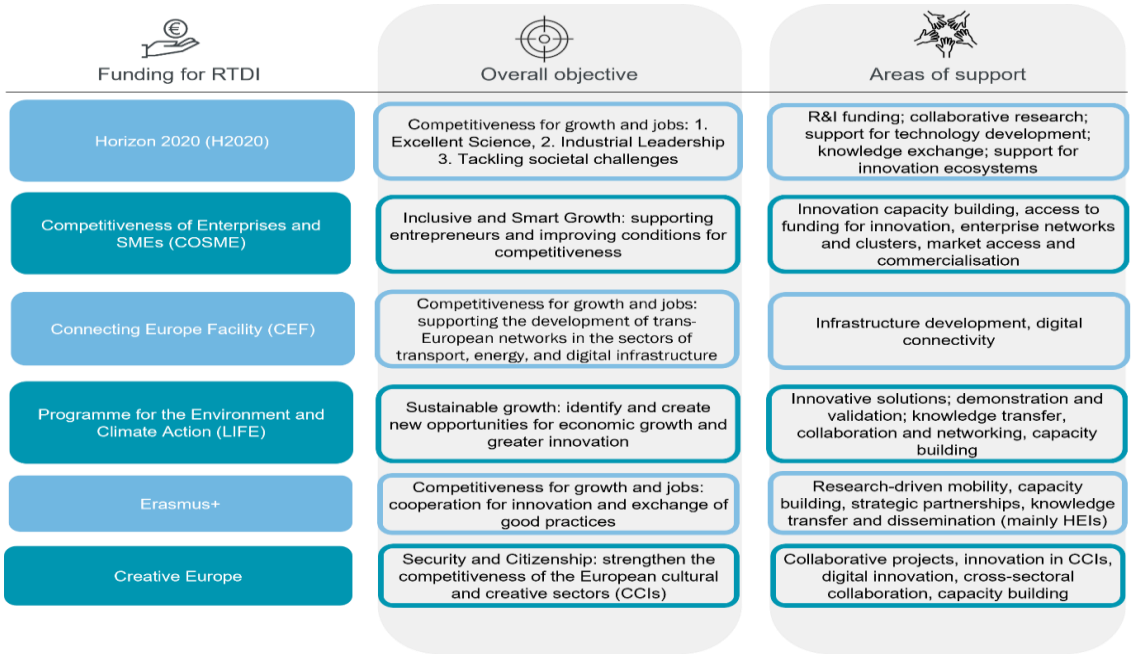
Synergies between ERDF and other RTDI funding programmes

During the 2014-2020 timeframe, the European Union allocated a larger proportion of its budget[30] to R&I than ever before through various funding programmes and initiatives, as shown in Figure 8. . **The financial support for RTDI primarily flowed through two main channels: the eighth framework programme for R&I, known as Horizon 2020 (H2020), and the European Structural and Investment Funds (ESI Funds), with 95% of the latter sourced from the ERDF.** H2020 received a substantial budget allocation of EUR

[30] In total, this constituted around 12% of the entire EU budget during the 2014-2020 period.

76.4 billion, while the ERDF invested EUR 59 billion through around 225 operational programmes. While in absolute terms the ERDF is a significant investment (which is further amplified by national co-funding), it also needs to be put into perspective. According to the figures published by Eurostat[31], in 2020 alone, the Member States of the EU invested around EUR 311 billion in R&D.

Figure 8. Overview of other EU programmes supporting RTDI in the 2014-2020 period



Source: Prognos / CSIL / Visionary Analytics (2024).

With the aim to increase the effectiveness and efficiency of H2020 and ESI Funds as well as to achieve greater impact in terms of innovation results, the Commission fostered the stimulation of various types of synergies, namely:

- **Sequential funding upstreamed:** using ESI funds to fund actions that build R&I capacities needed to compete in H2020 and participate in international networks
- **Sequential funding downstreamed:** using ESI funds to fund actions that capitalise on already implemented H2020 projects and exploit and diffuse their R&I results
- **Alternative funding (Seal of Excellence):** providing ESI funds to project proposals that had received a Seal of Excellence (SoE), i.e. they were positively evaluated under H2020 and ranked above a predefined quality threshold but were not funded due to insufficient budgetary resources
- **Complementary (cumulative) funding:** bringing together funding from H2020 and ESI Funds in the same project

The creation of synergies was particularly relevant for those countries that are performing less well in R&I and consequently participating less in H2020. While the planned measures to create upstream synergies were well implemented, measures to generate downstream synergies were hardly applied due to a number of reasons, including the lack of alignment between rules and regulations or limited cooperation between the two programmes' stakeholders.[32]

[31] https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20211129-2 .

[32] Please see: Special Report 23/2022: Synergies between Horizon 2020 and European Structural and Investment Funds (europa.eu).

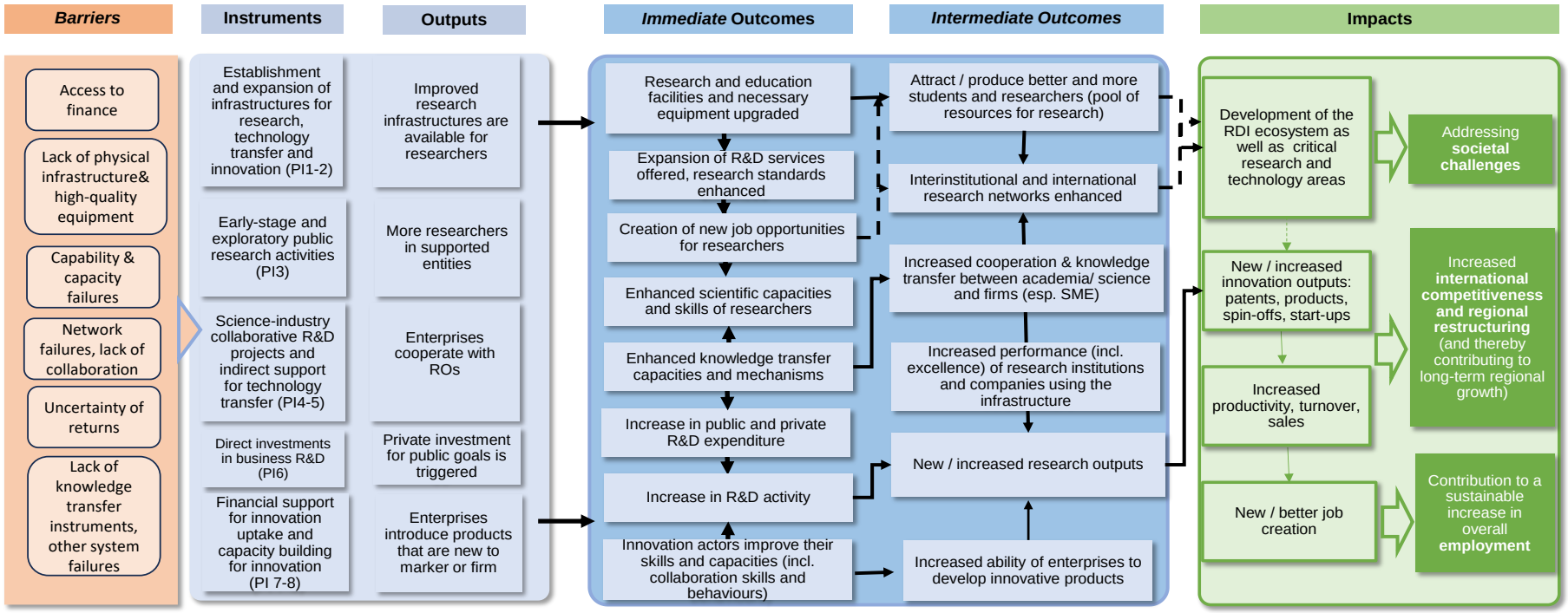
2.2. Simplified Theory of Change for RTDI support under Cohesion Policy 2014-2020

This section presents a simplified Theory of Change (ToC) for ERDF support in the field of RTDI. In essence, **the ToC illustrates how the ERDF RTDI intervention influenced the sequence of immediate, intermediate, and ultimate outcomes, as well as highlights the underlying factors that shaped these outcomes.** The causal chain linking policy inputs and results commences with the identification of the existing barriers and systemic failures characterising each region or Member State. These are factors that impede RTDI, and that public policy is expected to address. The ERDF support (input) can be delivered through a variety of *policy instruments*. Furthermore, the ERDF may provide support for specific industries and/or R&D areas if they have been selected as regional Smart Specialisation areas.

Each instrument generates a specific set of *outputs* and (immediate and intermediate) *outcomes*. These include increased R&D activity, new skills or capabilities of innovation system actors, enhanced knowledge transfer capacities, and so forth. Each instrument can be associated with one or more outcomes, and multiple instruments can contribute to achieving the same outcome. The mechanisms by which these outcomes are achieved can follow different *pathways* (i.e. specific causal chains), depending on the activities implemented, the stakeholders involved, the types of beneficiaries affected, and other aspects related to the way the policy instrument is delivered in specific contexts. For the sake of simplicity, the general ToC visualisation does not encompass all the mechanisms through which outcomes are attained.

In light of the aforementioned rationale for ERDF support to RTDI, the simplified visualisation of the ToC also indicates **some broader contextual factors (preconditions, enablers, risks)** that contribute to the achievement of the desired outcomes and long-term policy goals. These include the maturity of the innovation system, institutional and governance capacity, the combination of complementary measures within the RTDI policy mix, and the availability of skilled labour or absorptive capacity within firms. The visual representation of the general ToC, presented in the Figure below, provides a more detailed account of these factors.

Figure 9. Visual representation of ToC on RTDI support from ERDF 2014-2020



Preconditions and Enablers

Governance Factors

1. High level of policy making and implementing capacity
2. Utilised policy synergies, eg. between ESF and ERDF
3. Long-term commitment to public R&D funding
4. Sufficent administrative capacities

National / Regional Innovation System

5. Effective science-business collaboration system
6. Availability of skilled local SMEs / research partners in specific sector
7. Regional R&D infrastructure is developed
8. Regime of appropriability is positive (ability to utilise benefits from projects)

Economic Factors

9. Stable policy and macroeconomic environment

Risks and barriers

1. Instability of policy or legislative framework
2. External shocks like Covid-19, war in Ukraine
3. Existing technological or industrial ecosystem not sufficiently mature, not connected to priority areas
4. Inappropriate design, poor targeting of beneficiaries
5. Policy fragmentation, lack of critical mass, lack of synergies
6. Implementation weaknesses, excessive bureaucracy
7. Lack of (at least minimal) absorptive capacities of enterprises
8. Unavailability of skilled personnel to utilise project results
9. Lack of entrepreneurial and collaboration incentives within public research sector
10. Supply-side risks, e.g. limited availability of high qualiy innovation advisory services for capacity building

Indirect and wider effects

a. Spillover effects to local and regional economy (esp. knowledge spillovers)
b. Development of human capital base in region
c. Increase of FDI

Source: Prognos / CSIL / Visionary Analytics (2024).

2.3. Baseline situation: Performance of regional innovation ecosystems across the EU in 2014

This chapter offers a baseline overview of the performance of regional innovation ecosystems across the EU at the beginning of the programming period in 2014. As contextual information, one can outline that the beginning of this programming period coincides with the time of the European financial crisis which also impacted the innovation convergence across the EU.[33,34]

To start with, Figure 10. shows the performance of European regions in the **Regional Competitiveness Index** 2016. This Regional Competitiveness Index captures a wide range of factors related to innovation, governance, transport and digital infrastructure as well as health and human capital.[35] The reason for referring to the 2016 version of the Regional Competitiveness Index is to account for time lags in the data that is used in the calculation of the index. As shown in Figure 10. , the strongest regions in the Regional Competitiveness Index 2016 are mostly located in Scandinavia and Central Europe (e.g., in Austria, Belgium, Germany, Netherlands). Less competitive regions in the Regional Competitiveness Index 2016 were found to be in eastern and southern regions of the EU. The Regional Competitiveness Index 2016 report[36] finds that over time regions in France, Germany and Sweden had improved their competitiveness while the contrary is found for some regions in Ireland, Greece and the Netherlands. The competitiveness level is found to have been stable in many eastern European regions between 2010 and 2016.

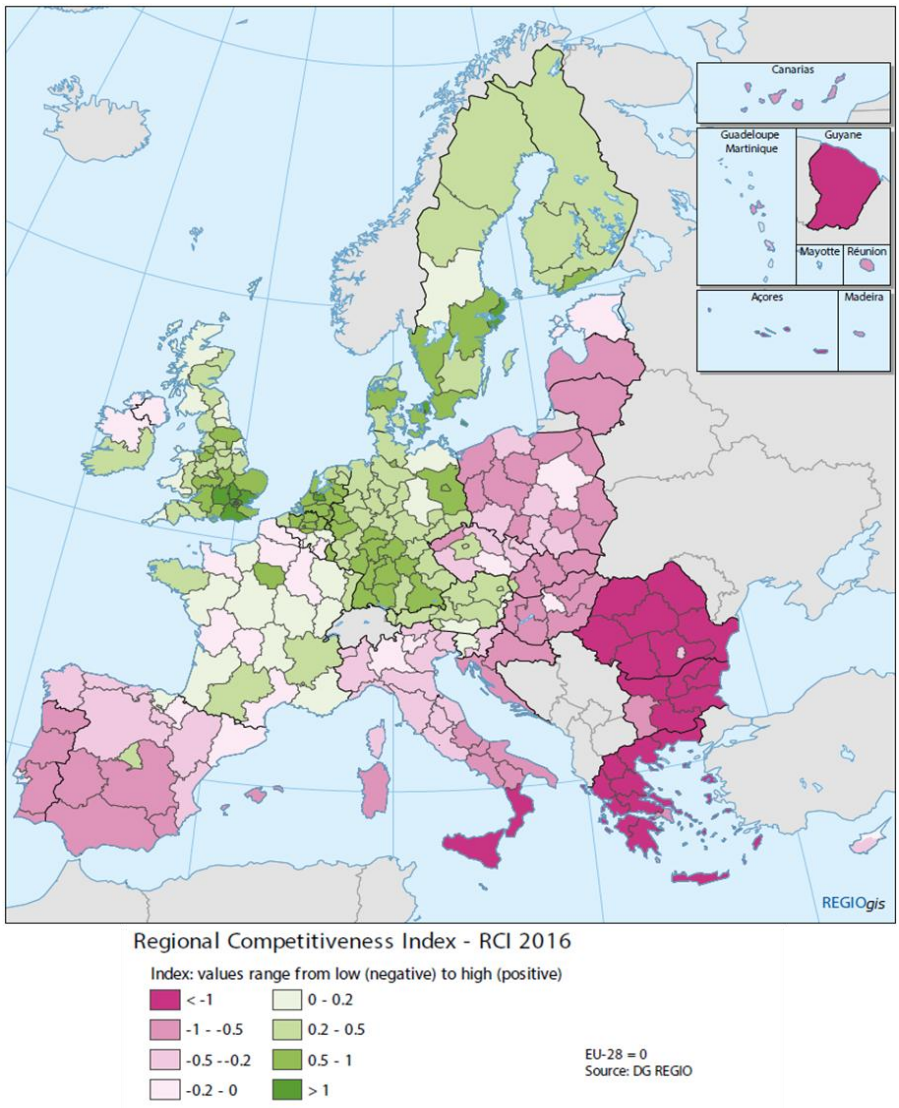
[33] https://ec.europa.eu/commission/presscorner/detail/es/MEMO_14_244 (last access 20.06.2024)

[34] European Commission (2014): Innovation Union Scoreboard 2014. Available online: https://op.europa.eu/en/publication-detail/-/publication/d1cb48d3-4861-41fe-a26d-09850d32487b/language-en/format-PDF/source-326464128 (last access 20.06.2024)

[35] European Commission (2016): The EU Regional Competitiveness Index 2016. Available online: https://ec.europa.eu/regional_policy/en/information/publications/working-papers/2017/the-eu-regional-competitiveness-index-2016 (last access 26.07.2024)

[36] European Commission (2016): The EU Regional Competitiveness Index 2016. Available online: https://ec.europa.eu/regional_policy/en/information/publications/working-papers/2017/the-eu-regional-competitiveness-index-2016 (last access 26.07.2024)

Figure 10. Performance of European regions in the Regional Competitiveness Index 2016



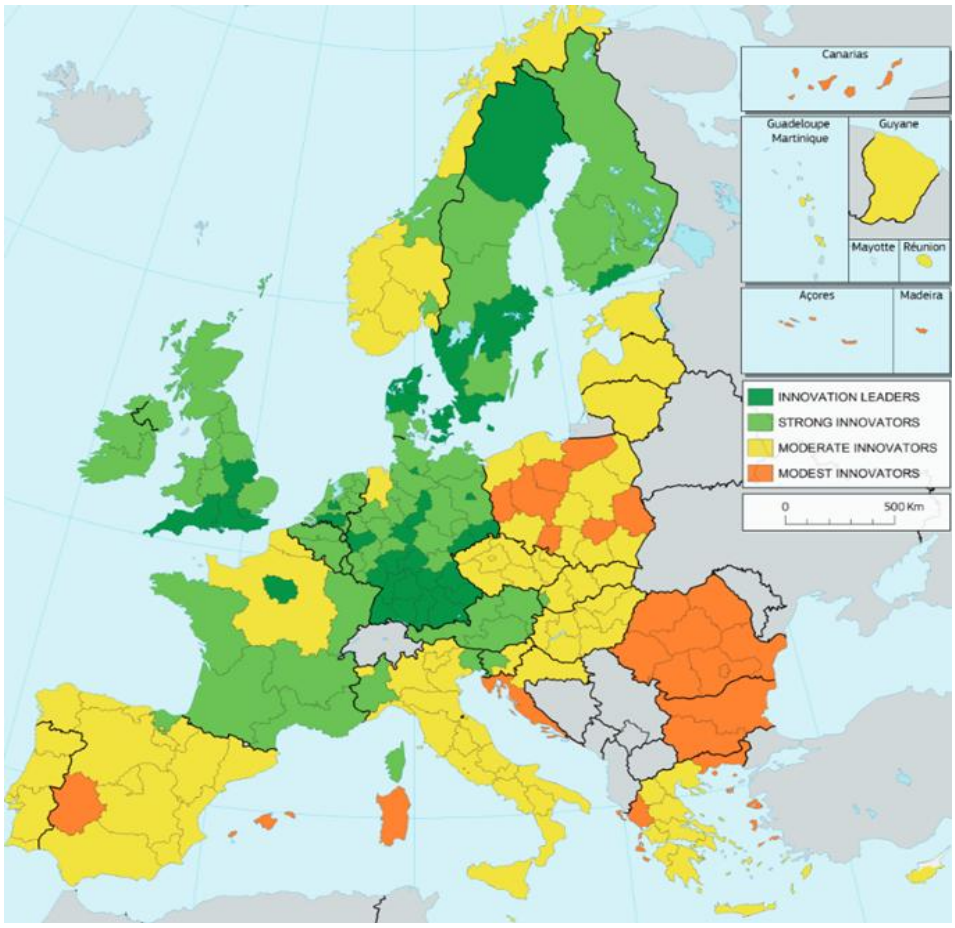
Source: European Commission (2017): The EU Regional Competitiveness Index 2016

Following this assessment of competitiveness, a **detailed analysis of the innovation performance can be provided based on the data in the Regional Innovation Scoreboard (RIS).** To start with, the RIS 2016[37,38] revealed identifies a heterogeneous performance of innovation ecosystems across the EU, while noting that innovation performance was converging across Member States. This is also reflected in Figure 11, which illustrates the performance of the various European regions in the RIS 2016. This figure demonstrates that the majority of Innovation Leaders (regions with an innovation performance well above the EU average) are primarily located in Scandinavia and the central part of Europe. Conversely, Modest Innovators, which encompass regions with an innovation performance way below the EU average, were predominantly situated in Eastern Europe.

[37] European Commission (2016): Regional Innovation Scoreboard 2016. Available online: https://op.europa.eu/en/publication-detail/-/publication/693eaaba-de16-11e6-ad7c-01aa75ed71a1 (last access 20.06.2024)

[38] The Regional Innovation Scoreboard 2016 is used to account for the time lag of the data in the Regional Innovation Scoreboard which can be up to 2 years. Hence, the Regional Innovation Scoreboard is best suited for the analysis of performance of regional innovation ecosystems across the EU in 2014.

Figure 11. Performance of European regions in the Regional Innovation Scoreboard 2016



Source: European Commission (2016): https://op.europa.eu/en/publication-detail/-/publication/693eaaba-de16-11e6-ad7c-01aa75ed71a1

On a more detailed level, Figure 12. provides a stocktaking of the maturity of the innovation ecosystems in the EU at the inception of the ERDF funding period in 2016. It displays the average normalised scores of each cohesion group across nine specific indicators, selected for this analysis.[39] It allows for the identification of key indicators that stand out within each group and facilitates a comparative assessment.

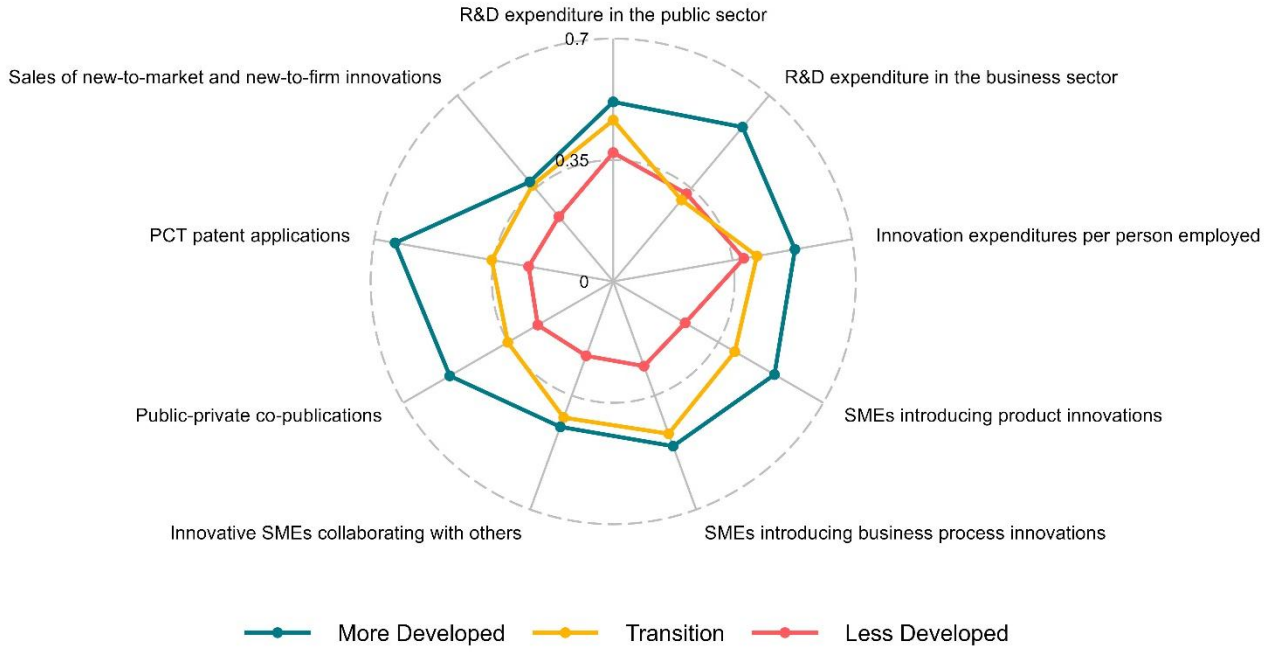
More precisely, Figure 12. illustrates that in **2016, more developed regions[40] exhibited higher performance in all nine indicators**, indicating a positive relation between GDPs per capita[41] and the development of the RTDI system. Some differences between the cohesion policy groups, however, were more pronounced than others. For instance, the most notable difference was in the R&D expenditure in the business sector, with expenditures in more developed regions being double that in transition or less developed regions. PCT patent applications and public-private co-publications were two other indicators that highlighted the clear difference between the more developed and transition/less developed regions in 2016.

[39] A further detailed overview of each of the nine RIS indicators, including their definitions, rationale, and data sources can be found in the Annex. RIS and RCI data preparation and limitations are also described in detail there.

[40] This is based on the Cohesion Region classification of the European Commission. See https://ec.europa.eu/eurostat/web/cohesion-policy-indicators/context/cohesion-regions (last access on 26.07.2024)

[41] It is important to mention that the EU cohesion taxonomy is based on the regions' GDP per capita in relation to EU's GDP per capita.

Figure 12. Comparison of selected RTDI indicators by Cohesion Regions in 2016 (normalised scores)



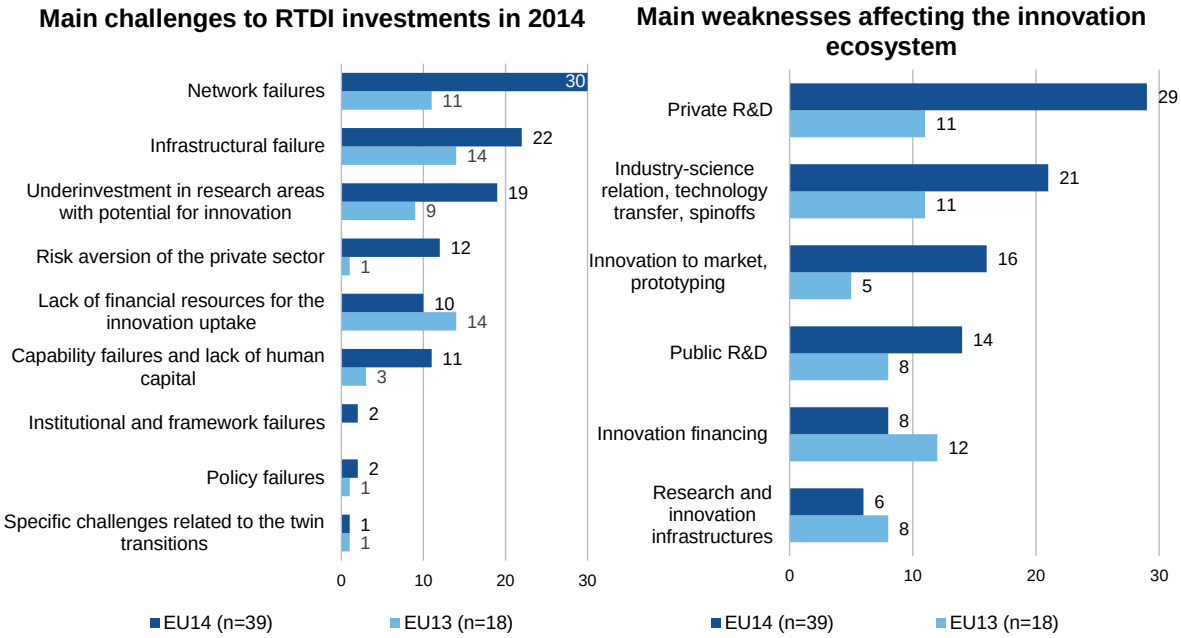
Source: Prognos / CSIL / Visionary Analytics (2024) based on Regional Innovation Scoreboard data and ERDF list of regions eligible for funding. Number of regions by cohesion group: less developed – 68, transition – 27 and more developed – 127. For more information see Annex IV.

Other components of the RTDI system exhibited minimal variation between the cohesion groups. For instance, the number of SMEs introducing business process innovations was comparable between transition and more developed regions (however, less developed regions exhibited a notable discrepancy). The differences in innovation expenditures per person employed were less pronounced between all three cohesion groups, indicating that GDP per capita exerts a relatively limited influence on RTDI systems.

Figure 13. complements the prior assessment by delineating the principal challenges that impede RTDI investments, as identified by the ERDF Operational Programmes (OPs) at the outset of the programming period. Additionally, it highlights the primary weaknesses that affected the respective innovation ecosystems in 2014. This analysis is based on insights generated by the assessment of 57 ERDF programmes (see also Section Mixed methods analytical approach). In general, the three **main challenges to RTDI investments in 2014 that were to be addressed by the ERDF Operational Programmes at hand were network failures, infrastructural failure and underinvestment in research areas with innovation potential**. However, a differentiation by EU14+UK/EU13[42] Member States shows that the lack of financial resources for innovation uptake was a key challenge to be addressed particularly by ERDF OPs in the EU13 Member States.

[42] EU14+UK includes Member States that have joined the EU before 2004. These are Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden and UK. EU13 includes Member States that have joined the EU since 2004. These are Bulgaria, Croatia, Cyprus, Czechia, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia, and Slovenia.

Figure 13. Main challenges representing obstacles to RTDI investments (left) and main weaknesses affecting the regional innovation system, by EU14+UK /EU13



Source: Prognos / CSIL / Visionary Analytics (2024) based on the review of 57 ERDF Operational Programmes. For each Operational Programme (OP), up to three main challenges representing obstacles to RTDI investments that the OP chose to address at the beginning of the programming period and up to three main weaknesses affecting the regional innovation system in 2014 were identified.

This analysis of the **principal weaknesses** affecting the regional innovation system in 2014 for the assessed ERDF programmes indicates that private R&D investments and industry-science relations, technology transfer and spinoffs were key limitations. This is followed by weaknesses related to the commercialisation of innovations (innovation to market, prototyping) and public R&D investments. As before, there was a variation in the weaknesses affecting the regional innovation system in 2014 between ERDF programmes from EU14 and EU13 Member States. At the outset of the programming period, a greater proportion of ERDF programmes from EU13 Member States identified financing innovation, and research and innovation infrastructures as weaknesses compared to programmes from EU14 Member States. Overall, in the inception of ERDF funding in 2014, there were clear differences in the performance of the regional innovation ecosystems across the different regions in the EU, which will be important to consider in the ex-post evaluation of RTDI support from Cohesion Policy programmes in the 2014-2020 period.

3. The interventions supported

This chapter provides an examination of the RTDI interventions supported by the ERDF over the 2014-2020 period. Section 3.1 begins by examining the general investment patterns in RTDI, outlining how funds were allocated and spent across different regions and sectors during the 2014-2020 period. It offers a comprehensive analysis of the main trends and identifies the most important areas of investment. Subsequently, a detailed analysis of investments in Smart Specialisation Strategies (S3) is provided. This section examines how the S3 approach, which aims to stimulate innovation by focusing on regional strengths and potential, was implemented and financed through the Cohesion Policy.

Section 3.2 then turns to the various policy instruments that were used to distribute ERDF funds. It begins with an overview of the main features of these instruments, providing a clear understanding of their design, purpose, and operational mechanisms. The subsequent analysis covers the policy mix across different countries and regions, comparing and contrasting the approaches taken to achieve regional development goals. This comparative analysis provides insights into the diversity of strategies and their effectiveness in addressing regional disparities.

The key takeaways from Chapter 3 are outlined in the box below.

KEY TAKEAWAYS

- In the 2014-2020 programming period, 229 out of 290 programmes allocated ERDF and national funds to RTDI objectives. By the end of 2023, a total of **EUR 59 billion supported RTDI investments** in these programmes, of which **the EU contribution covered EUR 40 billion**. This is slightly less than originally allocated at the beginning of the programming period due to the COVID-19 crisis, with spending priorities realigned to focus on support for SME and health infrastructure.
- There was a **significant concentration of ERDF support for RTDI on a limited number of programmes**. In 2023, just 14 programmes from 12 countries accounted for half of the total planned expenditure. Less developed regions received around 50% of RTDI support from the ERDF while **the ERDF was a primary source of funding for RTDI in EU13 countries**. In Lithuania, Poland, and Latvia, ERDF funding represented around a third (30%) of the total RTDI funding. In a vast majority of cases, absorption rates were positive or superior to 90% by 2023.
- **Around 64% of ERDF RTDI operations projects were thematically aligned with the thematic/sectoral S3 Priority Areas**. There were some regional differences, with transition and less developed regions showing stronger alignment. The majority of ERDF RTDI operations thematically aligned to the S3 were directed toward the thematic domains of ICT & Industry 4.0, Health & Life Sciences, Agrifood & Bioeconomy.
- RTDI support was delivered through eight different policy instruments corresponding to three broad types of instruments: funding for RTDI projects, support to infrastructure and soft support. By the end of 2020, **the largest share of expenditure (38.6%) supported research activities in businesses**. Overall, RTDI projects (including research activities in business and in research organisations, as well as science-industry projects) accounted for 68% of the total expenditure. Infrastructure investments consumed 15% of the total expenditure.
- As of the end of 2020, **74.9% of the operations were distributed to sole beneficiaries, mostly enterprises** (40%). The other sole beneficiaries were higher education institutions (10%) and research organisations (9%). Collaborative projects represented 23,4% of total operations. In total, around 51,700 SMEs and enterprises,

9,890 research organisations, and 13,920 higher education institutions benefited from ERDF support to RTDI.

- **The vast majority of RTDI support (more than 90% of total expenditure) was deployed through non-repayable grants**. Only 32 OPs mobilised financial instruments with a total of EUR 1.7 billion (end 2023) which is lower than was planned at the beginning of the programming period. Financial instruments have mainly been used to provide finance to enterprises (SMEs). They were primarily used as indirect support for technology transfer, research activities in businesses and business investments to support innovation uptake.
- During the 2014-2020 programming period, the composition of **RTDI policy mixes remained stable** across regions. Less developed regions favoured measures that supported RTDI in enterprises directly, transition regions spent more on infrastructure investments for research, while more developed regions supported technology transfer and science–industry collaborative projects. The level of maturity of the regional innovation ecosystem as well as the governance structure in place, can explain the differences in the policy mix observed across countries and regions.

3.1. ERDF RTDI support: funding allocation and expenditure analysis

3.1.1. General investment patterns on RTDI under Cohesion Policy programmes 2014-2020

At the beginning of the 2014-2020 period, a total of **EUR 63.5 billion** was allocated to support RTDI under the **11 fields of intervention** (FOIs) within the scope of this evaluation, of which the ERDF resources covered EUR 42.6 billion[43]. However, the COVID-19 crisis necessitated a reshuffling of spending priorities, resulting in a slight reduction in the funding available for RTDI. This reallocation favoured support for SMEs and health infrastructure instead. By the end of 2023, the total funding allocated to the 11 FOIs had decreased to **EUR 59 billion, including EUR 40 billion of ERDF resources**.[44] Despite this slight decrease, the ERDF resources allocated to RTDI during the 2014-2020 period still represent a significant amount compared to the previous programming period and other currently available sources of financing for RTDI (see Box 2 below).[45]

[43] Figures based on ESIF 2014-2020 categorisation ERDF-ESF-CF planned vs implemented .
For the sake of consistency with other Work Packages of ERDF ex-post evaluation, we considered the variable "Planned_Total_Amount_(Notional)" and "EU_amount_planned" and the year 2016. Therefore, the figure may differ from the one reported in the First Interim Report, which referred to the Total_Eligible_Costs_Decided_(selected).

[44] Figures based on ESIF 2014-2020 categorisation ERDF-ESF-CF planned vs implemented considering the variable "Planned_Total_Amount_(Notional)" and "EU_amount_planned" and the year 2023.

[45] During the 2007-2013 period, approximately EUR 17 billion of ERDF resources (nearly 5% of the total ERDF allocation) were invested through 215 OPs in projects supporting RTD infrastructure, competence centres, and activities in EU Member States and regions (expenditure codes 01 and 02). More than EUR 11 billion (65.5% of the total) was allocated to research infrastructure support (expenditure code 02), and around EUR 5.8 billion (34.5% of the total) to research activities support (expenditure code 01). Nevertheless, it should be pointed out that the scope of this evaluation is much broader than the field of interventions covered by the previous ones. For more details, see. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52023SC0071&from=EN

Box 2. ERDF support to RTDI in a global perspective

- EU27+1 Horizon 2020 between 2014-2020: approximately EUR 80 billion
- EU27+1 national budget for RTDI between 2014-2020: EUR 1,155 billion
- Average R&D investment of the three top US companies (Alphabet, Meta, Microsoft) in 2022: EUR 31 billion each

Source: Prognos / CSIL / Visionary Analytics (2024) based on WIPO, EUROSTAT (COFOG data).

ERDF support for RTDI was concentrated on a limited number of programmes. A total of 229 programmes (174 national and regional mainstream programmes and 55 cooperation programmes) allocated resources to support RTDI.[46] As of 2023, 85% of the total planned allocation has been concentrated in 71 programmes, while 85% of the total EU contribution has been concentrated in 68 programmes. Planned allocation for RTDI has been geographically highly concentrated, with 14 OPs from 12 countries accounting for 50% of the total planned budget for the RTDI sector, and the five OPs with the highest budgets taking 33% of the total (see the Box below).[47]

Box 3. Top 5 OPs with the highest RTDI planned budget

1. "Smart growth" (PL): EUR 8.8 billion (84%)
2. "Multi-regional" (ES): EUR 3.7 billion (22%)
3. Enterprise & Innovation for Competitiveness (CZ): EUR 2.6 billion (34%)
4. Competitiveness and Internationalisation (PT): EUR 2.3 billion (34%)
5. England (UK): EUR 1.9 billion (29%)

Source: Prognos / CSIL / Visionary Analytics (2024) based on EC categorisation data (as of the end of 2023).
Note: the figure in brackets shows the total funds allocated to RTDI over total funds allocated to the OP.

As of 2023**, 48% of the total planned allocation (EUR 28.3 billion) and 54.3% of the EU contribution (EUR 21.7 billion) were allocated to less developed regions**[48]. Conversely, more developed regions and transition regions received 33.6% (EUR 19.8 billion) and 13.6% (EUR 8 billion) of the total planned allocation[49], respectively. As of 2023, approximately EUR 1.6 billion of total expenditure has been allocated to the FoI within the scope of this evaluation through the REACT EU initiative.[50]

[46] In total ERDF supported 290 programmes in 2014-2020 period, out of which 76 were cooperation programmes.

[47] The other nine OPs are: "England" (UK), "Integrated Infrastructure" (SK), "Sachsen" (DE), "Research Development and Education" (CZ), "Nordrhein-Westfalen" (DE), "Competitiveness Programme" (RO), "Competitiveness and Cohesion" (HR), "EU Structural Funds Investments" (LT), "Competitiveness Entrepreneurship and Innovation" (GR).

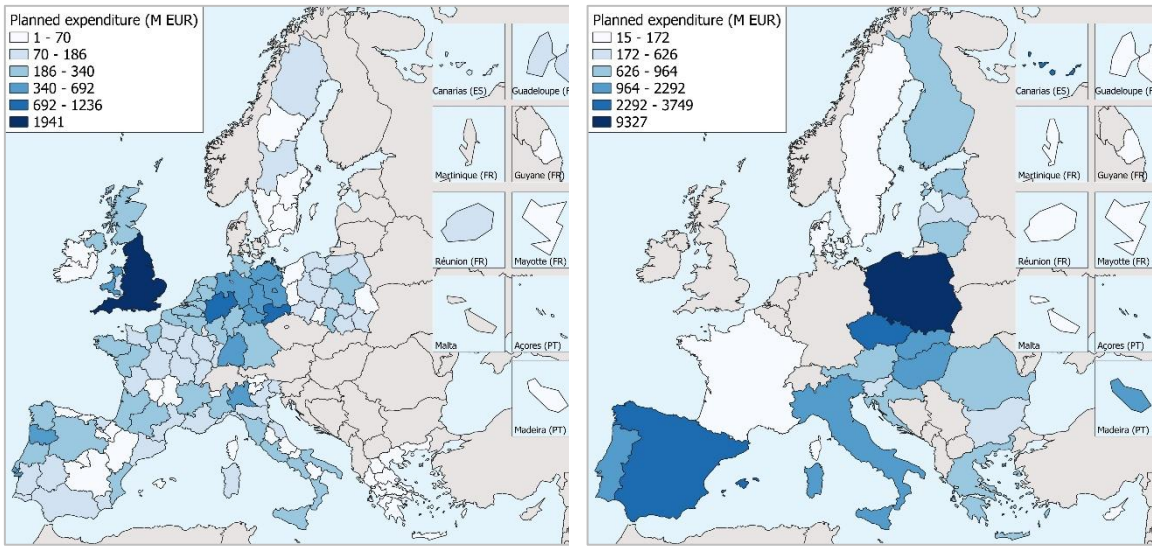
[48] Less developed regions: where GDP per inhabitant was less than 75 % of the EU average; transition regions: where GDP per inhabitant was between 75 % and 90 % of the EU average; more developed regions: where GDP per inhabitant was more than 90 % of the EU average.

[49] The remaining portion consists of planned expenditure for which it is not possible to classify the region category, specifically for Interreg programmes (4.1%) and REACT-EU allocations that do not have a territorial specification (0.6%).

[50] https://ec.europa.eu/regional_policy/funding/react-eu_en. Due to the cut-off date of the WP2 Single Database (end of 2020), the operations funded through REACT-EU are not recorded in the database of operations used to map the policy instruments.

Figure 14. Distribution of total expenditure planned for RTDI support by OPs (2023)

Regional programmes **National and multiregional programmes**



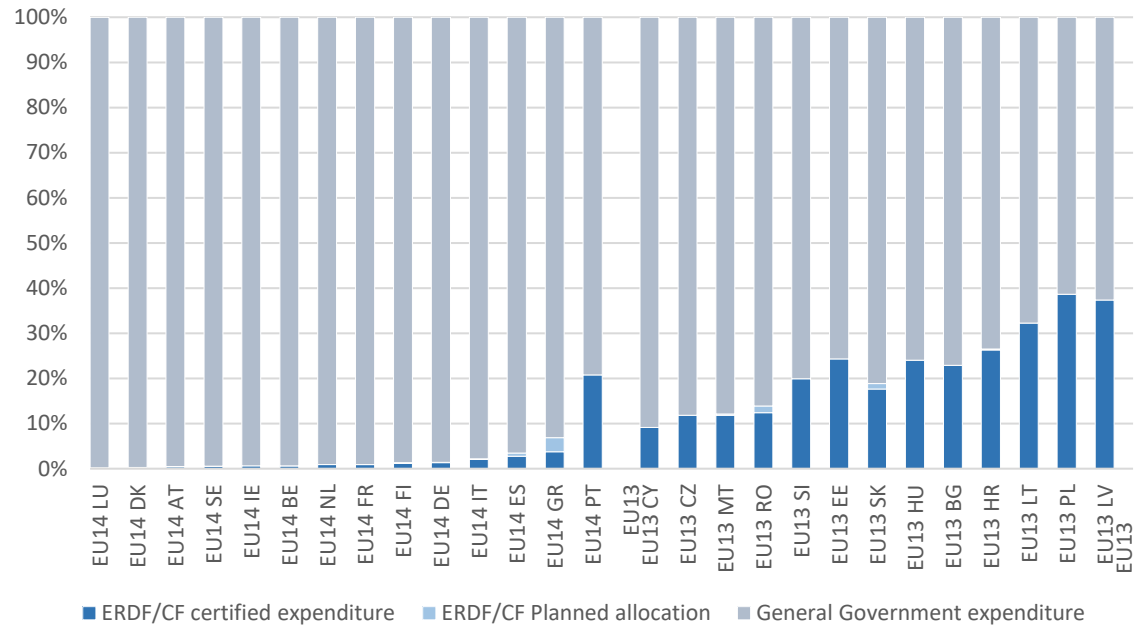
Source: Prognos / CSIL / Visionary Analytics (2024) based on EC categorisation data (as of end of 2023). Note: The maps refer to the total expenditure classified under any of the selected 11 fields of intervention above. It does not show Interreg programmes. In the map for national and multiregional OPs, the whole country is in blue if there is an OP, although in some cases the OP may target only less developed regions (this applies in particular to the OPs Enterprise and Innovation for Competitiveness – CZ, Economic Development, and Innovation Programme – HU, Competitiveness and Internationalisation - PT) or to transition and less developed regions only (Research and Innovation – IT, Enterprises and Competitiveness - IT). Eligibility criteria were however extended to the whole country, in some cases, after the pandemic and specifically especially with REACT EU.

The ERDF was a primary source of funding for RTDI in EU13 countries (see Figure 15.). As of 2023, the share of ERDF funding over total expenditure for RTDI from national sources was considerably higher in EU13 countries compared to EU14 countries. Except for Portugal, ERDF funding in EU14 countries accounted for less than 3% of total expenditure. Conversely, in EU13 countries, it consistently exceeded 10%. In Lithuania, Poland, and Latvia, ERDF funding even represented around a third (30%) of the total RTDI funding.

Similar patterns of territorial concentration of ERDF expenditure were also observed in the 2007-2023 programming period, on the one hand as a result of eligibility rules and territorial concentration of RTD capacities on the other. in the EU13 countries, ERDF support represented the first systematic set of interventions addressed to the research field after years of underinvestment and limited political priority. 70% was concentrated in less developed regions and 64% in urban areas.[51]

[51] For more details see https//eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52023SC0071&from=EN

Figure 15. Share of ERDF expenditure compared to the total RTDI funding by country

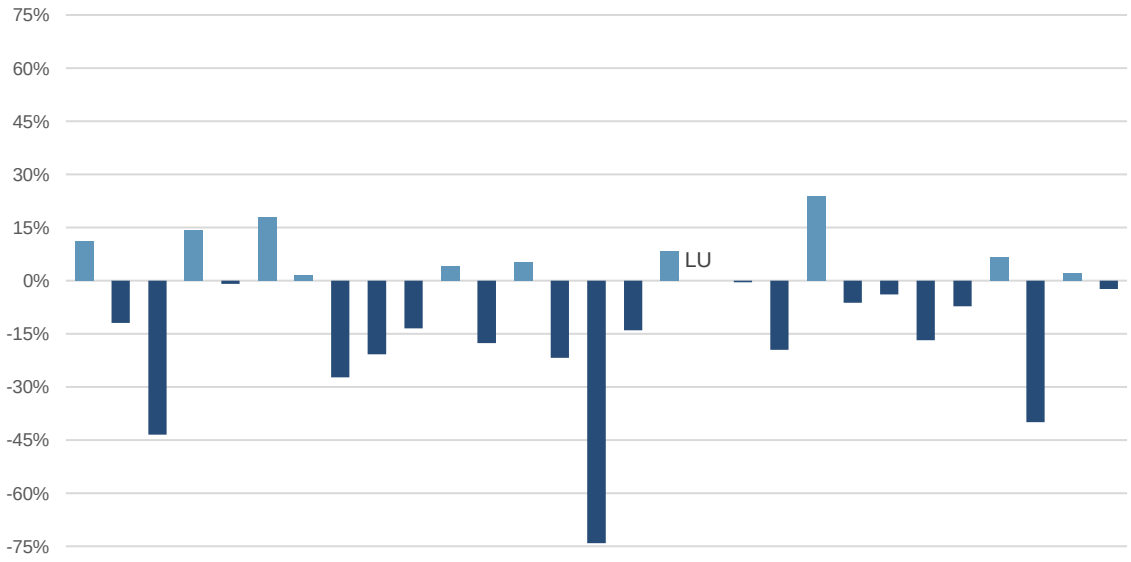


Source: Prognos / CSIL / Visionary Analytics (2024) based on EC categorisation data (as of the end of 2023) and Eurostat data on general government expenditure by economic function according to the international Classification of the Functions of Government (COFOG).

Between 2016 and 2023, despite the additional resources made available by REACT-EU to cope with the COVID-19 crisis, **EU Member States showed a decreasing trend in allocating resources to RTDI.** Specifically, Spain and Slovakia saw substantial decreases in planned RTDI funding, with reductions of over EUR 1 billion compared to 2016. Poland and Italy also experienced significant reductions, each by about EUR 700 million. Evidence from this evaluation suggests that funds were redirected to more urgent needs, particularly to support SMEs and mitigate the immediate impacts of the pandemic.

There are notable exceptions to this general decreasing trend. Germany saw an increase of EUR 1 billion in planned RTDI funding (+18%), as resources from REACT-EU expanded the ERDF budget for research and innovation and were distributed to various German regions. Similarly, the Netherlands observed a slight increase in RTDI planned allocations, with 47% of REACT-EU resources directed towards research and development initiatives, thereby increasing the overall funding available for RTDI. In Austria, the REACT-EU funds were also used to strengthen support for RTDI.

Figure 16. Variation in total planned allocation for RTDI intervention fields between 2016 and 2023



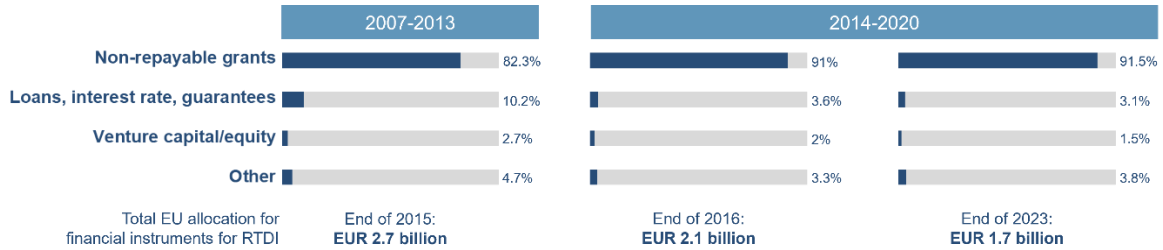
Source: Prognos / CSIL / Visionary Analytics (2024) based on EC categorisation data (as of the end of 2023).

Overall, less developed regions decreased their share in RTDI planned allocation during the period assessed. Due to the relaxation of eligibility criteria introduced by the Coronavirus Response Investment Initiatives (CRII and CRII+), which expanded the regions eligible for support, the concentration of ERDF resources in less developed regions has slightly decreased as resources were redirected to other priorities and region categories. Initially, less developed regions accounted for 58.7% (51.8% including national co-financing) of the allocated funds for RTDI support. By the end of 2023, this share had declined to 54.3% (48% including national co-financing) across the EU. In some countries, the shift of resources towards more developed regions was particularly significant. For instance, in Italy and Belgium, there was a noticeable shift post-pandemic, with their relative allocations increasing by around 10 and 15 percentage points, respectively. A similar reshuffling was observed in the previous programming period, where resources for RTDI were reallocated in response to the economic crisis and the need to better target funds toward instruments that appealed more to potential beneficiaries. This adjustment aimed to enhance the performance and absorption of funds.[52]

This shift in funding priorities due to COVID-19 also **reduced the resources committed to financial instruments for RTDI initiatives**. Although expenditure for the period 2014-2020 is not directly comparable to that of 2007-2013 due to changes in the intervention fields categorising ERDF spending, there appears to be a reduction in the use of financial instruments for the RTDI sector between the programming periods. Data suggests that the experience of the 2007-2013 period led Managing Authorities to view financial instruments as a financing solution with limited scope for research funding, an option that was not further explored in the 2014-2020 period (see Figure 17. below). Structural reasons supporting grants as the most suitable mode of delivery to achieve RTDI objectives were identified through the evaluation as described in Section 4.1.3.

[52] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52023SC0071&from=EN.

Figure 17. Use of financial instruments in the 2007-2013 and 2014-2020 periods



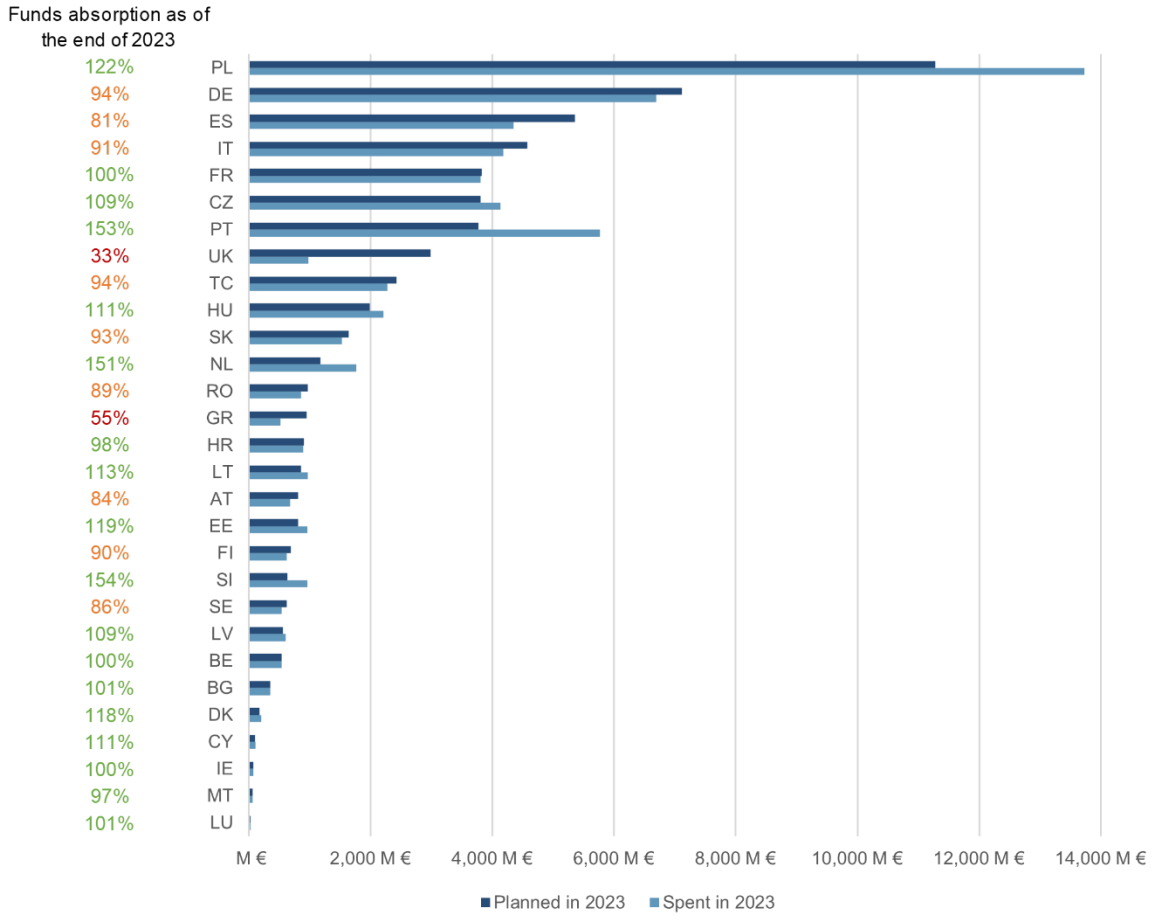
Source: Prognos / CSIL / Visionary Analytics (2024) based on DG REGIO 2007-2013 Cohesion data from closure reports and EC categorisation data (as of the end of 2023). Note: The chart considers for the period 2007-2013 the ERDF amount allocated as of the end of the period to priority themes linked to RTDI[53], while for the period 2014-2020 it considers the EU expenditure planned (variable 'Planned EU amount) in 2016 and 2023 under Thematic Objective 1 (Research and Innovation).

The Member States generally recorded high absorption rates of ERDF resources allocated to the RTDI sector. In 2023, the total declared expenditure of ERDF resources earmarked for RTDI amounts to 102% of the planned allocation. While this indicates a generally good uptake of funds, with reported spending exceeding the planned amount by 2%, there are significant variations in performance across countries (see the Figure below). Eighteen countries have either spent the same amount as planned or exceeded it, either through overbooking practices or by reallocating unspent resources from other objectives to RTDI initiatives. Seven countries show absorption rates between 90% and 100%. Lower rates can be observed in Austria, Spain, Sweden, and Romania, while Greece and the UK record the lowest performance. According to a recent study for the European Parliament, the most common challenges that Member States encountered can be grouped into four categories: those related to the European policy and legal context, those related to national institutional, policy and legal context, those related to the national socio-economic context, those related to the administrative capacity and the delivery modes.[54] According to the European Parliament study, the latter type of challenge is the strongest predictor of absorption rates. Evidence collected under Tasks 1 and 3 of the present study shows that the most common issues identified included delays in adopting legal frameworks and guidelines of EU and national institutions, late adoption of OPs, difficulty in adapting to complex rules and procedures (in particular, compliance with State Aid) as well as changing context (COVID-19), and frequent changes or unclear demarcation between regulations at national and EU levels.

[53] The categories of expenditure were considered: 01 - R&TD activities in research centres; 02 - R&TD infrastructure (including physical plant, instrumentation and high-speed computer networks linking research centres) and centres of competence in a specific technology; 03 - Technology transfer and improvement of cooperation networks between small and medium-sized businesses (SMEs), between these and other businesses and universities, post-secondary education establishments of all kinds, regional authorities, research centres and scientific and technological poles (scientific and technological parks, technopoles, etc.); 04 - Assistance to R&TD, particularly in SMEs (including access to R&TD services in research centres); 07 - Investment in firms directly linked to research and innovation (innovative technologies, establishment of new firms by universities, existing R&TD centres and firms, etc.); 09 - Other measures to stimulate research and innovation and entrepreneurship in SMEs.

[54] Ciffolilli, A., Pompili, M., Borowczak, A., Hranilovic, M., Renka, H., Carmen, H. O. Y. A., ... & CIFFOLILLI, A. (2024). Research for REGI committee-Absorption Rates of Cohesion Policy Funds Final Study. https://www.europarl.europa.eu/RegData/etudes/STUD/2023/747284/IPOL_STU(2023)747284_EN.pdf

Figure 18. Amount of ERDF funds (in million EUR) planned and spent for RTDI in 2023



Source: Prognos / CSIL / Visionary Analytics based on EC categorisation data (as of the end of 2023). Note: The chart considers the total expenditure planned (variable 'Planned Total Amount (Notional)' in 2016 and 2023 and variable "Total eligible expenditure declared" in 2023) under the selected 11 FoI. The data concerning the absorption rate by the end of 2023 is calculated as the ratio between the declared expenditure ('Total Eligible Expenditure Declared') and the planned expenditure ('Planned Total Amount (Notional)') as of the end of 2023. TC stands for trans-national cooperation – Interreg programmes. Countries are sorted by planned resources.

3.1.2. Investments in Smart Specialisation Strategies under Cohesion Policy 2014-2020

As explained previously (see Section ERDF priorities in the RTDI over the period 2014-2020), the requirement to develop Smart Specialisation Strategies (S3) was introduced for the Cohesion Policy period 2014-2020). As a result, the majority of European regions had to restructure their ERDF RTDI support for this period. Here, the well-defined thematic priority areas of the S3 play a key role. These areas can be differentiated by knowledge fields or activities, including science-based, social, cultural, and creative ones. They might represent sub-systems within a specific economic sector or span multiple sectors. Priority areas could also target particular market niches, clusters, technologies, or applications of technologies addressing specific societal and environmental challenges. These areas should align with the region's existing assets and leverage innovation opportunities. Defining and selecting priority areas is as crucial to the strategy's success as translating them into funding measures and operations. The priority areas chosen for S3 **should aim to diversify into innovation activities related to the region's existing economic structure and strengths, generating social and economic impact while also creating**

new capabilities and sources of future competitive advantage.[55] Against this background, the extent to which ERDF RTDI funding under the Cohesion Policy 2014-2020 has been thematically aligned with the national/regional S3 priority areas is assessed below.

An **AI-enabled matching approach** (see Annex IV for a description of the methodology), was applied to examine the extent to which the ERDF RTDI (2014-2020) operations are thematically aligned with the thematic/sectoral S3 priority areas. Although this matching approach follows an established procedure[56], some limitations must be kept in mind (see Annex IV for a detailed assessment of the approach and the limitations). The effectiveness of matching ERDF RTDI project descriptions with the thematic S3 priority areas largely depends on the quality and quantity of keywords used. While some priority areas provide extensive and detailed keyword lists, others offer very few, which affects the success rate of matches. Regions with more keywords have a higher likelihood of successful matches.

Around **59,700 out of 92,700 (64%) ERDF RTDI (2014-2020) operations were thematically matched to the S3 priority areas** on an aggregate level. These findings are in line with earlier studies.[57] A detailed overview of the share of ERDF RTDI operations (2014-2020) thematically aligned to the S3 priority areas is provided in Figure 19. . Here, some differences in the shares of S3-aligned ERDF RTDI operations across the EU Member States and regions emerge. While some regions are characterised by high shares of S3-aligned ERDF RTDI operations (e.g., Mecklenburg-Western Pomerania (DE), Flanders (BE), Lorraine (FR)), other regions display quite low shares of ERDF RTDI operations aligned to their S3 priority areas (e.g., Dalarnas län (SE), Castilla y León (ES)). Some regional differences also appear when assessing the shares of ERDF RTDI operations that are aligned to S3 priority areas by Cohesion Regions. Here, transition regions have the highest shares of ERDF RTDI operations thematically aligned with the S3 priority areas (68%), followed by less developed regions (65%) and more developed regions (60%).

Considering the budget of the ERDF RTDI operations (2014-2020), around **68% (EUR 42.1 billion out of EUR 61.6) was spent on operations that are thematically aligned to the respective S3 priority areas**. The remaining 32% of the budget could not thematically be linked to the respective S3 priority areas. However, although not thematically linked, these investments are generally still in line with the relevant S3. Similar differences in the linked ERDF RTDI operations budget across the different EU Member States and regions compared to shares of the linked ERDF RTDI operations as outlined before emerging in the spatial analysis (see Panel b of Figure 19.). The share of ERDF RTDI operations budgets thematically aligned with the S3 is the highest among the less developed regions (70%), followed by transition regions (68%) and more developed regions (63%). This can be seen as an indication that the less developed regions have followed the S3 prioritisation approach more strictly. Other studies further support this by finding evidence that calls for proposals in less developed regions on average required a stricter alignment to the S3 thematic priority areas.[58] Most OPs refer to S3 and the respective priority areas and explicitly list an alignment with S3 priority areas as an eligibility criterion for operations to

[55] Foray, D., Morgan, K., and S. Radosevic (2018). The Role of Smart Specialisation in the EU Research and Innovation Policy Landscape. Brussels: European Commission

[56] Prognos & CSIL (2021): Study on prioritisation in Smart Specialisation Strategies in the EU. Study commissioned by DG REGIO. Available online: https://op.europa.eu/en/publication-detail/-/publication/fd1c28cd-fb18-11eb-b520-01aa75ed71a1 (last access 21.06.2024).

[57] Prognos & CSIL (2021): Study on prioritisation in Smart Specialisation Strategies in the EU. Study commissioned by DG REGIO. Available online: https://op.europa.eu/o/opportal-service/download-handler?identifier=fd1c28cd-fb18-11eb-b520-01aa75ed71a1&format=pdf&language=en&productionSystem=cellar&part= (last access 10.08.2023).

[58] Prognos & CSIL (2021): Study on prioritisation in Smart Specialisation Strategies in the EU. Study commissioned by DG REGIO. Available online: https://op.europa.eu/o/opportal-service/download-handler?identifier=fd1c28cd-fb18-11eb-b520-01aa75ed71a1&format=pdf&language=en&productionSystem=cellar&part= (last access 10.08.2023).

be selected. As Section Targeting investments through S3 strategies is beneficial, but only to the extent that S3s reflect the underlying economic and technological specialisations. below will discuss, such alignment criteria can play a key role in the effective implementation of operations in the S3 priority areas.[59] This is also in line with other research that finds that most ERDF-Thematic Objective 1 (TO1) calls (84%) in 2014-2020 required an alignment with the S3 priority areas.[60] For the eligibility criterion, some OPs state that priority in the operation selection was given to operations related to the priority areas of the S3 (e.g., in the Italian region Emilia Romagna) whereas other OPs mentioned a strict reference to S3 priorities in their eligibility criteria (Lithuania). These differences in the eligibility criteria can potentially explain the heterogeneous shares of ERDF RTDI operations and budgets linked to S3 as described before since stricter eligibility criteria can be expected to increase the number and related budget of operations linked to S3.

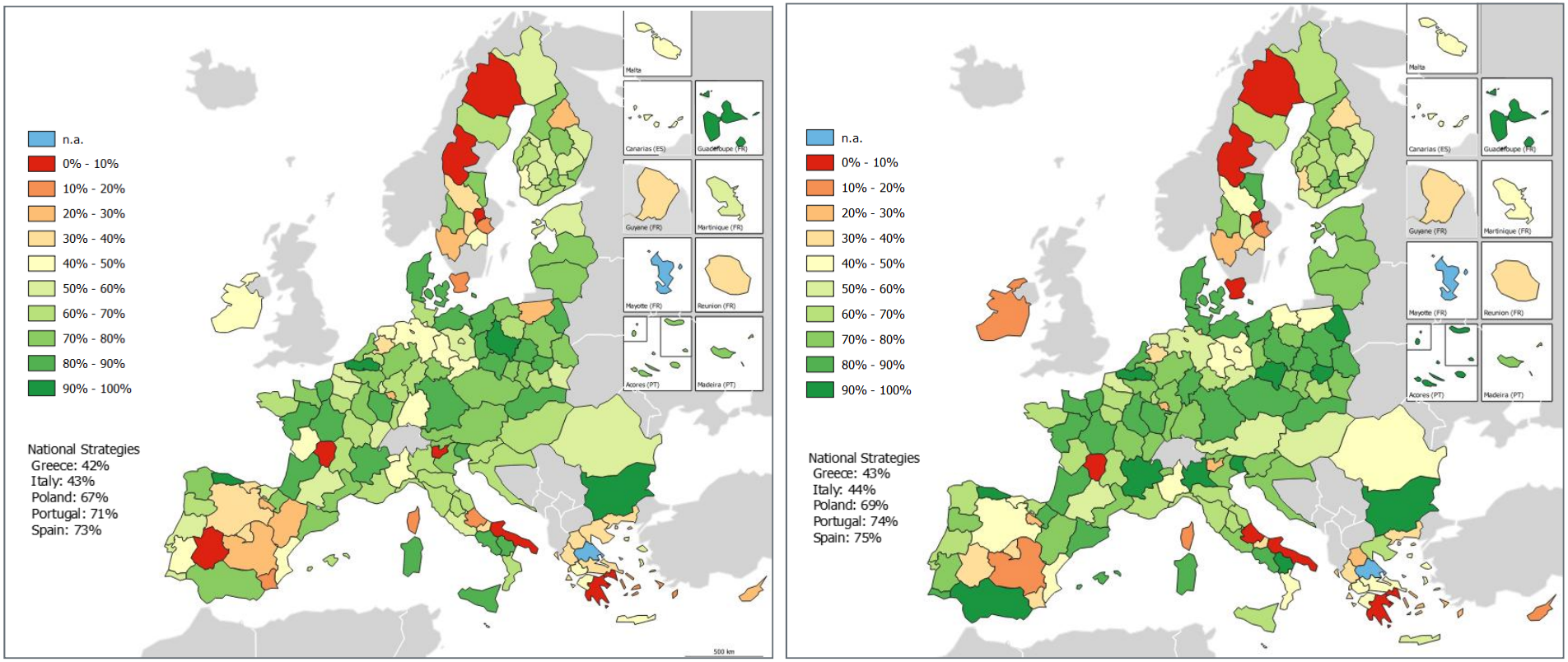
Overall, these quantitative findings demonstrate that **the investments made under the ERDF are thematically in line with the priority areas of the respective S3**. These figures also need to be assessed against the fact that the development of a "national and regional research and innovation strategy for smart specialisation" was only introduced as an ex-ante conditionality 1.1 of the Cohesion Policy period 2014-2020 (see above) and did also not identify a specific percentage share of funding that should be channelled into the priority areas.

[59] Nieth, L., P. Benneworth, D. Charles, L. Fonseca, C. Rodrigues, M. Salomaa, and M. Stienstra. 2018. 'Embedding Entrepreneurial Regional Innovation Ecosystems: Reflecting on the Role of Effectual Entrepreneurial Discovery Processes'. European Planning Studies 26 (11): 2147–66. https://doi.org/10.1080/09654313.2018.1530144

[60] Prognos & CSIL (2021): Study on prioritisation in Smart Specialisation Strategies in the EU. Study commissioned by DG REGIO. Available online: https://op.europa.eu/o/opportal-service/download-handler?identifier=fd1c28cd-fb18-11eb-b520-01aa75ed71a1&format=pdf&language=en&productionSystem=cellar&part= (last access 10.08.2023) and Gianelle, C., Guzzo, F., & Mieszkowski, K. (2019). Smart Specialisation: what gets lost in translation from concept to practice? Regional Studies, 54(10), 1377–1388. https://doi.org/10.1080/00343404.2019.1607970

Figure 19. Share of operations and share of budget of ERDF RTDI operations (2014-2020) thematically aligned with S3 priority areas

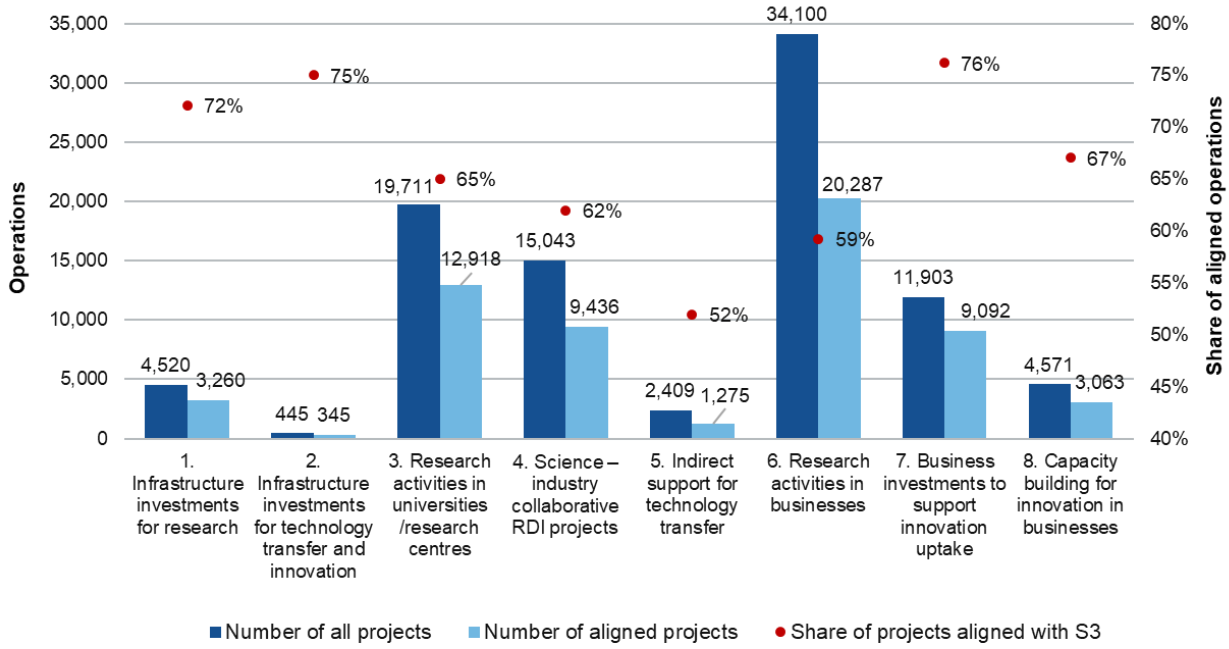
Panel a: Share of ERDF RTDI operations aligned with S3 priority areas (left); Panel b: Share of ERDF RTDI budget aligned with S3 priority areas (right)



Source: Prognos / CSIL / Visionary Analytics (2024). n = 172 regions. Note: The figure is based on the ERDF RTDI operations that were successfully connected using a Word embedding approach with the S3 priority areas. Data for Romanian regions is aggregated at the NUTS0 level. When a region is covered by both a national strategy and a sub-national strategy, the coloured area of the sub-national region refers to the correspondence of the sub-national strategy. The values for the national strategies are given by the figures on the left part of the map. These Member States are Italy, Greece, Spain, Poland, and Portugal.

Complementing the previous assessment, Figure 20. gives an overview of the number and share of ERDF RTDI operations (2014-2020) thematically aligned with S3 priority areas, allocated by Policy Instrument (PI). For more details on the policy instruments see the following Section ERDF expenditure across policy instruments. Overall, it can be said that on an aggregate level, all PIs have been used for implementing the S3. Nonetheless, some variations between the different PIs exist. Overall, the operations related to **"Research activities in businesses" followed by "Research activities in universities/research centres" were by far the most prevalent type of operations that are thematically aligned with the S3 priority areas**. In relative terms, some differences across the PI emerge. For instance, whereas 76% of the operations allocated to the "Business investments to support innovation uptake" are thematically aligned with S3 priority areas, only 52% of the operations allocated to the "Indirect support for technology transfer" are thematically aligned with S3 priority areas.

Figure 20. Number and share of ERDF RTDI operations (2014-2020) thematically aligned with S3 priority areas, by allocated PI



Source: Prognos / CSIL / Visionary Analytics (2024). Note: operations / programmes that are not linked to a S3 (e.g., Interreg) are left out of the analysis.

This assessment of ERDF RTDI operations (2014-2020) linked to S3 priority areas by allocated PI is further complemented by a dedicated assessment of the respective topics of the S3 priority areas. For this, the 14 overarching S3 priority areas that were developed in the "Study on Prioritisation in Smart Specialisation Strategies in the EU"[61] were used. These overarching S3 priority areas include areas such as Aerospace & Defence, Energy & Energy Storage or Mobility & Logistics. **Error! Reference source not found.** gives an overview of the shares of ERDF RTDI operations thematically aligned with S3 priority areas by allocated PI and addressed overarching priority area.

[61] Prognos & CSIL (2021): Study on prioritisation in Smart Specialisation Strategies in the EU. Study commissioned by DG REGIO. Available online: https://op.europa.eu/o/opportal-service/download-handler?identifier=fd1c28cd-fb18-11eb-b520-01aa75ed71a1&format=pdf&language=en&productionSystem=cellar&part= (last access 10.08.2023)

Most ERDF RTDI operations thematically aligned with the S3 have been directed toward the thematic domains of ICT & Industry 4.0, Health & Life Sciences, Agrifood & Bioeconomy. Besides this cross-cutting concentration, some findings for specific PIs emerge. For instance, operations allocated to infrastructure investments for technology transfer and innovation as well as capacity building for innovation in businesses are largely focusing on the domain of ICT & Industry 4.0. Moreover, research activities in universities /research centres are mostly implemented in the domain of Health & Life Sciences.

Table 1. Shares of ERDF RTDI operations thematically aligned with S3 priority areas, by PI and priority area

	Aerospace & Defense	Agrofood & Bioeconomy	Blue Growth	CleanTech & Circular Economy	Construction	Energy & Energy Storage	Fashion, Media & Creative Industries	Health & Life Sciences	ICT & Industry 4.0	Materials & Advanced Manufacturing	Mobility & Logistics	Social Innovation & Welfare	Tourism, Cultural & Creative Industries	Other	Total # of projects aligned with S3
PI1 Infrastructure investments for research	8%	16%	1%	6%	0%	4%	0%	24%	21%	12%	5%	1%	2%	1%	**3,260**
PI2 Infrastructure investments for technology transfer and innovation	1%	15%	1%	1%	2%	4%	2%	12%	28%	18%	8%	0%	9%	1%	**345**
PI3 Research activities in universities /research centres	7%	17%	1%	7%	0%	2%	0%	40%	11%	3%	5%	5%	2%	0%	**12,918**
PI4 Science – industry collaborative RDI projects	1%	14%	1%	7%	0%	8%	2%	20%	14%	19%	8%	0%	5%	1%	**9,436**
PI5 Indirect support for technology transfer	0%	13%	1%	3%	0%	4%	4%	10%	21%	12%	10%	2%	18%	1%	**1,275**
PI6 Research activities in businesses	3%	15%	1%	7%	0%	8%	1%	14%	22%	16%	7%	1%	4%	1%	**20,287**
PI7 Business investments to support innovation uptake	7%	10%	2%	5%	1%	6%	1%	6%	25%	20%	10%	1%	7%	1%	**9,092**
PI8 Capacity building for innovation in businesses	1%	5%	2%	1%	1%	3%	0%	6%	40%	15%	7%	0%	18%	0%	**3,063**
Total # of projects by priority area	**2,342**	**8,300**	**815**	**3,698**	**237**	**3,387**	**650**	**11,445**	**11,742**	**8,283**	**4,340**	**988**	**3,039**	**411**	

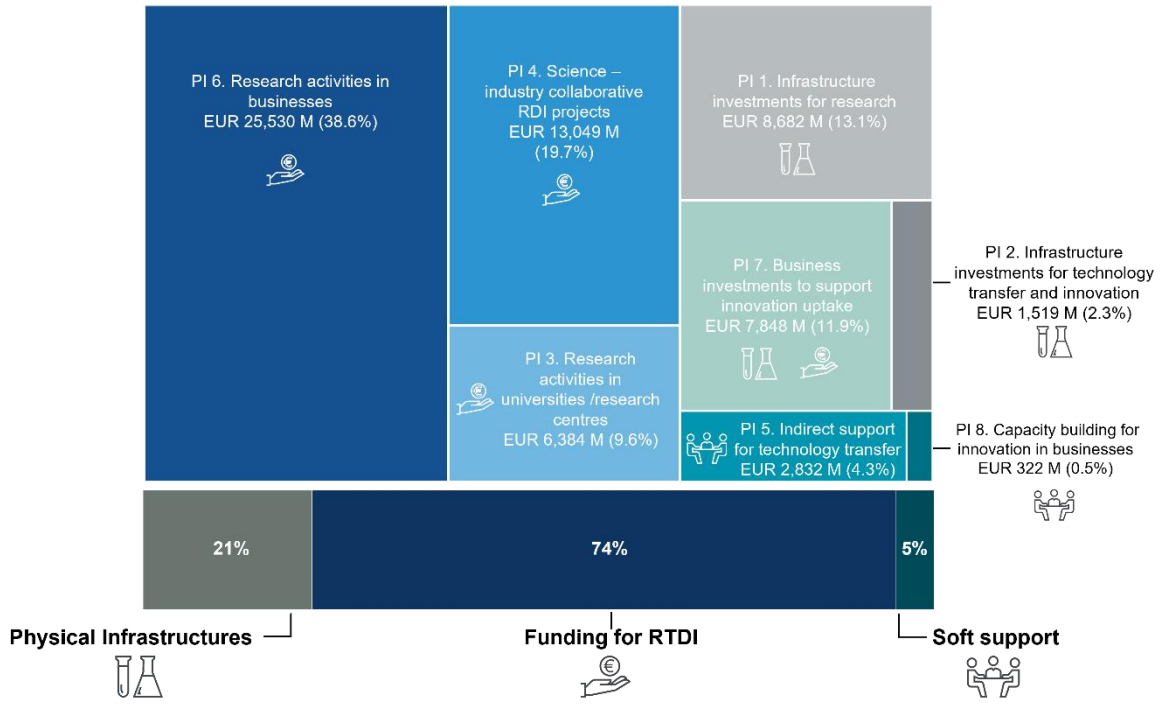
Source: Prognos / CSIL / Visionary Analytics (2024). Note: The shares indicate the proportion of the number of ERDF RTDI operations linked to S3 priority areas by allocated PI and addressed overarching priority area divided by all ERDF RTDI operations linked to S3 priority areas by allocated PI. Darker blue shaded fields indicate higher shares.

3.2. ERDF expenditure across policy instruments

3.2.1. Main features of the policy instruments

Eight types of ERDF policy instruments[62] (PIs) to strengthen RTDI over the period 2014-2020 were identified in this report through analysis of ERDF expenditure data (see Section Objective and scope of the study)[63]. These policy instruments include investments in **physical infrastructure** (such as the construction, upgrade, and modernization of facilities, as well as the purchase of equipment for testing and validation), funding for **RTDI projects** (ranging from early stage to applied research), and **soft support** (such as promoting exchanges between research centres, universities, and enterprises, as well as investments in capacity building). **Error! Reference source not found.** in Annex III offers a more comprehensive description of the identified policy instruments. A theory of change for each of those policy instruments was presented in the First Intermediate Report of the study and further enriched and tested in the policy instrument case studies (Second Intermediate Report).

Figure 21. RTDI policy instruments expenditure allocation and share of the total



Source: Prognos / CSIL / Visionary Analytics (2024) on WP2 expenditure data (last update: end of 2020).

[62] A policy instrument is defined as a consistent set of activities towards a policy goal, i.e., addressing the same market/systemic failures and challenges and having the same expected impact(s). For more details on how this typology of policy instruments was inferred from data and literature review, please see Annex III.

[63] Art 5 of Regulation (EU) No 1301/2013 acknowledges that ERDF support shall strengthen RTDI through various forms of support. The Regulation mentions that the ERDF can be directed to (a) enhancing research and innovation infrastructure and capacities to develop R&I excellence, and promoting centres of competence, in particular those of European interest; (b) promoting business investment in R&I, developing links and synergies between enterprises, research and development centres and the higher education sector, in particular promoting investment in product and service development, technology transfer, social innovation, eco-innovation, public service applications, demand stimulation, networking, clusters and open innovation through Smart Specialisation, and supporting technological and applied research, pilot lines, early product validation actions, advanced manufacturing capabilities and first production, in particular in key enabling technologies and diffusion of general purpose technologies.

Out of the eight policy instruments[64], the most used provided funding for RTDI projects, while comparatively less emphasis was placed on infrastructure investments and soft support.

Focusing on **funding for RTDI projects** (74% of total ERDF expenditure, i.e. EUR 48.9 billion), the largest share (38.6%) of expenditure by the end of 2020 was directed towards supporting research activities in businesses (PI 6 addressing both SMEs and large companies). Other investments in RTDI projects (PI3, PI4) accounted for 29.4% of the total expenditure (EUR 19.5 billion). **Infrastructure investments** accounted for 15.4% (EUR 10.2 billion) of total RTD expenditure. Specifically, 13.1% (EUR 8.6 billion) of the total expenditure funded infrastructure investments for research, consisting mainly in research infrastructures, laboratories, purchase of equipment for research, etc. 2.3% (EUR 1.6 billion) of the total expenditure were used to support infrastructures for technology transfer and innovation (PI2, e.g., construction/ refurbishment of competence centres, science parks, incubators, etc.) . Considering the overall expenditure for infrastructure, the total amount is close to the amount funded by the ERDF in the 2007-2013 period (EUR 9.3 billion).[65] In addition, enterprises could purchase physical infrastructure under PI7 "Business investments to support innovation uptake". However, that same policy instrument, accounting for 11.9% of the total expenditure, also funds intangible assets for innovation uptake, as well as measures for process and organisational innovation. **Soft support measures** (PI5 and PI8) represent 5% of the total expenditure (EUR 3.1 billion) and were primarily aimed to creating RDI ecosystems, bringing together skills and knowledge of multiple actors, to generate innovation in a specific field. A residual number of operations (5.4%), amounting to less than 0.5% of the expenditure, were directed towards enhancing the innovation skills and capacity of enterprises, enabling them to purchase consulting services for business plans or feasibility studies, providing financial support to register IPR, or financing collaboration with a researcher (PI8). The evidence collected through the evaluation did not reveal any significant shifts in the mix of policy instruments mobilised following the pandemic after 2021. No additional policy instruments were detected.[66]

A total of 95,237 operations were funded under these policy instruments as of the end of 2023,[67] and in the majority of cases, these operations correspond to individual projects. However, by definition, they can also refer to groups of projects (i.e., Action Plans, investment strategies, voucher schemes, State Aid schemes, etc.) or a financial instrument.[68] Out of the total number of operations, **74.9% were undertaken by sole beneficiaries**, predominantly enterprises (about 40%), higher education institutions (10%), and research organisations (9%). Collaborative projects constituted 23.4% of all operations, while a small proportion (1.7%) involved multiple beneficiaries[69]. **In total, around 51,700**

[64] In 2007-2013 period, the ERDF support was heavily focused on infrastructure investment, which constituted 72% of total expenditure. Specifically, more than half (57%) of this was directed towards research infrastructure. The primary goal was to bridge the infrastructure gap and enhance systematic interaction among regional actors to promote regional development. There was a notable diversification in the types of projects and initiatives supported by the ERDF during 2014-2020. While infrastructure investment remained important, the policy mix broadened to include a wider range of activities, reflecting evolving regional development needs and priorities. For more details see https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52023SC0071&from=EN

[65] Due to the different scope of the evaluation, it represented 57% of the total expenditure in the 2007 – 2013 period (CSIL, Prognos AG & Technopolis, 2021).

[66] A systematic comparison of funding initially planned and actually spent at the policy instrument level is not feasible. Policy instruments were identified by analysing and clustering data on operations funded, but they only cover expenditure up to the end of 2020. The database of operations assembled in Work Package 2 – Preparatory Study (European Commission, 2022a) includes expenditure data with a cut-off date at the end of 2020.

[67] This figure has been retrieved from the EC Categorisation Data considering the number of operations funded as of the end of 2023 under the 11 FoIs in the scope of the evaluation.

[68] In a minority of cases an operation can also refer to individual components within the same project.

[69] The typology of beneficiaries builds upon the information available from the WP2 database. However, whilst the WP2 classification primarily considered the legal status of the entity, the classification developed in this study focuses on the role and function of the beneficiaries within the RTDI ecosystem. To this end, the team aggregated some WP2 categories

enterprises (mostly SMEs), around 9,890 research organisations, and 13,920 higher education institutions benefited from ERDF support to RTDI either as sole beneficiaries, through collaborative projects or as multiple beneficiaries[70].

The following observations emerge from the analysis of the key statistics of the policy instruments:

- **Expenditure per operation: The average and median expenditures per operation vary significantly depending on the type of policy instrument**. The policy instrument dedicated to capacity-building initiatives for business innovation had the lowest average expenditure per operation (around EUR 62,910) and the lowest median expenditure (around EUR 19,865). In contrast, infrastructure investments for technology transfer and innovation saw the highest average and median expenditures, EUR 3,265,891 and EUR 991,955, respectively. Other policy instruments with high expenditures included infrastructure investments for research and activities supporting technology transfer. The policy instrument with the most funding, research activities in businesses, had an average allocation of EUR 741,456, while the median was around EUR 238,902.
- **Operation duration**: **The average duration of operations was 21.4 months**. The longest operations involved research activities in universities/research centres and significant infrastructure projects, specifically those related to research and technology transfer and innovation. On the other hand, the shortest operations were those providing business investments to support innovation uptake and capacity building for business innovation, as these did not involve implementing investment projects. The regions with the longest average duration of operations (over eight years) were in Belgium, focusing primarily on research activities in universities/research centres and infrastructure investments for research.
- **Form of finance: According to the latest expenditure data available, non-repayable grants constituted the vast majority of RTDI support, representing 91.5% of the total deployed over the 2014-2020 funding period**. Repayable grants were also utilised, primarily for infrastructure projects, comprising 6.9% of the expenditure in PI1 and 4.3% in PI2. Conversely, financial instruments were primarily employed for indirect support for technology transfer (PI5, 3.9%; 8 operations), research activities in businesses (PI6, 7%; 410 operations), and business investments to support innovation uptake (PI7, 8.1%; 18 operations). They were selected to address the challenge of limited access to finance for large-scale innovative projects. According to data updated as of the end 2020, the expenditure allocated through financial instruments for RTDI policy instruments amounted to EUR 2.57 billion (3.9% of the total expenditure). Out of 168 regional and national OPs financing RTDI policy instruments, only 32 programmes from ten Member States relied on the use of financial instruments, and they did so to various extents (see more statistics in Annex V). Pomorskie Voivodeship (PL) and Andalucía (ES) allocated 50.7% and 43% of their total expenditure through financial instruments, respectively. Financial instruments covered more than a quarter of the expenditure in another 7 OPs in Italy, the Netherlands, Spain, and Germany. A range of different options was made available to cater to diverse needs: the use of venture capital via a fund of funds enabled the scaling of complex projects; guarantees were provided to facilitate the banking sector while loans for individual ventures characterised by high market and technological risks (see Section Grants predominate as the mode of delivery in a policy area that involves high-risk projects, but financial instruments have untapped potential for more details).

and reclassified some beneficiaries (e.g., private research centres classified as enterprises in the WP2 database are now considered as “research organisations”). More details on this classification are provided in the First Interim Report.

[70] Additional 386 collaborative projects had as beneficiaries either higher education institutions or research organisations.

The table below summarises some of the **key features of the policy instruments** (see Annex V for additional statistics).

Table 2. Key characteristics of RTDI policy instruments

Policy instruments	Total expenditure allocation in 2020 (BEUR)	Share of total expenditure allocation in 2020 (% over total expenditure for RTDI sector)	Number of operations to end of 2020	Share of operations (%)	Average duration of operations (years)	Most frequent types of direct beneficiaries (by share of expenditure)	Most used form of finance (by share of expenditure, excluding missing)
Infrastructure investments for research (PI1)	8.7	13.1%	4,589	4.8%	2.7	HEI (32.7%) RO (32.5%) MIX[71] (30.4%)	Non-repayable aid (89.7%)
Infrastructure investments for technology transfer and innovation (PI2)	1.5	2.3%	468	0.5%	3	MIX (40.2%) RO (17.4%) RTTO (14.1%)	Non-repayable aid (82.8%)
Research activities in universities /research centres (PI3)	6.4	9.6%	19,838	20.8%	3.	HEI (53.1%) RO (37.7%) HEI / RO (5.2%)	Non-repayable aid (98.5%)
Science – industry collaborative RTDI projects (PI4)	13	19.7%	16,093	16.9%	2.7	MIX (99.5%)	Non-repayable aid (92.4%)
Indirect support for technology transfer (PI5)	2.8	4.3%	2,508	2.6%	2.5	MIX (36.6%) BSO (15.9%) Enterprises (11.8%)	Non-repayable aid (88.2%)
Research activities in businesses (PI6)	25.5	38.6%	34,440	36.2%	2.1	Enterprises (95.5%)	Non-repayable aid (84.1%)
Business investments to support innovation uptake (PI7)	7.8	11.9%	12,177	12.8%	1.3	Enterprises (98.3%)	Non-repayable aid (89.5%)
Capacity building for innovation in businesses (PI8)	0.3	0.5%	5,124	5.4%	1.4	Enterprises (91.3%) BSO (5.8%) RTTO (2.8%)	Non-repayable aid (77.7%)

Source: Prognos / CSIL / Visionary Analytics (2024) based on WP2 expenditure data (last update: end of 2020).
Note: HEI: Higher education institutions; RO: Research organisation; MIX: Mix of beneficiaries; RTTO: Research and technology transfer organisation; BSO: Business support organisation

[71] Collaborative projects

3.2.2. The policy mix across countries and regions

The RTDI policy mix remained stable throughout the period. Countries and regions experiencing slight alterations in terms of changes in total funding for RTDI, reallocation of funding between PIs and adjustment in the program's focus, objectives, or instruments were a minority.

If support for research activities in business (PI6) was the most used policy instrument across a majority of the Member States, the newly entered EU13 Member States generally allocated a greater share to this policy instrument, with an average of 42.9% of total RTDI funds compared to 37% in the EU14+UK countries. Another difference emerges when comparing allocations for the policy instruments Research activities in universities/research centres (PI3) and Science–industry collaborative RDI projects (PI4), where the newer Member States allocated, on average, less than the other countries. Conversely, the EU13 countries reserved significantly more resources from their RTDI policy mix for business investments to support innovation uptake (PI7), allocating 23.9% compared to 2.6% in the EU14+UK countries.

Looking at the policy mix across different types of regions, it is evident that less developed regions have prioritized measures directly supporting RTDI in enterprises. The policy instrument for "Research activities in businesses" (PI6) was predominant across all regions, with a particularly concentrated expenditure on this instrument in less developed regions. Additionally, the share of expenditure allocated to "Business investments to support innovation uptake" (PI7) was higher in less developed regions compared to other types of regions. In contrast, less developed regions allocated a lower share of expenditure to research activities in universities or research centres, as well as to measures aimed at reinforcing the ecosystem through technology transfer activities and collaborative projects, compared to transition and more developed regions. Transition regions allocated a significant portion of their expenditure to infrastructure investments for research, suggesting a need to enhance infrastructure to facilitate research scaling. Conversely, in more developed regions, where established intermediary organisations and networks exist, there was a higher share of expenditure dedicated to supporting technology transfer and science-industry collaborative projects compared to the other types of regions.

Table 3. Geographical concentration of expenditure by policy instrument

Infrastructure investments for research (PI1)	This is the most funded policy instrument in the RTDI policy mix in Romania (46.7%) and in the three European small member-states: Cyprus (64.9%), Luxembourg (70.9%), and Malta, the last of these allocating its entire RTDI budget to research infrastructure investments. German programmes have committed nearly 20% of the total ERDF funds allocated for research infrastructure investments.
Infrastructure investments for technology transfer and innovation (PI2)	This is the most funded ERDF policy instrument in Bulgaria, with 29% of its ERDF budget. Around 45% of the expenditure allocated to this policy instrument is for projects implemented in more developed regions.
Research activities in universities/research centres (PI3)	On average transition and more developed regions allocate around 15% of their ERDF RTDI funds to this policy instrument, while less developed regions allocate just over 6%. In fact, on average, the EU14+UK countries invest more in this policy instrument than the EU13 countries, which have more regions that are less developed.

	Spanish programmes have committed more than 30% of the total EU ERDF funds for research activities in universities and research centres.
Science-industry collaborative RTDI projects (PI4)	This policy instrument is the most funded in six Member States (Finland, Germany, Ireland, Latvia, Netherlands, and UK) and is the most funded instrument by Interreg territorial cooperation programmes, which collectively allocate 79.8% of their ERDF budget to collaborative research projects.
Indirect support for technology transfer (PI5)	Sweden and Denmark allocate a large portion of their funds to indirect support activities for technology transfer, allocating 59.2% and 68.5% of their ERDF budget for RTDI sector to these projects, respectively. On average, transition and more developed regions have higher allocations for these activities.
Research activities in businesses (PI6)	Approximately 60% of the total expenditure allocation for research activities in business is allocated to less developed regions. In 12 Member States, the policy instrument that funds research activities in businesses has the largest share of the ERDF budget for RTDI sector. Polish programmes constitute nearly 33% of total ERDF funds for research infrastructure investments.
Business investments to support innovation uptake (PI7)	On average, the EU13 countries allocate 28.9% of their RTDI resources for business investments to support innovation uptake, while the EU14+UK countries only 2.6%. This is the most funded policy instrument in Slovakia (42.6% of the RTDI budget) and Czechia (34.3%) and the second most funded in Poland (29.4%). 57.8% of the EU expenditure allocated to this policy instrument is in Poland.
Capacity building for innovation in businesses (PI8)	This is the least funded policy instrument in many Member States, with no localisation trends emerging. The UK is the country with the highest share of expenditure for these activities, dedicating 3.5% of its RTDI policy mix.

Source: Prognos / CSIL / Visionary Analytics (2024) based on WP2 expenditure data (last update: end of 2020).

Programmes allocating fewer resources to the RTDI objectives tended to concentrate them on a smaller number of policy instruments, as shown in the Table below. Examples include the 'Integrated Regional Programme' in Romania and the 'Småland and islands programme' in Sweden. Due to constraints in the budget for RTDI initiatives, these programmes concentrated their resources on indirect support initiatives for technology transfer.

Table 4. Relationship between number of policy instruments and budget allocation

Number of different policy instruments in each OP	Number of programmes	Average budget allocation per programme (MEUR)
1 or 2	61	44
3 or 4	66	165
5 or 6	59	349
7 or 8	25	1,279
Total	**211**	**314**

Source: Prognos / CSIL / Visionary Analytics (2024) based on WP2 expenditure data (last update: end of 2020).

The governance system of a country, and consequently the number of activated OPs, also influenced the policy mix and the number of policy instruments on which resources are concentrated. Single OP territories tended to focus on specific areas, while those with multiple OPs had more diverse and region-specific policy mixes. Countries with multiple OPs at different levels of governance often demonstrated complementary strategies in their policy mix to balance national and regional objectives. In territories with multiple OPs at the same governance level, the approach was more varied, with regional differences in emphasis reflecting specific regional characteristics.

The distribution of expenditure across policy instruments varied significantly by country and OP, influenced by specific regional needs, strategic choices of Managing Authorities, and other contextual factors such as existing support from regional or national sources. In most cases, there was a diverse range of policy instruments implemented, encompassing support for infrastructure, research activities in universities and research centres, and businesses (or collaborations between them). However, a few countries – specifically Austria, Bulgaria, Cyprus, Denmark, Luxembourg, and Malta – exhibited a notable concentration of funding on one policy instrument, typically infrastructure investments for research.

The analysis of the policy mix highlights the following trends across Member States:

- **PI1 covered more than 50% of the expenditure in eight out of the national and regional 174 OPs**. In Malta, the share of PI1 expenditure was 100%. This concentration was the result of adjustments due to COVID-19 and the country's low absorption capacity.[72]
- **Infrastructure investments usually concentrated on research infrastructures (PI1)**, and only in limited cases (Belgium, Bulgaria, Croatia) were they coupled with investments for infrastructures favouring technology transfer and innovation (PI2).

[72] For instance, the concentration of funding on the development of research infrastructures in Malta was decided in the reprogramming following the outbreak of Covid-19 and considering the lack of absorption capacity of the Maltese enterprises for research funding. The initially envisaged policy mix comprised different interventions aimed at tackling several deficiencies of the Maltese RTDI ecosystem – lack of research infrastructure and human capital for research, lack of appeal to external researchers, low investments from enterprises in research and innovation, lack of collaboration between the university and enterprises. However, following the pandemic outbreak, all areas of intervention related to RTDI were defunded, with the exception of the intervention field for public infrastructure for research and development, for which the financial allocation increased from EUR 36.6 million to EUR 48.6 million. The MA decided to focus resources and efforts on PI1 as the two projects financed under this policy instrument were positively evaluated and efficiently absorbed the allocated funds.

The share of expenditure on infrastructure investments for technology transfer and innovation (PI2) was generally very low (less than 5%) in most countries, with the exception of Bulgaria[73].

- **Funding for research activities in universities and research centres (PI3) was usually coupled with funding for research activities in businesses (PI6)**, for instance in Italy, Spain, Ireland, Germany, Luxembourg, and Portugal.
- **Indirect support for technology transfer (PI5) is prevalent in only two countries: Denmark and Sweden**, which, according to the European Innovation Scoreboard, are the leading innovators in Europe. In mature innovation ecosystems, where actors from both enterprise and research have good capability levels, the focus was on linking the two (to address network failures).

[73] The OP "Science and Education for Smart Growth" invested all the funding under the priority axis "Scientific research and technological development" in infrastructure investments, in view of the lack of physical infrastructures able to produce excellent research and translate it into innovation. The OP targeted both aspects, financing the development of Centres of Excellence (PI1) and of Competence Centres (PI2), and leveraging consortia with multiple partners.

Figure 22. Share of total eligible expenditure by policy instruments across countries

Country	PI 1 Infrastructure investments for research	PI 2 Infrastructure investments for technology transfer and innovation	PI 3 Research activities in universities /research centres	PI 4 Science – industry collaborative RDI projects	PI 5 Indirect support for technology transfer	PI 6 Research activities in businesses	PI 7 Business investments to support innovation uptake	PI 8 Capacity building for innovation in businesses
AT	4.87%	11.87%	6.02%	7.52%	5.81%	63.91%	0.00%	0.00%
BE	17.27%	10.10%	16.98%	2.67%	8.81%	34.32%	8.10%	1.75%
BG	27.98%	29.01%	0.00%	0.00%	5.92%	13.31%	23.78%	0.00%
CY	64.90%	0.00%	14.42%	0.00%	0.00%	11.59%	8.94%	0.16%
CZ	12.90%	3.37%	0.17%	24.84%	1.89%	22.34%	34.31%	0.18%
DE	24.73%	3.33%	12.06%	31.38%	6.06%	21.49%	0.94%	0.00%
DK	0.00%	0.00%	0.00%	31.51%	68.49%	0.00%	0.00%	0.00%
EE	10.57%	0.00%	31.00%	13.37%	8.87%	36.20%	0.00%	0.00%
ES	17.49%	1.18%	28.89%	4.04%	1.44%	46.74%	0.21%	0.01%
FI	6.61%	2.54%	6.42%	59.68%	8.92%	12.30%	3.34%	0.18%
FR	24.69%	3.05%	14.17%	20.62%	6.61%	26.64%	3.96%	0.26%
GR	3.26%	0.26%	46.32%	9.37%	3.02%	35.77%	0.73%	1.27%
HR	24.78%	12.71%	0.96%	13.32%	1.93%	46.30%	0.00%	0.00%
HU	16.59%	0.00%	8.89%	18.14%	0.76%	46.56%	9.01%	0.04%
IE	0.00%	0.00%	43.51%	48.10%	0.00%	8.39%	0.00%	0.00%
IT	10.83%	0.22%	3.94%	24.80%	2.74%	47.74%	7.71%	2.02%

LT	14.21%	6.85%	6.44%	19.28%	5.86%	44.09%	1.81%	1.47%
LU	70.89%	0.00%	26.15%	2.96%	0.00%	0.00%	0.00%	0.00%
LV	19.34%	0.00%	17.90%	20.82%	9.03%	14.37%	17.71%	0.82%
MT	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
NL	0.05%	5.34%	0.72%	58.49%	7.24%	27.23%	0.91%	0.02%
PL	7.57%	1.11%	2.11%	3.70%	1.85%	53.95%	29.37%	0.34%
PT	2.81%	1.77%	14.34%	21.12%	1.98%	56.69%	1.20%	0.10%
RO	46.67%	0.59%	12.08%	18.52%	3.67%	18.47%	0.00%	0.00%
SE	9.51%	0.00%	0.00%	31.25%	59.24%	0.00%	0.00%	0.00%
SI	12.73%	0.00%	1.39%	15.90%	4.50%	62.24%	0.00%	3.24%
SK	19.46%	1.77%	7.72%	20.70%	4.43%	3.20%	42.64%	0.08%
TC	2.92%	0.06%	4.44%	79.80%	8.50%	4.08%	0.09%	0.11%
UK	4.71%	4.82%	2.84%	51.97%	10.37%	15.14%	6.62%	3.52%
Total	**13.12%**	**2.30%**	**9.65%**	**19.72%**	**4.28%**	**38.58%**	**11.86%**	**0.49%**

Note: TC stands for transnational cooperation – Interreg.

Source: Prognos / CSIL / Visionary Analytics (2024) based on WP2 expenditure data (last update: end of 2020).

4. Key evaluation findings

Chapter 4 of this report employs a Theory of Change approach to provide a comprehensive analysis of the design, implementation process, and outcomes of ERDF RTDI support in the 2014-2020 period. Section

Strategic approaches to RTDI support under Cohesion Policy examines the strategic approaches, emphasising the value of targeting investments through Smart Specialisation Strategies (S3), the necessity for enhanced policy mix articulation, and the potential of financial instruments in conjunction with the predominant grants. Section Implementation: a view on the disbursement process of RTDI support under ERDF 2014-2020 reviews the disbursement process of RTDI support under ERDF 2014-2020. Sections From projects and operations to tangible outputs of RTDI support and Moving from projects to tangible and intangible outcomes of RTDI support for beneficiaries discuss the tangible and intangible outputs and outcomes of RTDI projects, with a particular focus on the enhancement of R&I infrastructure, knowledge production and transfer, and collaborations. Finally, Section ERDF contribution to the convergence in innovation performance across EU regions examines the ERDF's role in fostering innovation performance convergence across EU regions.

The key takeaways from this chapter are outlined in the box below.

KEY TAKEAWAYS

- **Targeting and priority selection**: Regional and national S3s have been used to thematically direct ERDF support for RTDI towards selected priority sectors to a significant extent. Yet there is scope for improvement in how S3s are designed, especially in relation to their breadth, depth, and selection of thematic priorities.
- **Articulation of the policy mix**: Though the ERDF has gained a certain centrality within the policy mix to support RTDI, a synergetic articulation with other sources of support is still missing. Synergies with Horizon 2020 exist but could be improved both upstream and downstream.
- **Mode of delivery**: Grants have predominated as a mode of delivery in a context in which implementing financial instruments was difficult (low interest rates initially and COVID-19 pandemic subsequently). Yet financial instruments, though difficult to implement, have significant potential to support the knowledge valorisation phase of the innovation cycle.
- **Implementation**: The disbursement of grant-based ERDF support measures to RTDI, which constituted the bulk (91.5%) of support measures, proceeded smoothly. However, financial instruments suffered from crowding out effects from the support provided in the wake of the COVID-19 pandemic. It proved more difficult to implement infrastructure-related support compared to other types of support.
- **Enhancement of R&I infrastructure and capacities**: ERDF has supported the creation and modernisation of R&I infrastructure and the enhancement of institutional capacities. Nevertheless, some implementation and use challenges occurred, primarily due to the lack of strategic planning.
- **Knowledge creation and diffusion**: ERDF investments in RTDI have played a substantial role in knowledge production and dissemination, as evidenced by: 1) more than 138,000 scientific publications in credible journals that have acknowledged the

receipt of ERDF support in the 2014-2020 period; 2) nearly 79,000 scientific publications by ERDF RTDI beneficiaries.

- **Collaborations:** The ERDF has stimulated knowledge sharing and the formation of regional partnerships, primarily through science-industry collaborative RDI projects, which represent the second largest RTDI policy instrument. The output indicator demonstrates that by the end of 2022, the ERDF supported more than 75,500 enterprises in collaboration with research institutions, exceeding the target value by 115%. The majority of publications by ERDF RTDI beneficiaries between 2016 and 2023 (60,000) were from science-industry collaborative RDI projects**,** irrespective of the type of Cohesion Region.
- **Technological development**: The ERDF has made a significant contribution to the technological advancement of EU regions, with over 7,000 registered patents that build upon the knowledge generated by the ERDF RTDI support. The micro-level data collected for this evaluation demonstrates that, on a per capita basis, the highest number of these patents that build upon the knowledge generated by the ERDF RTDI support are found in Western Europe (especially in Portugal and the Netherlands), the Nordic countries (especially Denmark and Finland) as well as Estonia. Almost 50% of these patent registrations are associated with a broad domain of "human necessities", encompassing a diverse range of technologies that have a direct impact on people's daily lives. Conversely, 45% of these patent registrations are directly linked to STEM-related domains, including chemistry, metallurgy, physics, and electricity.
- **Systemic effects:** Although the reported outcomes for beneficiaries are meaningful, the evaluation has identified only preliminary indications that ERDF support for RTDI has resulted in discernible effects at the regional level. The extent to which ERDF instruments have contributed to more systemic effects and overall change in regional research and innovation performance remains uncertain due to the long-term nature of outcomes, the presence of multiple external factors (i.e., economic conditions, policy changes, market dynamics), as well as funding sources and initiatives supporting RTDI.

4.1. Strategic approaches to RTDI support under Cohesion Policy

4.1.1. Targeting investments through S3 strategies is beneficial, but only to the extent that S3s reflect the underlying economic and technological specialisations.

In an effort to improve the efficiency and the targeting of ESIF support to RTDI, during the 2014-2020 programming period, the European Commission introduced the requirement – under the form of an ex-ante conditionality – for European regions to develop a Research and Innovation strategy for Smart Specialisation Strategy (S3, see also Section Rationale to support RTDI within Cohesion Policy). Doing so required European regions to identify, based on their regional comparative advantages and their scientific and technological specialisations, a number of “priority areas” within which to seek more “coordination among entrepreneurial activities” which would be favoured by “targeted public support”, in an overall effort to boost regional innovation performance.[74] Section Investments in Smart Specialisation Strategies under Cohesion Policy 2014-2020 already illustrated that

[74] Foray et al (2021): Smart specialization strategies—insights gained from a unique European policy experiment on innovation and industrial policy design. In Review of Evolutionary Political Economy

alignment between ERDF spending and S3 strategies was, on the whole, satisfactory, since roughly 68% (EUR 42.1bn out of EUR 61.6bn) was spent on operations thematically aligned to the respective S3 priority areas. In analysing alignment quantitatively and qualitatively (through interviews), the evaluation uncovered a significant body of evidence that, when combined with existing literature, also allowed for a normative assessment of whether the S3 paradigm is effective for reaching the objective of improving regional innovation performance through targeted public support. Ultimately, the **evaluation has concluded that while the regional S3 did indeed function as a strategic framework to target investments, its effectiveness as a targeting vehicle is conditional on the proper application of the prioritisation logic during the design of the S3 strategy**. What follows will illustrate these findings more in detail. As described in Section Investments in Smart Specialisation Strategies under Cohesion Policy 2014-2020, roughly 64% of all ERDF operations to support RTDI in the 2014-2020 period could be thematically matched to the S3 priority areas of the regions in which they were undertaken. These operations accounted for 68% of the ERDF budget dedicated to supporting RTDI across the EU27 countries. It is thus clear that ERDF Managing Authorities made, when deemed appropriate, an attempt to target ERDF support towards S3 related areas. Figure 19. shows that, though this occurred with varying intensity across European regions, the majority of Managing Authorities directed at least 50% of the budget for supporting RTDI towards the priority areas identified in the S3 strategies. The use of S3s as a tool for directionality is also confirmed by qualitative evidence: the majority of the MAs interviewed as part of the evaluation confirmed that the S3 approach allowed for prioritisation and gave form to a more coherent approach to spending ERDF funds earmarked for RTDI support. Considering that the S3 paradigm represented a novelty for ESIF programming in the 2014-2020 period, such feedback can be welcomed positively. The novelty of the S3 paradigm also helps to explain why the overall levels of thematic alignment are not higher. Though all ERDF expenditure was, in broad terms, linked to the underlying regional S3 strategy, the specific targeting of S3 *priority areas* also implies reducing the funding envelope for non-priority areas. Especially in regions with a less articulated policy mix for supporting RTDI, an excessive emphasis on thematically aligning expenditure would have led to, amongst others, difficulties in ensuring fund absorption. In other words, managing authorities of less developed and transition regions, where the ERDF constitutes the bulk of support for RTDI (see Section Articulation of the policy mix: Improving strategic policy planning with better utilisation of synergistic funding approaches), preferred not to run the risk of aligning ERDF expenditure with too few priority areas, in order to avoid excessive concentration of funding and thereby run into absorption problems. All in all, however, **the evidence collected as part of the evaluation indicates that Managing Authorities were able to thematically direct RTDI funding to the selected priority areas to a relevant degree and to this extent at least, the introduction of the S3 framework can be said to have contributed to the desired directionality of support**.

This general finding must be complemented by a more articulated reflection on the appropriateness of S3 strategies as a framework for targeting public support for RTDI. The appropriateness must be assessed against the backdrop of the overall intent of the S3 paradigm, which, according to Foray, is to "*design an innovation policy whose goal is the creation and development of networks of innovators in order to generate some desired structural changes within the framework of a regional economy.*"[75]. To this end, Foray calls for identifying a small number of priority areas and supporting the development of the corresponding "transformative activities", namely collective action to build "*a collection of related innovation capacities and actions, all [of which are] oriented towards [delivering] a certain structural change.*" Recent conceptualisations of how policymakers should go about doing so hold that two components should coexist within this process: a top-down planning component, through which policymakers identify the priority areas of interest for the S3

[75] Foray et al (2021): Smart specialization strategies—insights gained from a unique European policy experiment on innovation and industrial policy design. In Review of Evolutionary Political Economy

strategy based on an in-depth quantitative and qualitative mapping (incl. comprehensive stakeholder consultations), and a bottom-up, decentralised discovery process in which the stakeholders of the innovation ecosystem combine their unique knowledge to trace – step by step – a path towards achieving the transformative activity. In this latter component lies the *Entrepreneurial Discovery Process* (EDP) of the S3 strategies. Within this framework, policymakers thus play a twofold role: on the one hand, they must identify priority areas that reflect regional specialisation characteristics, including by leveraging public consultations with the stakeholders concerned[76]; on the other, they must facilitate within every selected priority area the discovery process that, through the decentralised interaction of stakeholders, gives "direction" to the innovation process.

The evidence that has emerged from the evaluation suggests that **policymakers have struggled with both of these responsibilities**. In particular, significant difficulties have emerged in relation to the choice of priority areas. Three issues have been identified in this respect:

1. **Breadth of S3**: often, Managing Authorities have selected too many priority areas, giving rise to S3 strategies that are too broad. During the interviews conducted, several Managing Authorities (PL, EE) acknowledged that **such broad strategies did not enable effective prioritisation**, in that they did not target sufficient ERDF funding within a priority area so as to achieve the "critical mass" which could affect the innovative performance of the sector concerned.
2. **Depth of S3**: several regions chose as "priority areas" very broad economic sectors (e.g., *mobility*) without complementing the selection with a higher level of granularity (i.e. *which specific transformational activities and sub-sectors within the mobility sector should be prioritised?*). In this respect, Foray et al (2021)[77] is clear that "**the appropriate level of granularity at which the S3 must materialize**" **is at the level of the 'transformational activity', not at the level of the selected area of strategic priority**. Existing literature indicates that "policy priorities are defined in line with a multilevel, tree-like structure whose higher hierarchical level usually contains a few broad dimensions, and whose branches cover several specific activities".[78]
3. **Thematic alignment of S3**: in some cases, the priority areas selected for specialisation simply do not reflect existing regional comparative advantages nor the regional technological or scientific specialisations.

Several prior studies corroborate this qualitative finding. As regards the thematic alignment of S3 strategies with the strengths of the regional economy, the *Study on prioritisation in Smart Specialisation Strategies in the EU*[79] found that, though the priority areas chosen in the regional S3 strategies often "do not match the economic profiles of the respective regions", they rather reflected the respective scientific and technological specialisations. This finding was derived via the computation of unique scores for the aforementioned

[76] In the 2021 paper "*Smart specialization strategies – insights gained from a unique European policy experiment on innovation and industrial policy design*", Foray et al. stress that though priority areas should be selected by leveraging stakeholder consultation processes, these should be "*simple participatory processes"*. Indeed, they stress that "*the selection of priority areas is not done through an entrepreneurial discovery process (EDP)*"; the latter is a more articulated, dynamic and longer process that allows regional innovation stakeholders to trace and continuously shape the transformational activity sought within priority area.

[77] Foray et al (2021): Smart specialization strategies—insights gained from a unique European policy experiment on innovation and industrial policy design. In Review of Evolutionary Political Economy

[78] Gianelle, C., Guzzo, F., & Mieszkowski, K. (2019). Smart Specialisation: what gets lost in translation from concept to practice? Regional Studies, 54(10), 1377–1388. https://doi.org/10.1080/00343404.2019.1607970

[79] Prognos & CSIL (2021): Study on prioritisation in Smart Specialisation Strategies in the EU. Study commissioned by DG REGIO. Available online: https://op.europa.eu/o/opportal-service/download-handler?identifier=fd1c28cd-fb18-11eb-b520-01aa75ed71a1&format=pdf&language=en&productionSystem=cellar&part= (last access 10.08.2023

regional characteristics (economic, technological and scientific profile). An analysis within this ex-post evaluation shows that a statistically significant relationship exists between the degree (measured as the unique score) to which a regional S3 reflects the underlying regional economic and technological specialisation and the extent to which Managing Authorities were able to direct ERDF funding towards S3 priorities. That is, **the more regional S3s reflected the underlying economic and technological profiles, the more successful Managing Authorities were in targeting ERDF RTDI support towards the selected priority areas**. Though this finding should not come as a surprise – the stakeholders in selected S3 priority areas should be relatively more numerous and thereby have a higher absorption capacity – it nonetheless indicates that **when the prioritisation logic is applied correctly the S3 framework can indeed be an adequate one for targeting ERDF RTDI investments**.

This finding is reinforced by existing analyses of regional S3 strategies, such as that contained in the *Analysis of key parameters of Smart Specialisation Strategies*.[80] The study uses existing literature to identify the characteristics of potentially beneficial S3s based on the technological opportunities existing within regions[81]. To do so, it relies on the concepts of relatedness density – i.e., *the degree to which the technologies produced in the region are related to each other and to existing capabilities and are able to diversify into new technologies easily* – and knowledge complexity – i.e., *the degree of sophistication of the technologies produced*. Theoretically, regions (including countries) would benefit the most from reducing their reliance on low-value-adding activities and low complexity technologies, by upgrading towards more complex activities. Diversification towards more complex technologies is relatively easier or less risky when it builds on inputs related to those already present in the economy (e.g. complementary skills and/or knowledge)[82]. Hence, regions with higher technological relatedness density are in an advantageous position. Because they already have competences and knowledge in several fields, diversification into related fields is expected to be more achievable. Based on this framework, Prognos/CSIL defined **four potential Smart Specialisation Strategies[83]**:

1. **S3 as the "High Road Strategy":** These regions enjoy technological capacities closely connected to their production structure (high relatedness) that simultaneously allow for upgrading (to higher complexity). This can be defined as a "high road strategy". A strategy focused on these technological areas would be both beneficial and a safe bet. Not all regions have the luxury of opting for this strategy because it is available only when regions possess capabilities in a good number of high-value-added areas.
2. **S3 as the "Casino Strategy":** Another scenario that yields high benefits in terms of sophistication of the production structure (high complexity) would require regions to accept higher risks. In such a scenario, diversification would be towards technological areas that are distant from the technological specialisation of the region (low relatedness). Due to the high risks involved with this strategy, this policy is referred to as the "Casino Strategy."

[80] Prognos & CSIL (2022): Analysis of key parameters of Smart Specialisation Strategies (S3). Study commissioned by DG REGIO. Available online: https://op.europa.eu/o/opportal-service/download-handler?identifier=3026007b-8be2-11ed-999b-01aa75ed71a1&format=pdf&language=de,en,fr&productionSystem=cellar&part= (last access 10.08.2023).

[81] Balland, P., Boschma, R. 2019a. 'Exploring the Impact of Inter-Regional Linkages on Regional Diversification in Europe in the Context of Smart Specialisation'. DG Regional and Urban Policy. Brussels: European Commission.

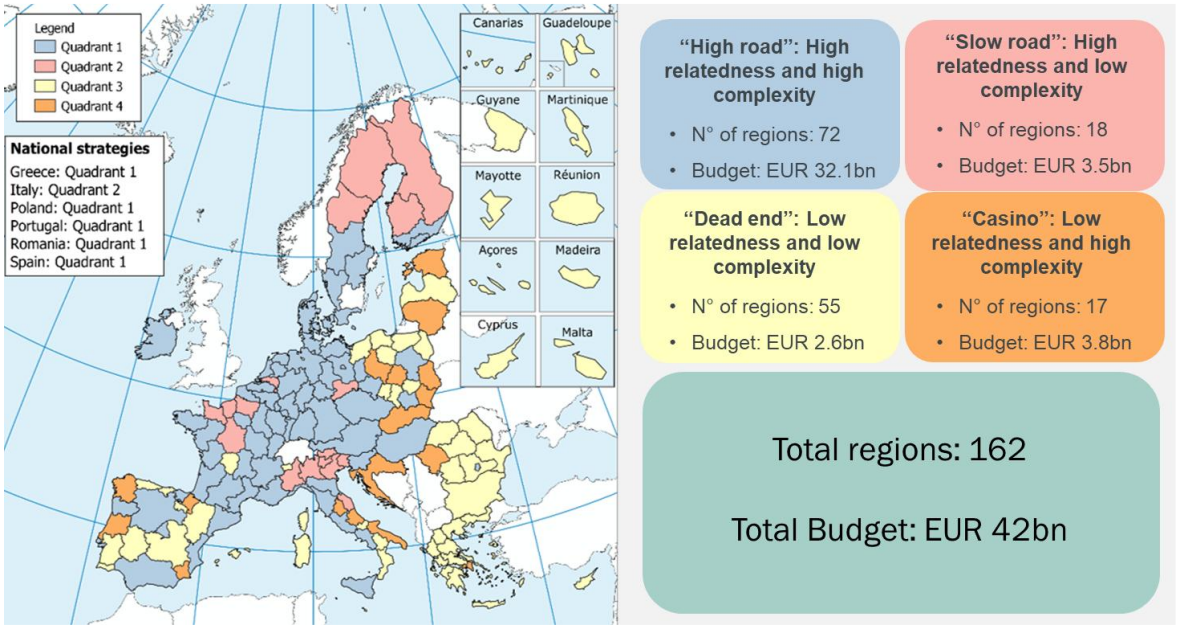
[82] Pinheiro, F.L., Hartmann, D., Boschma, R., Hidalgo, C.A., (2021). "The time and frequency of unrelated diversification". Research Policy, 104323.

[83] Prognos & CSIL (2022): Analysis of key parameters of Smart Specialisation Strategies (S3). Study commissioned by DG REGIO. Available online: https://op.europa.eu/o/opportal-service/download-handler?identifier=3026007b-8be2-11ed-999b-01aa75ed71a1&format=pdf&language=de,en,fr&productionSystem=cellar&part= (last access 10.08.2023).

3. **S3 as the "Slow Road Strategy":** The region could diversify into areas having strong linkages with its technological profile (high relatedness) but low benefits in terms of upgrading (low complexity). The approach can be named the "Slow Road Strategy" as slow progress is expected - but at least there will be progress.
4. **S3 as the "Dead-End Strategy":** The fourth and last scenario would lead regions to focus on technological opportunities that share few commonalities with existing production assets (low relatedness) and, at the same time, do not allow for upgrading into more promising technological areas (low complexity). Such a "Dead-End Strategy" is unlikely to benefit the region as it will consume resources without resulting in significant economic progress.

Most of the ERDF support for RTDI has been dedicated to "High-Road" S3 strategies, with EUR 32 billion out of EUR 42 billion allocated under the ERDF 2014-2020 (Figure 23.). In other words, 76% of ERDF support to RTDI has been directed towards beneficiaries by means of S3 strategies that are able to avail of the full spectre of regional development opportunities. It is worth highlighting that the majority of the "High-Road" S3 strategies are from regions that tend to have stronger innovation ecosystems (see Figure 23.). Around EUR 3.8bn of the budget is allocated to S3 that are classified as "Casino Strategies". Although this type of strategy can yield high benefits, it should be noted that many of these strategies are located in regions with less mature innovation ecosystems, which raises the question of whether the potential benefits of this type of strategy could be realised. Notably, 32% of the analysed regions (55 out of 162) did not have adequate S3 strategies in place according to this framework, yet these accounted for only EUR 2.6bn of expenditure, indicating that where S3 strategies are not appropriate, Managing Authorities face more of a challenge, or see less of a benefit in directing their RTDI support through the S3 vehicle.

Figure 23. Breakdown of S3 strategies by typology and number of regions



Source: Prognos / CSIL / Visionary Analytics (2024) based on the "*Analysis of key parameters of Smart Specialisation Strategies (Prognos & CSIL, 2022)*"

All in all, though the introduction of the S3 paradigm has provided a framework for prioritisation and thus the targeting of ERDF support, it can be concluded that **targeting investments by means of an S3 strategy is effective as a means of boosting regional innovation performance only to the extent that the underlying S3 strategy is able to direct investments towards the more promising fields**. In light of this, policymakers should place more emphasis on ensuring that the regional S3s be neither too broad nor too superficial and that they reflect regional comparative advantages and technological and

scientific specialisations. Only when the targeting vehicle (S3) is fit for use will the prioritisation logic permit full delivery of the objectives of ERDF support to RTDI.

4.1.2. Articulation of the policy mix: Improving strategic policy planning with better utilisation of synergistic funding approaches

This section leverages interviews with Managing Authorities, a review of Regional/ National Operational Programmes and a mix of quantitative evidence to outline the role that the ERDF occupies within the policy mix of European regions. It builds on Section The policy mix across countries and regions. to showcase patterns of ERDF use, assess the adequacy of ERDF resource allocation within the overall RTDI support policy mix, and look at the capacity of Managing Authorities to establish synergies with other forms of support for RTDI, such as national/regional and EU support measures. Specific attention is given to synergies with the Horizon 2020 programme.

The description of the RDTI policy mix across the EU27+UK provided in Section The policy mix across countries and regions has identified the following:

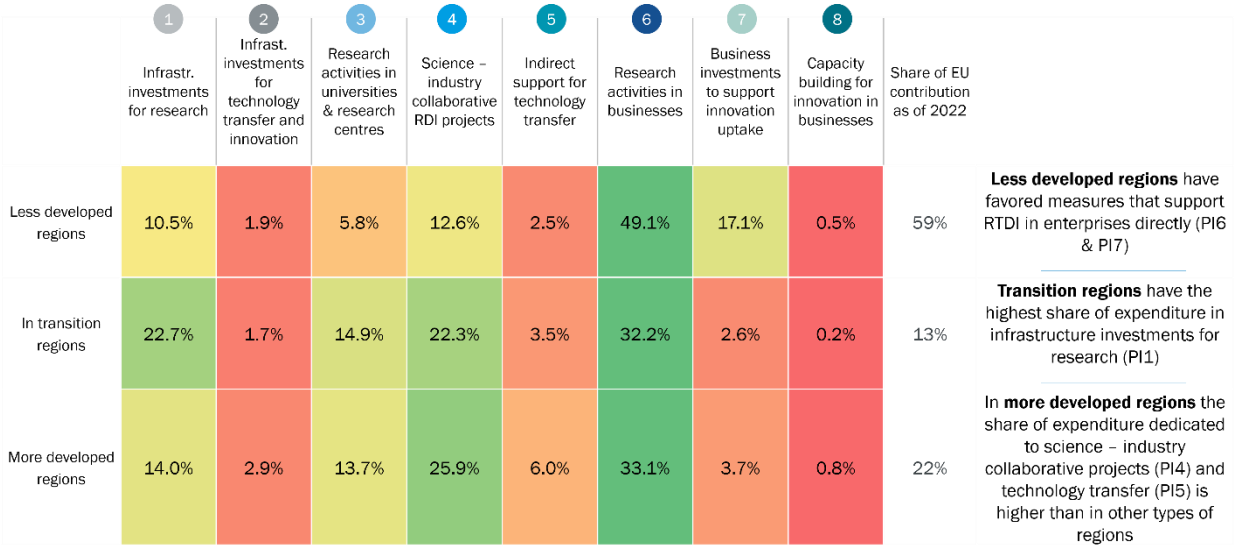
The RTDI policy mix was generally stable during the programming period: Only a minority of countries and regions experienced alterations such as slight changes in total funding for RTD, reallocation of funding between PIs and adjustment in the programme's focus, objectives, or instruments.

Support for research activities in business (PI6) was the most used PI across the board, although it was more prominent in EU13 countries than in the EU14+UK. The differentiation according to the category of Cohesion Regions has shown that:

- **Less developed regions** have prioritized measures directly supporting RTDI activities in private enterprises.
- **Transition regions** allocated a significant portion of their expenditure to infrastructure for research, reflecting a need to enhance infrastructure to facilitate research scaling.
- In **more developed regions**, where established intermediary organisations and networks exist, there was a higher share of expenditure dedicated to supporting technology transfer and science-industry collaborative projects compared to the other types of regions.

Figure 24. recaps the distribution of investments by type of region. These data act as the first building block for a normative assessment of the ERDF's existing placement within national and regional policy mixes. The subsequent assessment looks at what the ERDF's role within the policy mix is, the extent to which ERDF support is coherent with other RTDI support measures, and whether potential synergies with these have been adequately sought.

Figure 24. Breakdown of spending by policy instrument and type of Cohesion Region



Source: Prognos / CSIL / Visionary Analytics (2024)

ERDF centrality for RTDI support depends on the articulation of the policy mix

A baseline finding in this respect is that **the ERDF has come to represent an established source of support for RTDI activities in all EU regions**. **However, its centrality depends on the extent to which the local policy mix is articulated and developed.** The case studies have shown that the ERDF is even more central the less the policy mix of a given region is developed. This is best illustrated by two examples that lie at the opposite extremes: on one side lies the Belgian region of Flanders, which decided to use its entire ERDF allocation to fund one measure – dedicated to supporting infrastructure investments (mostly for technology transfer (PI2) and only residually for research purposes (PI1)) – while on the other side lie several less developed regions, where there is little support for RTDI other than that funded by the ERDF regional OP (i.e. Croatia, Romania). Given that more developed innovation ecosystems tend to be supported by better articulated policy mixes, it is not a surprise that the ERDF was less central in more developed regions, being used there to fill a known gap in the policy mix. This latter case occurred for infrastructure development in Italy, where part of the ERDF allocation flowed into a dedicated fund for infrastructure investments (FUIR), which was used to finance infrastructure projects following priorities identified in the National Plan for Research Infrastructure (PNRI). In addition, the case studies have shown that a relatively common approach in developed regions (FR, DE, NL) was to earmark ERDF funding for a specific phase of the innovation cycle, in order to complement national measures that focused on other phases. In contrast, countries and regions whose policy mix was less developed – that is, many of the less developed and transition regions, including Croatia and Romania – tended to structure the suite of RTDI support measures (and their entire national RTDI strategy) around an ERDF-funded core of measures.

The excessive dependence on ESIF funding in certain EU countries and regions should be cause for concern. Indeed, the interviews with Managing Authorities in countries such as Lithuania recurrently highlighted the complications arising from an RTDI policy mix that depended almost entirely on ERDF/ESIF funding. Among these are the significant fluctuations in potential financing volumes that such dependency entails, as well as the potential incentive distortions and inefficiencies that arise from the ”political obligation” of ensuring high absorption rates. More specifically, as literature on excessive dependencies

in the Baltic countries demonstrates[84], the overreliance on EU funds for RTDI support measures has given rise to a flurry of investments that do not always align with an underlying vision for the development of the national or regional RTDI ecosystem. For example, the case study on infrastructure investments for research has shown that, in Lithuania, investments in RTDI infrastructure do not always align with the needs of private sector stakeholders, thereby limiting their overall utility within the innovation ecosystem and making their sustainability dependent on acquiring additional funding in future programming periods. This dependency has negative implications should EU support be reduced in follow-up programming periods, as there is no adequate substitute for this source of funding. Similarly, the consistent support for research activities in businesses has led to an increase in the number of enterprises that rely on ERDF funding in their business plan.[85] This should be a cause for concern for less developed regions, which devoted 49.1% of ERDF investments towards supporting research activities in businesses. As these regions often heavily rely on ERDF funding for RTDI support, with little other forms of support being readily available, the wisdom of dedicating roughly half of the ERDF allocation towards research activities in businesses but only a meagre percentage for capacity-building measures must be questioned, given that the endogenous capacities for innovation of business in such regions are often limited[86]. In this respect, it would be more beneficial to devote a higher share of ERDF support towards building the capacity that is required for innovation to occur. In sum, this finding underscores the need for regions that rely extensively on EU funding to ensure that RTDI investments are, to the extent possible, enshrined in a strategic vision and that they respond to the specific needs of the local innovation ecosystem rather than to the pressure of ensuring "absorption" at any cost – a behaviour which only increases the risk of reiterating existing dependencies.

Having established this, a second important aspect in relation to the ERDF's role within the policy mix relates to Managing Authorities' capacity to achieve coherence within the overall policy mix and give rise to synergies between different sources of RTDI support, including other ESIF funding and H2020 measures. Concerning coherence, the evaluation finds that **Managing Authorities united ERDF support and other EU-level instruments into a comprehensive mix of policies** in most instances. However, the mechanisms that helped the cases to achieve high degrees of policy coherence differed: in some cases, coherence was the result of policy design and was envisioned ex-ante, thereby allowing for potential synergies, whereas in others it was rather "incidental" – i.e. more the fruit of efforts to avoid overlaps between support measures than the result of a comprehensive policy-planning exercise (**Error! Reference source not found.**, below, provides examples on how coherence was achieved). Where it was envisioned ex-ante, Managing Authorities employed **several different demarcation mechanisms**, such as earmarking ERDF funding for specific phases of the innovation cycle (e.g. BE, DE, FR), targeting funding towards beneficiaries who had already undertaken projects under the previous programming period (RO, LT) – leveraging their experience to ensure absorption – or pooling ERDF funds with national funding in a common pot that was used to fund previously identified investment priorities (DE, IT). The case studies performed as part of the evaluation revealed several notable examples of ex-ante policy designs that ensured coherence between support measures. For instance, in Flanders (analysed within PI2 "Infrastructure investments for technology transfer and innovation") the ERDF Managing Authority (VLAIO), after documenting a specific demand during the previous programming

[84] Varblane, Urmas, EU Structural Funds in the Baltic Countries – Useful or Harmful? (June 7, 2016). Estonian Discussions on Economic Policy Vol 24, No. 2, 2016, Available at SSRN: https://ssrn.com/abstract=2892991 or http://dx.doi.org/10.2139/ssrn.2892991

[85] Ibidem.

[86] Tsipouri, L. (2018), "Fostering innovation in less-developed regions (with low institutional capacity)", Background paper for an OECD/EC Workshop on 22 June 2018 within the workshop series "Broadening innovation policy: New insights for regions and cities", Paris.

period, earmarked the entire ERDF allocation to investments in infrastructure necessary for knowledge valorisation. Given that it manages all RTDI-related supports in the region (except for a few selected grants for fundamental research), it was able to insert ERDF support within a comprehensive policy mix which covered all phases of the innovation cycle. The mix also included an ESF+ allocation to subsidise the employment of researchers for the specific infrastructure set up through ERDF support, as well as other regional support measures that covered specific phases of the innovation cycle. Finally, to ensure dynamic alignment, VLAIO set up a joint monitoring committee, to ensure synergies with other ESIFs, which meets once a year. VLAIO was thus able to set up a coherent policy mix and direct potential beneficiaries towards the most adequate support measure for their project, intending to ensure the synergetic use of support measures. Synergies between ERDF support and the Digital Europe programme were thereby identified, and the MA reported that a good share of the ERDF-funded projects build on the results of previous Horizon 2020 projects. All in all, though the capacity to ensure coherence and synergies varied substantially – and indeed depended upon the experience of Managing Authorities – the evaluation has found that overall, more than half of the analysed OPs complemented other national / regional policy interventions. A particularly high degree of complementarity was observed for the policy instruments “science – industry collaborative RDI projects”, “infrastructure investments for research” and “research activities in businesses”. Within this generally positive assessment, it is nonetheless **worthwhile to note that, in the case of financial instruments, coherence proved to be more difficult to achieve**, also considering the need to design instruments that could, notwithstanding a change in the underlying financial market circumstances, compete with private capital offers. Indeed, evidence has emerged suggesting that financial instruments suffered significantly from the crowding out effects arising from the financial support offered to offset the effects of the COVID-19 pandemic, though this should be read more as the result of a lack of flexibility in the conditions under which financial instruments are offered, rather than as an ex-ante policy-coordination failure (see Section Grants predominate as the mode of delivery in a policy area that involves high-risk projects, but financial instruments have untapped potential for more details on financial instruments).

Box 4. Case examples: Mechanisms to ensure synergies

In **Flanders** (Belgium), the MA has installed a joint monitoring committee to ensure synergies with other ESIFs. It meets at least once per year and aims to exchange synergies of projects and lessons learned and is an example of strengthened cooperation. In addition to this formal mechanism, there are also informal day-to-day exchanges between the people responsible for the management of the different funds.

In Greece (**Central Macedonia**), RTDI measures supporting the private sector, are complemented with actions for enhancing SME competitiveness and entrepreneurship. Combined, they served the objectives of the overall regional development strategy which is the transition of the regional economy into a new and sustainable production model with competitiveness, extroversion, innovative entrepreneurship, and smart and friendly use of key enabling technologies, especially ICT.

The ERDF dominates RDI project spending in **Slovakia**. The Slovak Government pointed to substantial resources provided by the ERDF and limited national project spending. Each ERDF call must identify synergies with national and/or European funding. As for national funding, the OP calls mostly refer to projects by the Slovak Research and Development Agency in the case of science–industry collaborative RDI projects, applied research projects and innovation projects. Given the low volume of national funding, it is difficult to say whether the synergies are successful or not. There is no regional funding for RDI in Slovakia.

Estonia has been heavily dependent on funding from EU Cohesion Funds. The role of national resources is rather limited in Estonia and the majority of support measures are funded using EU structural funds. However, there are still some nationally funded support measures, mostly provided by Enterprise Estonia and, to a smaller extent, by municipalities. For instance, the Programme for Applied Research supports the development of innovative products in order to grow companies' income by developing new or significantly enhanced technologies, processes, products or services. There is no specific coordination mechanism for the support; however, since Estonia is rather small, the coordination of these support schemes and ERDF-funded instruments is often achieved by personal connections and between people working in the same information space.

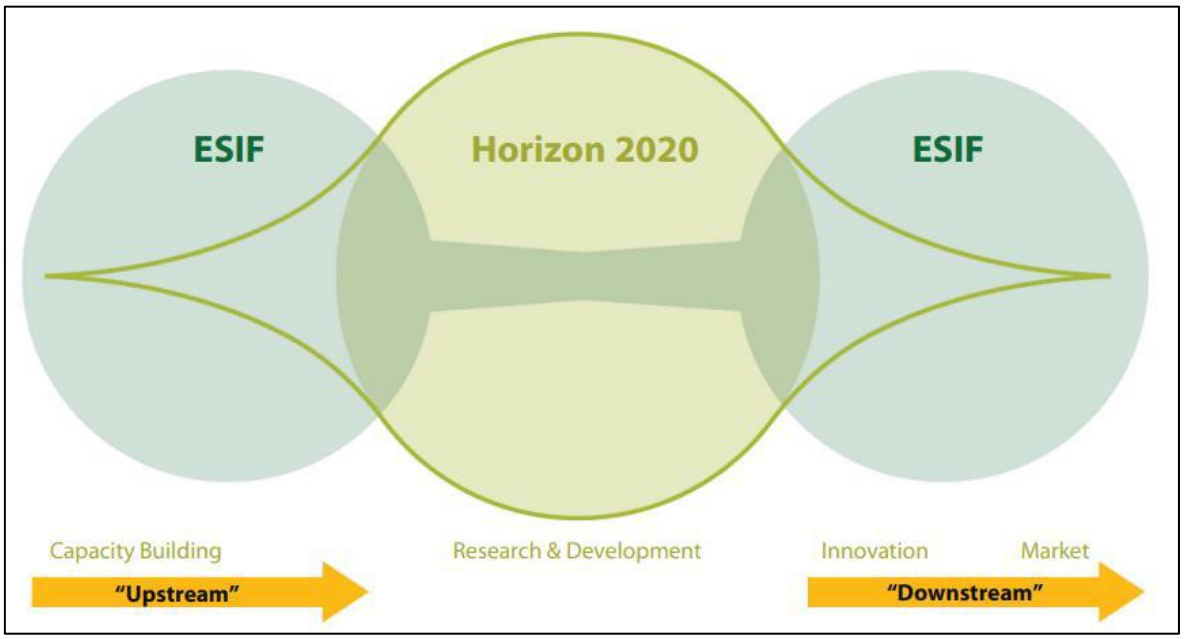
Source: Prognos / CSIL / Visionary Analytics (2024)

Synergies between the ERDF and H2020 programmes

Finally, particular attention during the evaluation has been paid to assessing synergies between the ERDF support for RTDI and that provided through Horizon 2020. **A significant effort to ensure synergies was made by the regulator in this respect.** Indeed, the Common Provisions Regulation included provisions indicating that regional and national Smart Specialisation Strategies should include actions to provide the means to exploit and diffuse R&I results stemming from H2020 into the market. To assess these synergies, the evaluation leveraged the conceptual framework of the **"Stairway to Excellence" stimulus**, which envisioned both upstream and downstream synergies. The former refers to using ERDF to fund actions that build R&I capacities needed to compete in Horizon 2020, while downstream synergies are those that seek to leverage the ERDF to fund actions that capitalize on already implemented Horizon 2020 projects. This framework, provided within the European Court of Auditors (ECA) special report on synergies between H2020 and ESIFs (2022)[87], is presented in the Figure below.

[87] See: Special Report 23/2022: Synergies between Horizon 2020 and European Structural and Investment Funds (europa.eu)

Figure 25. Schematic representation of the Stairway to Excellence approach to synergies



Source: European Court of Auditors (2020).

As outlined in Section Mixed methods analytical approach, the evaluation leveraged an "approximate String Matching" data-analysis technique to link beneficiaries of ERDF RTDI support 2014-2020 with those of Horizon 2020 (H2020), breaking down beneficiaries by Cohesion Regions and EU13/14 (see Annex IV for a detailed description). **The quantitative data available on the synergies between ERDF and Horizon 2020 funding indicates that 9.65% of ERDF RTDI beneficiaries also received funding under Horizon 2020 (in absolute terms, 6,002 out of the identified 62,194 beneficiaries) in the 2014-2020 funding period.** These beneficiaries (henceforth: "*dual beneficiaries*") accounted for 21.5% of all ERDF RTDI participations, suggesting that they possess a relatively higher capacity to apply for and absorb ERDF support compared to the remaining 90.3% of ERDF beneficiaries that did not receive H2020 funding. The regional distribution of the ERDF beneficiaries with H2020 funding shows that 71.4% come from more developed, 12.2% from transition, and 16.4% from less developed regions while splitting the beneficiaries by EU13/15 shows that 79.3% come from EU14, 12.7% from EU13, and 8.1% come from non-EU countries.

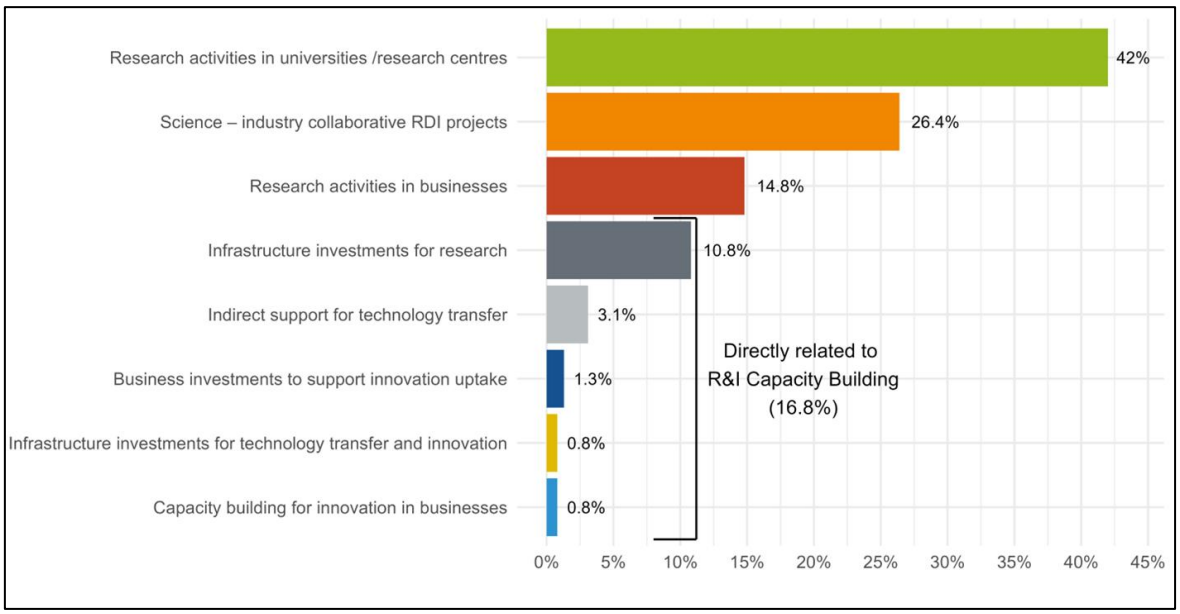
It is against this quantitative picture that upstream and downstream synergies are assessed. According to the ECA report[88], upstream actions typically include developing research infrastructure and support to help R&I stakeholders prepare project proposals for submission to the competitive H2020 calls for projects. To investigate them, the evaluation identified which of the 9.65% of dual beneficiaries received support that was directly related to building R&I capacity – i.e. how many of those beneficiaries received support via the five out of eight policy instruments highlighted in the figure below, the rationale being that the existence of a significant proportion of ERDF projects directly linked to R&I capacity building and undertaken by beneficiaries who also received H2020 funding would suggest that strong upstream synergies are present.

The analysis indicates that around 17% of the 24,833 ERDF projects were directly related to R&I capacity building, as shown in the Figure below, while 83% of the projects were not. In contrast to the conclusions of the (ECA) special report on synergies

[88] See: Special Report 23/2022: Synergies between Horizon 2020 and European Structural and Investment Funds (europa.eu)

between H2020 and ESIFs (2022)[89], which found that upstream synergies were well implemented[90], these figures would indicate that upstream synergies were limited.

Figure 26. Breakdown of the type of ERDF support received by beneficiaries of H2020 support



Source: Prognos / CSIL / Visionary Analytics (2024)

To reconcile this finding, one needs to introduce three (interlinked) levels of synergies between ERDF and H2020 programmes: strategic, operational and project synergies. The well-implemented synergies that the ECA report highlights are mainly on the strategic and operational levels, that is they relate to aligning overarching goals across funding programmes to address Europe's challenges cohesively, as well as to harmonising application and implementation processes across programmes to simplify access to funding. The finding here is on the project level, which is centred around complementing projects across ERDF and H2020 funds to enhance overall impact, from capacity building to research to innovation and market. **Given this observation, the current findings suggest that the upstream synergies on the project level between ERDF and H2020 programmes were limited.**

For what concerns downstream synergies – which, according to the ECA report, "were by far the least implemented" – the present evaluation looked at innovations from the Innovation Radar[91] that could be linked to ERDF funding. This approach responds to the assumption that ERDF support may be used to fund actions that capitalise on already implemented EU projects and, more specifically, seek to exploit and diffuse their R&I results. Figure 26. above, shows that 83% of the dual beneficiaries received a type of ERDF support that could be indicative of the existence of downstream synergies (i.e. beneficiaries who received support from one of the top three policy instruments). By linking ERDF beneficiaries and their projects with innovators and their innovations the evaluation

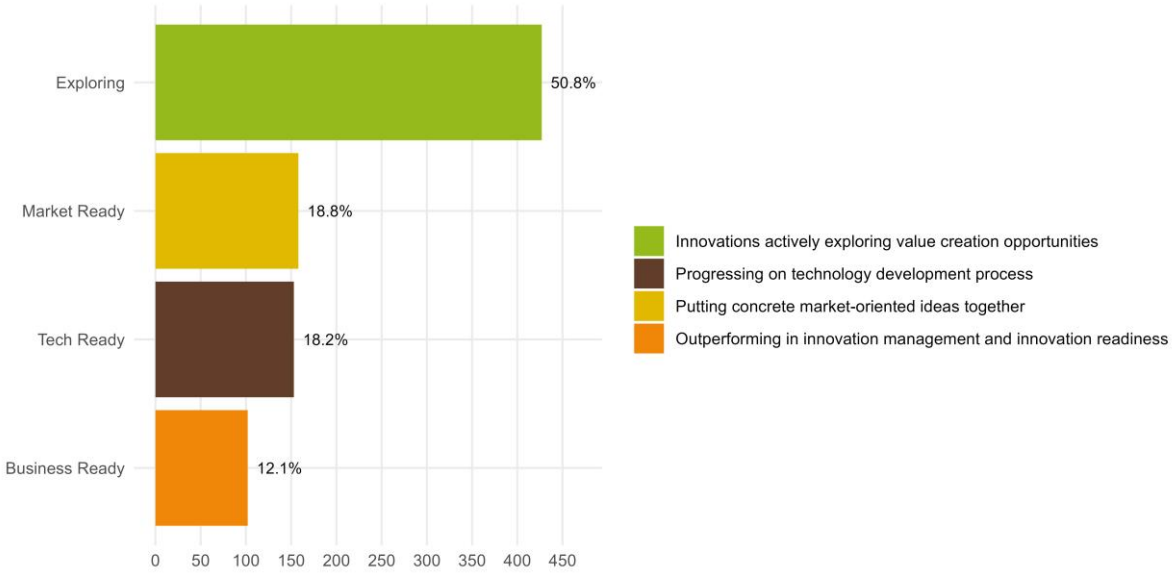
[89] Ibid.

[90] According to the ECA report, "All S3s and the respective OPs did include measures to create upstream synergies. However, the level of detail of the references made in the S3s and OPs varied considerably between the sampled Member States: in some countries references to actions addressing synergies were rather limited and/or very general (Croatia and Poland), while others (Slovenia, Romania and Portugal) included detailed descriptions of several measures"

[91] See Innovation Radar > About (europa.eu). The Innovation Radar builds on the data gathered by independent experts involved in reviewing ongoing projects funded by the Horizon 2020, LIFE Programme, Framework Programme 7 (FP7) or the Competitiveness and Innovation Programme (CIP). These experts also provided an independent view regarding the innovations in the projects and their market potential.

identified **840 innovations that benefited from ERDF funding, accounting for 10.7% of the 7,801 innovations in the Innovation Radar** as of June 2024. As illustrated in the Figure below, the majority (51%) of these innovations were classified as actively exploring opportunities for value creation, while 19% were deemed market-ready, 18% were considered to be at an advanced stage in the technological development process, and 12% were classified as business-ready, indicating that they outperformed in terms of innovation management and readiness. This number suggests that **ERDF funding for RTDI in the period 2014-2020 was, albeit to a limited extent, employed to support projects aiming to build on the results of prior EU-supported initiatives**. In this sense, the evaluation can conclude that downstream synergies were present, albeit to a limited extent. This evidence is confirmed by the interviews conducted with managing authorities (BE, FR), which confirmed that at least some ERDF funding was reaching beneficiaries that had previously benefitted from EU support.

Figure 27. Distribution of Innovation Radar innovations (by market maturity) linked both to ERDF RTDI-supported projects in the 2014-2020 period and other funding sources



Source: Prognos / CSIL / Visionary Analytics (2024) based on the ERDF Single Database and the Innovation Radar.

The evaluation thus finds that both upstream synergies on the project level and downstream synergies were limited and were rarely pursued systematically as part of a deliberate fund-targeting strategy. The case studies have identified a number of key bottlenecks. For instance, the Finnish Managing Authority indicated that it did not utilise the Seal of Excellence mechanism due to a perceived incompatibility between the ERDF's place-based project selection approach, which emphasises local strengths, and the EU R&I Framework Programme's focus on international collaboration and addressing global technological and societal challenges.[92]

The qualitative evidence collected during the case studies reveals also a number of practices that could be employed in order to ensure greater synergies between the ERDF and the Horizon programmes. For example, in **Lithuania**, there is evidence from anecdotal sources that demonstrates the effective alignment of ERDF funds with Horizon initiatives. This was accomplished through recommendations such as implementing a more competitive project selection process in the 2021-2027 programming period, as opposed to

[92] These issues have already been addressed by the European Commission through the dissemination of information. The guidance on new opportunities to maximise the synergies between Horizon Europe and the ERDF programmes was published by the European Commission on 5 July 2022.

the disparate ratio approach in the period 2014-2020. **In the Italian region of Lombardy**, complementarity with European funding was achieved by offering supplementary funding to SME beneficiaries who had secured Horizon 2020 funding within 12 months of receiving ERDF support for a comparable project. The aforementioned SMEs were awarded an additional 5% of eligible expenses as a non-repayable grant. This was based on the premise that participation in Horizon 2020 demonstrated the SME's capacity to undertake R&D activities, thereby warranting a higher proportion of non-repayable grants. In **North Rhine-Westphalia** (DE), priority was given to market projects with clear connections to Horizon 2020 applications, if competing projects were of equivalent quality. In **Northern Portugal**, the ERDF provided support for business innovation (PI8) activities, including the preparation of applications and the dissemination of R&D results. A particular focus was placed on Horizon 2020.

4.1.3. Grants predominate as the mode of delivery in a policy area that involves high-risk projects, but financial instruments have untapped potential

During the 2014-2020 programming period, 91.5% of the ERDF support for RTDI was delivered through grants, with the residual 8.5% being delivered through financial instruments. Managing Authorities across the EU thus opted for a widespread, almost systematic use of grants: only 32 of the 174 OPs (18%) included some form of financial instrument, while all included support in the form of grants. The latter accounted for 91.5% of the total ERDF expenditure for RTDI support. Moreover, in several cases, financial instruments were dynamically designed to complement a support measure deployed through grants, so that beneficiaries could combine the two forms of support to cover the full innovation cycle. It is thus clear that **grants constituted the predominant form of delivery, while financial instruments played an ancillary if at times complementary, role**. The predominance of grants is owed to several factors, all of which pertain to the preferences of either Managing Authorities or beneficiaries. That is, beneficiaries perceive grants for their RTDI activities to be more attractive than financial instruments for many of their purposes. Managing Authorities prefer to disburse ERDF support for RTDI via grants because they afford more control over how beneficiaries use public funds while allowing for broader beneficiary-targeting strategies. Finally, grants were shown to be comparatively easier to implement. In comparison, during the programming period, financial instruments demonstrated themselves to be relatively difficult to implement: on the one hand, before the COVID-19 pandemic, the low-interest rate environment discouraged their use, since affordable private venture capital supply abounded, as confirmed by the interviews with intermediate bodies of the financial instruments (NL, IT) analysed as part of the case studies. Moreover, as Section ERDF RTDI support: funding allocation and expenditure analysis indicated, the experience of the 2007-2013 period led Managing Authorities to conclude that financial instruments have a limited role within the toolkit through which RTDI support can be delivered. This lies in stark contrast to ERDF-supported investments in other policy fields, such as the SME one, where financial instruments played a prominent role in the delivery.

As the following paragraphs will illustrate, in the RTDI space, grants remain the more suitable mode of delivery to achieve the objectives of RTDI support under cohesion policy. Nonetheless, despite their inherently more complex nature, using financial instruments to support RTDI activities in specific instances may prove advantageous for Managing Authorities, if they are adequately designed and therefore meet sufficient demand. Interviews with beneficiaries and quantitative data on the uptake of grants and financial instruments confirmed that, for beneficiaries, grants remain the more attractive form of support for R&D activities. Indeed, while the vast majority of grant-based support measures were met with substantial demand, many of the financial instruments analysed as part of the evaluation went undersubscribed – as illustrated in what follows. This finding holds

across the three categories of support measures analysed in the evaluation – namely, support for the development or modernisation of physical infrastructure, funding for research, technology development or innovation activities, and soft support – indicating that structural reasons for such preferences on the side of beneficiaries exist. The first of these is that grants can absorb a significant (often 40-60%) share of the financial risk inherent in the undertaken activities. By doing so, grants enable the actors of the innovation ecosystem to undertake projects that they would not otherwise undertake, unlike financial instruments, which are directed towards projects that are in theory economically profitable but whose owners lack the initial capital endowment. Grants allow beneficiaries to cover those fixed costs that make undertaking the project without external support entirely unprofitable. In light of this, if the rationale for using grants for soft-support measures and to support the development of physical infrastructure is self-evident – lump-sum support for infrastructure development lowers the fixed costs of developing the infrastructure, whose financial sustainability in the long-term is uncertain – the preference for grants in the context of specific research projects within businesses (PI6) or as part of science-business collaborative projects (PI4) lies in the fact that grants enable researchers to focus on exploratory and pioneering work without the constraints imposed by financial return requirements – which cannot be guaranteed for research projects at lower TRL levels. Only for research projects at higher TRL levels, where long-term profitability is more predictable, do financial instruments become more attractive, in that they can often mobilise a substantially higher amount of funding. This is why Managing Authorities have chosen, in the two analysed financial instrument cases (i.e. Spanish region of Castilla y Leon and in Lombardy), to provide initial support for R&D projects through grants and follow-up support to the same beneficiaries through financial instruments, thereby using both possibilities afforded by the ERDF in a synergetic manner. Overall, however, the evaluation documented that, irrespective of the type of support received, the academic and business communities prefer grants. In fact, the established processes that characterise the grant-based funding model make it the preferred option for beneficiaries, and Managing Authorities must take this into account when delivering support for RTDI activities.

In addition to the preferences of beneficiaries, the case studies, conducted for the purpose of the evaluation, have demonstrated that grants can afford significant advantages to Managing Authorities as well. A key advantage in this respect is that **grants allow for broader beneficiary-targeting strategies**, in that they appeal to all different kinds of beneficiaries, irrespective of their nature – i.e. public or private – and the activity funded. That is, while financial instruments appear only suitable for funding specific activities within the innovation cycle, and specifically its knowledge valorisation phase, where financially profitable opportunities exist, grants can play a role across the entire spectre of the innovation cycle. In addition, **grants afford ERDF Managing Authorities a higher leverage on directionality**, in that they enable the design of calls with specific co-financing requirements. They are thus well suited to conveying private investments towards a specific R&D policy goal; in this sense, they may be the more appropriate mode of delivery when Managing Authorities seek to support a wide range of beneficiaries and achieve ecosystem-level effects, in that their broader appeal and higher capacity to direct private investments makes achieving system-level effects easier. Finally, the choice of using grants is also the result of their higher ease of implementation. This is reflected in the fact that, while most of the financial instruments analysed as part of the evaluation encountered significant difficulties in the preparation phase and therefore became operational only towards the end of the programming period, grant-based measures were able to provide support to beneficiaries early on. This is because the administrative capacity that is required for their implementation is limited and thus well within the reach of most Managing Authorities and, rigorous selection and initial oversight of beneficiaries notwithstanding, they are **generally easier to administer than financial instruments**, which require ongoing management and monitoring of repayments, amongst others.

In summary, the combination of the preferences of beneficiaries – for whom the lump-sum support provided through grants covers those costs that make R&D projects unprofitable – and the advantages that the delivery of support through grants can afford Managing Authorities explains the predominant use of grant-based measures in the delivery of ERDF support to RTDI. Conversely, as the next paragraphs illustrate, the rationale for the use of financial instruments is limited to specific instances, namely for those projects that anticipate returns on investment or cost savings sufficient for repayments to be made.

Financial instruments and their scope within RTDI support

Financially speaking, **the use of financial instruments is limited to those situations in which a research project, though potentially profitable, is considered too risky to undertake**. It is thus a question of additionality, in that financial instruments are suitable for financing projects that the market will not fund at adequate conditions owing to their riskiness. This imposes a significant constraint on their use for supporting RTDI initiatives, most of which are far from guaranteeing the long-term financial viability that using financial instruments requires. The choice of which financial instrument to employ is also contingent: typically, loan financial instruments are intended to cover the lack of affordable external financing, guarantees are designed to address the problem of insufficient available collateral, and equity and venture capital measures address the lack of financing for those companies with a history of activity that is too short and the nature of the activity, and/or the sector is too risky, and therefore credit institutions do not want to finance them. More specifically, the evaluation has found that:

- **Loans** are typically sought when internal funding is insufficient and external equity costs are high, making it necessary to preserve financial slack for strategic flexibility. However, loans may not be the preferred option when facing high uncertainty or lacking sufficient collateral, as banks usually set stringent conditions for granting high-risk loans. This preference aligns with the notion that firms may turn to loans when they aim to retain control and avoid the dilution of ownership associated with equity financing.
- **Guarantees** become relevant in contexts where firms face difficulty in securing loans due to high uncertainty or insufficient collateral. The matching of funding preferences with available options involves a complex interplay between the characteristics and reasons of each actor within the financing ecosystem. Guarantees can facilitate access to loans by mitigating lenders' risk perceptions, especially in environments where traditional lenders are risk averse.
- **Equity** financing is preferred for projects characterized by high uncertainty and a need for significant upfront investment. This option is favoured when seeking to share the risks and rewards of innovation projects with investors who can provide not just capital but also expertise and networks. The transition from personal to venture capital, to stock market finance, involves a gradual broadening of the investor base, reflecting a strategic choice that balances the desire for control against the need for substantial resources to support high-growth and high-risk endeavours (Sierra, 2020).[93]

The table below summarises the rationale behind the five financial instruments that were analysed as part of the evaluation. It is notable that at all five provided support to companies whose projects were in the latter stages of the innovation cycle – i.e. at a TRL level that was close to commercialisation. This indicates that, in the eyes of Managing Authorities, **financial instruments to support R&D projects have a rather confined scope for application** – indeed, it is only in these phases of the innovation cycle that the potential profitability assumption is strong enough for Managing Authorities to run the risk of

[93] Sierra, J. (2020). How financial systems and firm strategy impact the choice of innovation funding. European Journal of Innovation Management, 23(2), 251-272.

employing public resources in financial instruments. This is, ultimately, the main factor that has limited the use of financial instruments to deliver ERDF support for R&D activities.

Table 5. Summary of financial instruments analysed as part of the evaluation

Lombardy (PI4)	Fund 'Collaborative R&D Activities' (measure "*Linea R&S per aggregazioni*")	Support R&D projects conducted by businesses in collaboration with research organisations through a mix of not-repayable grants and loans (0% interest rate) for businesses and not-repayable grants only for ROs	• Address the lack of collaboration between enterprises, especially SMEs, and research organisations, by providing financial support to R&D projects (industrial research and/or experimental development) carried out by partnerships of at least three entities.
West Netherlands (PI5)	"Innovation Quarter Fund" (call 'P1.PZH.2')	Support innovation lifecycle stages, especially TRL 6-9	• Financial instruments were chosen over grants based on prior experience. Grants used for early innovation stages were insufficient for later stages. • Financial instruments' features provided more options for funding innovations at later stages.
Poland (PI6)	Fund of funds 'BRIdge VC' (measure '1.3.2 SG OP')	Develop a venture capital market using equity financial instruments. BRidge VC targeted start-ups at the growth and expansion stage, supplemented by five other capital support instruments to cover all development stages.	• The Polish capital market was highly underdeveloped, ranking 55th out of 142 countries in the Global Innovation Index 2014. • FI chosen due to limited access to debt in the banking sector, with SMEs facing a 37% rejection rate and a 39% collateral requirement. • Inadequate access to financial resources and a risk-averse attitude among businesses were barriers to R&D.
Italy (PI6)	Fund of funds "Research and Innovation' (*"Fondo di Fondi Ricerca e Innovazione*")	Address the gap between demand and supply of capital for R&I through a VC fund of Funds	• An estimated market gap for R&I projects in businesses was around EUR 10 billion, with EUR 5 bn for projects at TRL 2-5. • Insufficient funding availability was due to higher debt costs for Southern SMEs, lack of financing sources for high-risk R&I projects, high technological risk, long payback periods, substantial financial requirements for KETs projects, and the need for quick funding.
Castilla y Leon (PI6)	Fund "Financial Instrument for Guarantees for R&D Projects and Innovative Companies"	Address unmet demand for bank financing in Castile and Leon by providing state-backed guarantees for loans related to R&D projects,	• A pre-evaluation identified lack of collateral as a significant hurdle for obtaining credit. • Despite this, financial institutions perceived low demand for financing related to RTDI, indicating limited unsatisfied demand for credit.

Source: Prognos / CSIL / Visionary Analytics (2024).

Delivering support though financial instruments is complex

A second important explanatory factor documented in the case studies is the overall complexity that characterises the delivery of financial instruments. This complexity exists on both sides: financial instruments are harder to set up for Managing Authorities and impose a significant administrative burden on beneficiaries. On the side of Managing Authorities, the set-up of financial instruments requires the following elements:

- in-house financial expertise that enables the selection of adequate operational arrangements. In this respect, two-tier fund of funds structures proved more adequate to deliver (quasi-)equity financial products or a mix of products including (quasi-)equity, while single-tier structures proved nimbler and thus best suited to regional-level programmes;
- The negotiation of an adequate fee structure with financial intermediaries;
- A dynamic monitoring of market conditions which ensures that the appropriate adaptations to the instrument are made should market forces render the financial conditions with which the instrument was originally set-up unattractive. This was demonstrated by the impact of the COVID-19 pandemic, which significantly reduced the attractiveness of certain financial instruments as Member States made financial support at better conditions available in a bid to support private businesses.

These are in addition to the continuous oversight that is needed to manage repayments, assess risks, and ensure compliance. The combination of these conditions helps to explain why, out of the five financial instrument measures analysed, many became operational only towards the end of the programming period. This clearly emerged in the case of Castilla y Leon, where a faulty document collection process during the first two years of operation of the instrument, due to the MA's lack of experience, resulted in a retrospective document collection process that significantly complicated the delivery of the support.

More generally the case studies have shown that the success of financial instruments is heavily contingent on the ability of Managing Authorities to select competent intermediaries. This is best showcased by the fund of funds set up in Poland and Italy. If, in the latter, the expertise of the fund manager and external partners played a vital role in identifying the best projects to support, in the former the Managing Authorities' limited knowledge of the local venture capital market led to the set-up of an over-budgeted instrument. Indeed, the limited supply of fund management teams with the required investment experience and the low maturity of the Polish venture capital market significantly complicated the delivery of the measure, which went undersubscribed due to a lack of demand.

For all of the reasons outlined above, grants remain the predominant method through which ERDF support to RTDI is disbursed. Their ability to absorb risk and cover fixed (often irrecoverable) costs, combined with their relative ease of set-up, their capacity to appeal to all actors within the innovation ecosystem and the higher directionality that they afford Managing Authorities make grants the preferred option for disbursing and receiving RTDI support from the ERDF. Yet the traditional limits to the effectiveness of grants remain; in this respect, financial instruments have the potential to deliver RTDI support effectively and efficiently.

The untapped potential for financial instruments in RTDI support

The evidence collected as part of the evaluation shows that, in terms of effectiveness, financial instruments nonetheless have significant potential as a mode of delivery of RTDI support. Indeed, the outcomes for beneficiaries across the five instruments analysed as part of the evaluation were positive: they included new investments in tangible and intangible assets, acquisition of new skills (all three FIs), development of prototypes (Italy), introduction of innovative pilot processes in companies (Spain), commercialisation of new goods and services and increased patenting (all FIs), and increased revenues through productivity gains (Italy). More specifically, there are some indications that equity-based

measures are generally more suitable than debt-based for supporting RTDI investments. In Italy, the demand for equity and associated quasi-equity investment in the form of shareholder loans has been stronger than that for loan finance. This experience reflected the specific needs of local companies, including of spin-offs which require long term patient capital to support the development of new products. These instruments demonstrated a higher likelihood of reaching the target number of beneficiaries and proved more effective in attracting private capital. Similar results have emerged from the research on supporting the growth of young innovative companies. Gampfer et al.[9495] concluded that equity instruments (public VC funds and fund-of-funds) have a stronger positive impact on the growth of young innovative companies than debt instruments (loans and loan guarantees) and tax incentives and are thus better suited to support beneficiaries whose project is at the higher end of the TRL scale.

This positive evidence must be placed within the wider context of the benefits that financial instruments offer Managing Authorities. Indeed, these outcomes – most of which were also documented for the support disbursed through loans – were achieved against a backdrop of a sustainable use of public funds. More specifically, financial instruments offered benefits in terms of cost-effectiveness of the interventions and also resulted in positive externalities, in that they allowed for the development of local venture capital markets and endowed beneficiaries and financial intermediaries alike with additional skills related to the venture capital market. In relation to cost-effectiveness, two advantages of financial instruments stand out: reflows and leverage.

In terms of reflows – which are the key characteristic that sets financial instruments apart from grants, and encompass interest, guarantee fees, dividends, and any other capital gains – the case studies have revealed that different financial products have varying re-flow rates. Debt-based measures tend to have faster re-flows: the guarantees offered in Castilla y Leon had a re-flow rate of 52.9%, while the loans provided for under the 'Collaborative R&D activities' measure in Italy had a re-flow rate of 58.7%. In addition to loan repayments, the operation also generated EUR1.3 million in interest and other capital from fund programme payments. Moreover, the Managing Authorities have reported that repayment schedules for debt-based measures are generally being met: no issues related to repayment were identified under debt-based instruments in PI6 (Italy's national programme), and only a few struggling companies were identified in Lombardy and Castilla y Leon. In the latter, the EUR 1.4 million in arrears and/or defaults (only 8% of the amount formalised) was attributed to the innovative nature of the financed projects. As regards equity-based measures, though reflow figures are lower as of 2023 (most reflows on equity investments are achieved only at the exit of the investment), benefits in terms of improved management and organisational capacities within beneficiaries have been documented. This is because once equity funds invest, they seek to improve the profitability of the companies they invest in by imposing changes such as restructuring measures and cutting costs.[96]

Finally, as regards leverage – which the Financial Regulation defines as the ratio of reimbursable financing given to beneficiaries divided by the Union contribution – the data shows that each of the instruments managed to attract additional resources, though the leverage effect and the source of additional funding varied significantly between them. Guarantees are the instrument that is most apt to achieve leverage effects: the scheme in Castilla y Leon achieved a leverage effect of 5.5 – though the "InnovationQuarter Fund" in the Netherlands also achieved the same figure, which is significantly above the EU average leverage for risk capital (1.3), and above the expected leverage effect of 3.45. Furthermore, the fund attracted EUR 44.8 million in private investments stemming from the beneficiaries

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[95] Gampfer, R. M. (2016). Improving access to finance: which schemes best support the emergence of high-growth innovative enterprises? A mapping, analysis and assessment of finance instruments in selected countries.

[96] FI Compass. (2022). Research and Innovation Funds in Italy - ERDF loan and equity financial instruments.

themselves. In fact, it was the only analysed instrument to achieve the target level of private investment attraction, indicating that the effectiveness of the measures in mobilising private capital compared to grants remains an open question. In summary, the use of financial instruments to support RTDI projects at the latter end of the TRL is a cost-effective way to deliver ERDF support, provided that the conditions they offer allow for sufficient uptake.

Challenges in the implementation of financial instruments

The evidence indicates that ensuring sufficient uptake for financial instruments is a complicated endeavour. This is demonstrated by the fact that *all five of the analysed instruments failed to meet their target in terms of supported beneficiaries*. This can be attributed to both timing and optimistic planning. As regards timing, the grants analysed as part of this study were mostly disbursed before the COVID-19 pandemic, while the three financial instruments were disbursed concurrently with the COVID-19 pandemic support. The liquidity support offered by Member States to offset the effects of the pandemic being more generous, many financial instruments faced crowding out effects. However, it is also true that the financial instruments were oversized to start with, given that they were intended to target a limited spectrum of companies that are considered too risky to obtain capital in the market but have the potential to generate profits within a relatively short time. Both these factors reflect the difficulties that Managing Authorities face in leveraging the potential of financial instruments. Since many lack the adequate experience to successfully implement such measures, investing in capacity-building measures that endow Managing Authorities with such capacities is key to leveraging the potential of financial instruments. As a result of the evaluation, the following best practices for implementing financial instruments have been identified:

- **Appropriate requirements:** avoid high collateral requirements, as well as any other high-cost and non-cost barriers that render the instrument unattractive to innovative enterprises. Dynamically adapting the conditions at which the instrument is offered to ensure competitiveness over time is crucial.
- **Delivery and absorptive capacity:** the employment of experienced and skilled Managing Authorities and financial intermediaries to select high-quality projects and manage financial instruments effectively is key; Managing Authorities with no prior experience should invest in capacity-building measures and plan for the significant administrative burden that the implementation of FIs entails.
- **Targeting strategy:** the use of established intermediaries with extensive networks enables to reach a higher number of enterprises. Ensuring that as many potential beneficiaries of the support as possible are aware of its existence is key, given that financial instruments can only appeal to a limited subset of beneficiaries.
- **Avoid competition and ensure complementarity:** Coordinate the support to avoid competition for capital, private investments, and beneficiaries with other measures, and design them to ensure complementarity with other forms of public support (i.e. grants for supporting earlier phases of the innovation cycle).

To summarise, the evaluation has confirmed that within the context of ERDF support to RTDI, grants remain the predominant form through which the support is delivered. Their capacity to target a broader range of beneficiaries by covering a wider breadth of needs – from covering the fixed costs for infrastructure projects to enabling researchers to focus on exploratory projects without the constraints imposed by financial return requirements – renders them more attractive to beneficiaries and more suited to covering the whole set of needs of the actors within a given innovation ecosystem. However, for a specific subset of beneficiaries – namely those who face difficulties in accessing finance to conduct higher TRL-level projects – financial instruments have a significant appeal. Thus, for Managing Authorities, though grants are easier to implement, financial instruments have significant potential, in that they can support the R&D activities of beneficiaries while ensuring cost-effectiveness through capital reflows, giving rise to positive externalities and locking in the

incentives that force beneficiaries to make more efficient use of the support. To tap effectively into this potential, however, significant investments in capacity building, to ensure that adequate expertise for their implementation is in place, is paramount.

4.2. Implementation: a view on the disbursement process of RTDI support under ERDF 2014-2020

During the 2014-2020 programming period, particular emphasis was placed on ensuring that ESIF support would be delivered efficiently. In particular, several efforts were made to address the implementation bottlenecks identified in the previous programming period, which – according to the *2007-2013 Ex-post evaluation of ERDF investments in RTDI*[97] – were, amongst others, "the lack of clarity regarding public procurement, intellectual property rights, technology transfer and State Aid regulations" and a lack of administrative capacity for programme managers. To remedy these shortcomings, the European Commission put in place specific initiatives, such as the COMP-REGIO State Aid action plan, aiming to improve the administrative capacity of Managing Authorities and facilitate the interpretation of State Aid legislation. What follows provides an overview of how the ERDF implementation process played out during the 2014-2020 period, with an eye to outlining what the factors for successful implementation and the bottlenecks to it were.

Enablers and barriers affecting the implementation of ERDF support

As Section Implementation: a view on the disbursement process of RTDI support under ERDF 2014-2020 outlines, the ERDF support was delivered to a good extent as planned. That is, seven out of the eight policy instruments examined achieved an aggregate implementation rate of over 85% (as of 2022). Only ERDF-funded infrastructure projects were delayed in their implementation, mostly owing to the complications caused by the onset of the COVID-19 pandemic and the war in Ukraine. Evidence from the interviews conducted as part of the evaluation indicates that a series of underlying factors influenced the implementation process. These factors can be broadly categorised into two groups: those which are programme-specific and those which arise from the overall context in which the measures are implemented.

Concerning the former, the evaluation has found that the **presence of sufficient expertise for project implementation across all actors**, including Managing Authorities, Intermediate bodies and beneficiaries, positively influenced the design and allocation of resources as well as the smooth implementation of projects. Experienced Managing Authorities / Intermediate Bodies played a crucial role in clarifying procedures to assist the beneficiaries (e.g. incorporating public procurement and State Aid legislative constraints in the project calls to avoid ex-post complications) and guiding them through the exploitation of synergies. Conversely, where these actors lacked experience, lengthy ex-post adjustments and corrections were necessary. For instance, in Castilla y Leon, the implementation of a financial instrument-based measure was significantly complicated by an ex-post adjustment that forced beneficiaries to provide, after two years of project implementation, documentation that was not initially requested.

On the other hand, **beneficiaries with substantial experience** – in absorbing public funds, managing public procurement, intellectual property rights, and technology transfer processes – **demonstrated better performance** than those who did not. Indeed, several interviews, as well as the seminar discussions, highlighted that Managing Authorities themselves prefer to target support to experienced beneficiaries, when possible, since these are able to guarantee – through their reputation – that a viable long-term strategy for the utilisation of ERDF funding exists. Conversely, those beneficiaries who lacked

[97] See CSIL / Prognos / Technopolis: "Evaluation of investments in research and technological development (RTD) infrastructures and activities supported by the European regional development funds (ERDF) in the period 2007-2013"

experience and expertise encountered more difficulties in navigating administrative processes (PI1, PI2, PI3, PI4). Unlike SMEs, public research entities and large enterprises often had dedicated human resources to handle the administrative aspects of collaborative projects (PI4), especially public procurement and intellectual property aspects. This was also the case for investment in research infrastructures (PI1), for which it was observed that universities with dedicated units to coordinate procurement and implementation processes fared better than those with no experience in dealing with the administrative process of absorbing public funds. The case study on "Infrastructure investments for technology transfer" also showed that, in the case of SMEs, relying on external consultants to assist in the navigation of the constraints imposed by public procurement rules and State Aid legislation proved to be a successful strategy (see the following paragraphs for more details on this). Indeed, many such SMEs reported that in the absence of such assistance – which, it must be noted, imposes an additional cost upon beneficiaries – they would not have been able to navigate the complexities inherent to infrastructure projects.

Finally, other programmes or policy-specific factors include **the existence of networks that brought together academia and industry**, which was another key facilitator for science-industry collaborative projects (PI4) and innovation capacity building for businesses (PI8). In the latter case, communication and cooperation between beneficiaries and Managing Authorities were smooth, with no significant barriers identified in this regard, although many beneficiaries used consulting services for support, which facilitated their interaction with institutional bodies. Interestingly, this created an additional range of contractors, although it led to a wide variety of quality services, with some new companies producing unsatisfactory studies that caused problems at later stages of project implementation. Similarly, the fact that measures under infrastructure investments for technology transfer and innovation (PI2) were co-designed with local stakeholders (research organisations and industries) and/or built on existing partnerships was a great enabler for project implementation, as it ensured the attractiveness and demand for financial support, and it consistently attracted more applications than could be accommodated. In the case of indirect support to technology transfer (PI5), the pre-existence of collaborations and links was not always a factor in the success of measures in place. However, involving trade chambers and professional associations helped to achieve better performance.

As regards the contextual factors that influenced the implementation of ERDF support, the first key element that was documented across all case studies was the necessity for beneficiaries and MAs alike to have **clearly defined viable long-term strategies**. Such long-term strategies – of which an example on the side of MAs is the Italian National Plan for Research Infrastructure (PNRI) – enable the targeting of support towards projects that have a specific role within an articulated vision and contextually affords beneficiaries with the security that follow-up funding – be it from the ERDF or from national sources – is available, thereby allowing for the long-term planning which is indispensable for the success of infrastructure projects especially. Though evaluating long-term strategies of beneficiaries often requires substantial expertise within the Managing Authority, and though the stability of long-term strategies for investments on the side of the MA are often subject to variations based on changes in political direction, it is nonetheless paramount to ensure that these long-term visions are put in place, lest the overall effectiveness of ERDF support is put in question.

Another contextual factor is a lack of qualified human capital for implementing research projects. The issue, though documented across all the policy instruments, is particularly salient for infrastructure projects in less developed and transition regions (IT, RO).

Finally, the evaluation has identified a series of barriers to the successful implementation of ERDF support that were common across policy instruments. Foremost among these are the complications arising from public procurement rules, which slowed down the implementation of collaborative projects (PI4), causing delays and generating additional administrative burdens for research organisations. The frequent changes to the public

procurement code introduced uncertainties for infrastructure investments for research (PI1) and the weak administrative capacities of research infrastructure staff in managing complex public procurement exacerbated this issue. Beneficiaries of infrastructure investments for technology transfer and innovation (PI2) found that certain potential providers of the infrastructure to be procured backed out when faced with the prospect of having to go through a public procurement process.

Notably, State Aid legislation – which represented a significant issue in the previous programming period – did not constitute as much of a complication in the 2014-2020 period. This can be attributed both to the actions taken by DG REGIO and DG COMP (i.e., the State Aid Action Plans) and to the capacity of Managing Authorities to effectively incorporate the legislative constraints into the public calls that delivered ERDF support. In this respect, it is however worthwhile to indicate that, though Managing Authorities have indeed become accustomed to the complexities inherent to State Aid legislation, the auditing burden imposed by them upon beneficiaries of support for infrastructure projects is nonetheless extensive and, to a certain extent, runs contrary to the desired effect of the support. In other words, the constraints imposed upon the use of infrastructure developed or acquired through ERDF support result in beneficiaries having to sacrifice potential research activities or undertake complex accounting that require significant capacity that could have been used elsewhere.

Additional barriers were mostly country or policy instrument specific. The lack of flexibility in project modifications was perceived to create inefficiencies for infrastructure investments for research (PI1), especially in the aftermath of the COVID-19 pandemic. Conversely, Managing Authorities that were able to flexibly adapt their beneficiary selection processes – such as the Flemish one, which introduced a two-tier selection process that enabled a reduction in the administrative burden on both their side and that of beneficiaries – were also those most able to ensure an efficient implementation process, even despite the complexities inherent to infrastructure support. In addition, the limitations in the amount of funding awarded to the project were also a significant barrier to efficient implementation. In Czechia, for instance, some companies had to submit multiple applications to fund a single large project on capacity building for innovation (PI8). Additionally, in some instances, evidence of a lack of clear communication between Managing Authorities and beneficiaries was documented (PI1). In the case of indirect support for technology transfer (PI5), pre-existing schemes of collaboration constrained the implementation of new measures. Large companies prefer collaborating with universities, and collaboration with SMEs can be more challenging.

The impact of the COVID-19 pandemic on the implementation of ERDF support

The COVID-19 pandemic impacted the disbursement of ERDF support to RTDI in multiple ways.

On the one hand, the onset of the pandemic delayed the fund disbursement process for those measures that were still being implemented in 2020. Though the pandemic significantly impacted the support for research activities by delaying the execution of research projects within businesses (PI6), the most significant impact occurred in the case of infrastructure projects, which experienced notable delays that were compounded by the economic impacts of the war in Ukraine later. Yet these very complications also led to the streamlining of administrative procedures and communication between MAs and beneficiaries. For instance, Managing Authorities in Greece introduced a web-based digital platform that significantly accelerated the disbursement process.

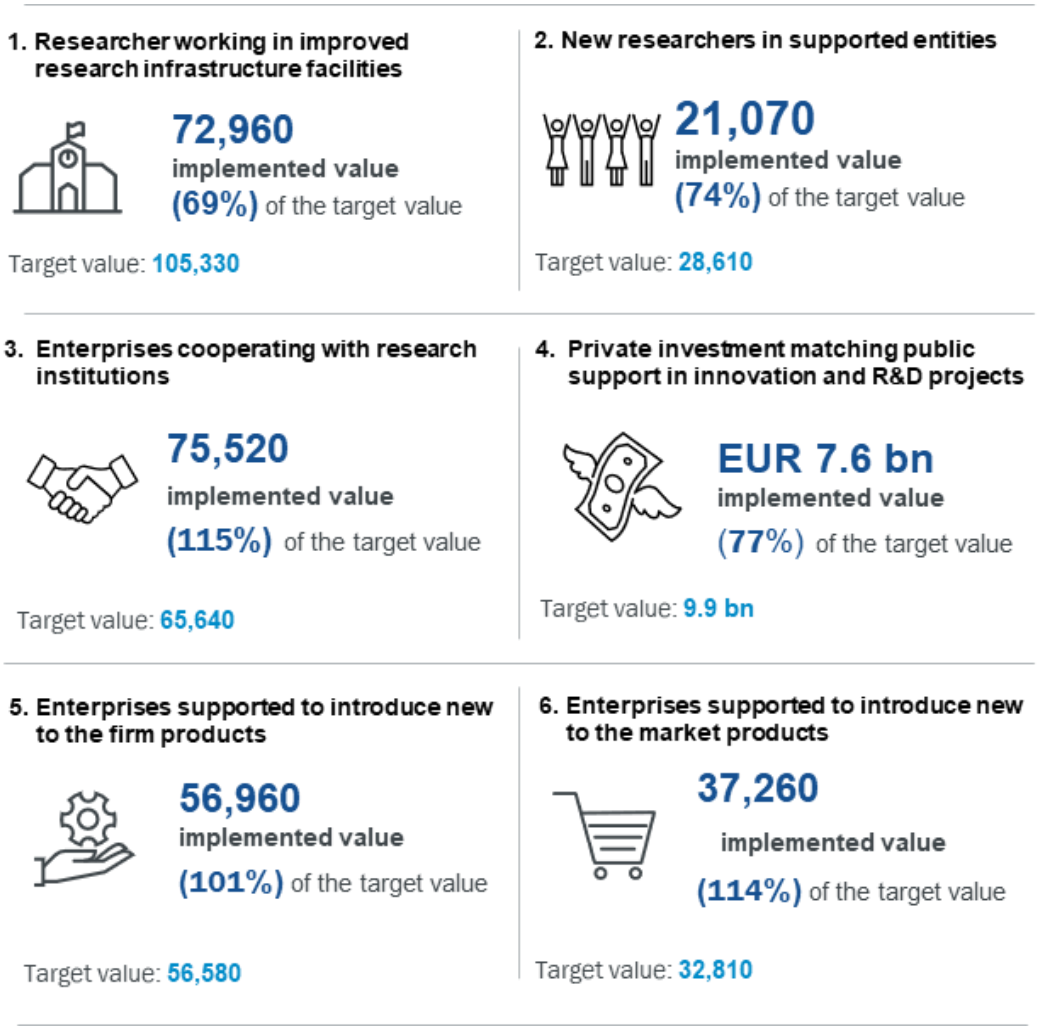
On the other hand, the overall relevance of ERDF support for RTDI temporarily decreased as a result of the COVID-19 pandemic. Indeed, the provision by national governments of substantial economic support, enabled by the temporary suspension of State Aid regulations, led to the crowding out of ERDF support for RTDI. This was particularly clear in the case of financial instruments: all the five instruments analysed as part of the

evaluation suffered significantly – to the extent that all fell short of their target number of beneficiaries. This was to be expected, since the COVID-19-related support measures offered more generous terms compared to market-based debt financing, making ERDF-supported financial instruments less attractive.

4.3. From projects and operations to tangible outputs of RTDI support

The overall success that Managing Authorities experienced in the implementation of ERDF support translated into significant tangible outputs, and positive effects on the innovation ecosystems of European regions. Below, some key output indicators around RTDI support are summarised, including absolute implemented values, their absolute target value (aggregate value, as set in the ERDF Operational Programmes) and the target value in per cent.

Figure 28. Summary visualisation of aggregated ERDF output indicators by December 2022



Source: Prognos / CSIL / Visionary Analytics (2024).

In absolute terms, ERDF support led to the addition of over 21,000 new researchers in supported beneficiaries, and almost 73,000 researchers benefitting from improved research infrastructures. Notably, both these indicators fell short of their most recent set targets. The effects of the COVID-19 pandemic are evident here: on one hand, the difficult implementation of infrastructure projects is reflected in the relatively low achievement rate

(69%), while the shortfall in terms of the number of new researchers in supported entities reflected, amongst others, the difficulties of hiring new researchers during and after the pandemic. On the other hand, the particular emphasis placed by programme authorities on using the ERDF as a tool to stimulate collaborations was successful: the number of enterprises collaborating with research institutions achieved 115% of the target value. Similarly, the effect of directing significant funding towards supporting research activities in businesses and, more generally, private innovation efforts is reflected in the overachievement in terms of the number of enterprises supported to introduce products that are either new to the market or new to the firm. Notably, however, the indicator for the capacity of ERDF support to mobilise private investments was also not reached, indicating that Managing Authorities were able to mobilise less private investment than expected, even accounting for the revisions made during the programming period to the targets of the output indicators.

4.4. Moving from projects to tangible and intangible outcomes of RTDI support for beneficiaries

4.4.1. ERDF has supported the enhancement of R&I infrastructure and institutional capacities, although some implementation challenges occurred

As was the case in the preceding period[98], **one of the primary objectives of ERDF support for RTDI between 2014 and 2020 was to enhance research and innovation infrastructure and capacities across EU regions**. ERDF investments in research infrastructures could be seen to be inextricably linked to the "stairway to excellence" logic, in that they provide the foundational support necessary for the fostering and enhancement of research and innovation capabilities. The ERDF addressed the critical need for state-of-the-art facilities that enable high-quality research by allocating substantial funds to the construction, upgrade, and modernisation of laboratories, research centres, and data centres. These investments guarantee that researchers have access to cutting-edge tools and environments, which represents the initial crucial step in the stairway to excellence. This foundational infrastructure not only supports basic research but also facilitates advanced scientific inquiry and innovation, driving the integration of regional and national research systems into broader European and global networks. In this way, it is aligned with the strategic priorities of the EU, enhances human capital, and supports applied research. This creates a robust and sustainable research ecosystem that promotes excellence, competitiveness, and economic growth across EU regions.

In order to address the necessity of expanding and modernising national and regional RTDI systems, Member States and the EU collectively invested EUR 10.2 billion (15.4% of the total expenditure) in RTDI infrastructure during the 2014-2020 period. Of this, EUR 8.68 billion (13.1% of total RTDI expenditure) was specifically allocated to the construction, upgrade or modernisation of research infrastructure (e.g., laboratories, machinery, data centres), making it the third most significant policy instrument among the eight analysed. Investment in research infrastructure was approximately equal between less developed regions (36%) and more developed regions (33%), with transitional regions receiving the smallest share (23%). Significant investments were made in state-of-the-art laboratories, advanced research facilities and equipment, and data centres to support scientific research and innovation activities. These investments were designed to foster excellence in R&I by providing researchers and innovators with the necessary tools and environments for groundbreaking work.

[98] Prognos, CSIL, and Technopolis (2021). Evaluation of investments in Research and Technological Development (RTD) infrastructures & activities supported by the ERDF in the period 2007-2013. Final Report. Available online.

The evidence, both quantitative and qualitative, indicates that **support for infrastructure investment in research provided by the ERDF has positively contributed to the creation or modernisation of public research and development facilities.**

To provide an example, in **Lithuania**, infrastructure investments, which constituted one of the primary focuses of ERDF funding for RTDI, accounted for 14,2% of the ERDF RTDI policy mix and represented a crucial source of funding available in Lithuania for this objective. These investments have modernised the infrastructure of flagship centres of excellence and parallel laboratories engaged in research activities that correspond with the S3 priorities. The investments have also included the integration of Lithuanian RTDI infrastructures into the European research (ESFRI) infrastructure, in accordance with the Lithuanian Roadmap for Research Infrastructures and the ESFRI Roadmap.

In **Italy**, the "Research Infrastructures" measure of the national "Research and Innovation" Operational Programme has supported the improvement of 18 research infrastructures, notably through the acquisition of assets and scientific equipment as well as the expansion of the beneficiary research infrastructure.[99] Integrating research instruments into the ESFRI roadmap emerged as a key success factor. By aligning the list of beneficiaries with the ESFRI roadmap, the Italian initiative gained a long-term strategic vision framework. The results of the online survey, conducted as part of the OP evaluation process, indicate that the beneficiaries[100] perceived a number of positive outcomes associated with the upgraded research infrastructures. In particular, the respondents highlighted that the modernised research infrastructures have enhanced the organisation's capacity to participate in research projects of national and international importance, as a result of new technological acquisitions, an increase in staff knowledge and skills, and an exchange of scientific and management skills. The survey of the beneficiaries also shows that 72% of the respondents stated that the measure dedicated to the enhancement of research infrastructures has promoted new opportunities through scientific publications.[101] Overall, this general positive correlation between the ERDF investments in research infrastructures and the increased volume of publications was stressed in the evaluation of the previous programming period. The results of the econometric analysis demonstrated a positive correlation between ERDF RTDI support in the 2007-2013 period and the growth rate in the number of scientific publications.[102] A more detailed account of the ERDF-supported knowledge production can be found in Section ERDF has facilitated the production and diffusion of knowledge, as evidenced by the nearly 79,000 publications resulting from ERDF RTDI beneficiaries.

Overall, ERDF support has positively influenced the attractiveness of national research systems by strengthening RTDI capacities, including in less developed and transitioning regions. As evidenced by the dedicated case study on RTDI infrastructure in this evaluation and a recent evaluation[103], ERDF investments in research infrastructure in **Romania** have significantly enhanced R&I capacities at the organisational level (the beneficiaries have generally achieved the intended results) by establishing new laboratories. During the case study, beneficiaries reported that the infrastructure developed with ERDF support has enabled a broader spectrum of research activities within the

[99] Eutalia, Servizio Valutazione PON Ricerca e Innovazione, Report di valutazione dell'Azione II.1: Infrastrutture di ricerca. Accessed May 2024. Available at: https://www.ponricerca.gov.it/media/397706/rapporto_finale_val_pon_ri_2014-2020_azione-ii1.pdf

[100] A specific questionnaire was developed for this purpose and sent online to 43 stakeholders. A total of 29 responses were received. The respondents included 23 public and 6 private entities. Of the 26 public institutions, 19 belonged to the research sector (universities and other public research bodies) and 5 represented public administration, while the remaining respondents were attributable to business system.

[101] Eutalia, Servizio Valutazione PON Ricerca e Innovazione, Report di valutazione dell'Azione II.1: Infrastrutture di ricerca. Accessed May 2024. Available at: https://www.ponricerca.gov.it/media/397706/rapporto_finale_val_pon_ri_2014-2020_azione-ii1.pdf

[102] Prognos, CSIL, and Technopolis (2021). *Evaluation of investments in Research and Technological Development (RTD) infrastructures & activities supported by the ERDF in the period 2007-2013*. Final Report. Available online.

[103] INCSMPS and Ernst and Young (2023). Evaluation of measures promoting research and innovation under the Competitiveness OP, 2014-2020, in Romania – 3rd report, https://files.evaluationhelpdesk.eu/evaluations/ROE92.pdf .

organisations and has facilitated collaborations with third parties. Furthermore, the EERTIS data on the availability of research infrastructure in the country indicates a substantial increase compared to 2014, with Romania now offering over 2,000 R&I infrastructures, over 9,000 research services and over 29,000 pieces of equipment.[104] The substantial investments made by the ERDF in research infrastructures have contributed to improving the attractiveness of Romania's research system, primarily through the Competitiveness Programme, which constituted one of the two sources of funding for the National Strategy for Research, Development and Innovation (SNCDI) 2014-2020.[105]

A similar outcome was observed in **Saxony-Anhalt (DE)**, where ERDF investments have facilitated the strengthening of the region's research infrastructure. This is evidenced by the case study, which details the University of Magdeburg's acquisition of a 7 Tesla (T) Magnetic Resonance Imaging (MRI) scanner, financed with EUR 12 million of ERDF 2014-2020 funds. The installation of the scanner has enabled the university to enhance its R&I capabilities while fostering regional collaborations. Furthermore, the investment has not only retained top talent but also facilitated additional funding from the German Research Foundation for projects encouraging the use of MRI in the private sector (see more in the Box below).

Box 5. Mini case study example: Saxony-Anhalt (DE)

Stengthening institutional R&I capacity through infrastructure investments for research in Saxony-Anhalt

Regional OP: Saxony-Anhalt	Purchase of the MRI scanner	Collaboration with local hospital	2015-2018

In the case of Saxony-Anhalt, ERDF funding was targeted towards developing infrastructure that could serve private sector R&D activity. Support for infrastructure projects was made available either directly to private companies or to public research organisations that pursued application-oriented projects. The underlying strategic choice was to leverage the comparative strength of the public R&D sector to bring the private sector on board through the creation of localised synergies. The benefits of investments in public R&D infrastructure were, nonetheless, relevant and durable, so much so that one can safely conclude that the investments led to an overall increase in the competitiveness of beneficiaries under several aspects. Regional ROs were able to attract more qualified human capital, increase the number of their collaborations and, at least in one instance, establish an international collaboration that could not have been set-up were it not for the ERDF funded infrastructure project.

One illustrative example is the acquisition of a powerful 7T Magnetic Resonance Imaging (MRI) scanner for a professor at the University of Magdeburg. Despite receiving offers from other universities, the professor chose to remain at the institution contingent on obtaining this advanced machine. The MRI was co-financed by the ERDF with EUR 12 million (80% of total funding) and is now used for various research projects in collaboration with the local teaching hospital, the Leibniz Institute for Neurobiology (LIN), and the regional sub-institute of the German Centre for Neurodegenerative Diseases. This acquisition has enhanced the university's R&I capabilities, attracting and retaining talent, and fostering collaborations within the regional research cluster. Furthermore, the professor was successful in obtaining funding from the German Research Foundation (DFG) for a project that encourages the shared use of the MRI with the private sector.

[104] European Research Infrastructure Systems, available here.

[105] The other was the National Plan for R&D in 2014-2020.

Infrastructure development, which may have created a conducive environment for more intensive and productive interactions between science and industry, requires time to consolidate and produce results. Despite the promising indications, the **completion rate of the projects related to infrastructure investments for research was relatively low, reaching 46% by November 2023**. This indicates challenges in implementing infrastructure investments and assessing their effectiveness. Key hurdles included difficulties in modifying original projects when circumstances changed, which was particularly evident during the COVID-19 pandemic and the war in Ukraine. For instance, Lithuania's policy instrument had to adapt significantly due to supply chain disruptions, leading to the transfer of physical activities online and extensions in project timelines.

Furthermore, the lack of skilled personnel, driven by the low attractiveness of research careers due to inadequate compensation and stringent employment requirements, along with a lack of highly qualified professionals in technical fields, presents a significant challenge to the sustainability of infrastructure investments. In Saxony-Anhalt (DE), beneficiaries addressed this issue by hiring researchers who worked with infrastructure funded by the ERDF, with the support of ESF funding. This funding was used to cover both human resource costs and expenses related to the publication and commercialisation of research results. Additionally, other incentives, such as tax breaks, are crucial for attracting highly skilled researchers, as illustrated by the example from the West Flanders region presented below.

Box 6. Mini case study example: Flanders (BE)

Attracting human capital and facilitating knowledge and innovation transfer through infrastructure investments in Flanders


Regional OP: Flanders


1 international training centre


4,000 post-graduates


2015-2018

The West Flanders Development Agency (POM West-Vlaanderen) benefited from the ERDF support to implement two complementary projects (falling under the “New materials” cluster), namely “Circularity in & with new materials” and “Unlimited recycling”. The former project culminated in the creation of the Circular Materials Centre, while the latter aimed to promote the use of that infrastructure. The use of the infrastructure is open source, although the owner of the building, POM, requests a small fee every time stakeholders external to the original project make use of the machines it hosts. These machines can be used for different types of research activities, namely fundamental research, applied research and validation. The majority of research activity concerns the two latter (i.e. relatively high TRL), but substantial variation exists.

ORSI is an international training centre for minimal invasive and robotic surgery that was established in 2010. During the 2014-2020 period, ORSI requested and obtained ERDF funding to undertake a significant expansion of the Academy’s facilities, namely the construction of a new building that would allow the Academy to satisfy the high demand for its services. Construction occurred between 2015 and 2017, and the new building was opened in September 2018. The total budget for the project was 16 million, of which 5 million was provided by the European Regional Development Fund (ERDF). The project resulted in an increase in human resources. Indeed, the previous facilities, which became operational in 2012, were only able to accommodate 500-600 students, while the new facilities currently host 4,000 post-graduates (94% of whom are from outside of Belgium). Investment has also allowed for an expansion of the Academy’s research portfolio towards neurology, thanks to the acquisition of machinery that enabled image-guided surgery. Interviewees emphasised that the general innovation ecosystem was a significant factor in the project's success. In Flanders, industry, doctors and academia have a long-established collaborative culture, which has fostered a thriving innovation ecosystem. Its activities are facilitated by a well-designed policy mix that combines various incentives to encourage R&D

activity. For example, tax breaks for personnel costs can be combined with funding for infrastructure and aid for individual research projects. Additionally, researchers are relatively well compensated, which ensures a steady supply of human capital and encourages external collaboration with ORSI on research and development projects.

In addition, the effective utilisation of the established infrastructure, especially by private innovators, remains a critical factor and should be incorporated into the strategic development plan of the beneficiary. The case study on "Infrastructure investments for research" (PI1) illustrates that underutilisation of the infrastructure is a significant issue, particularly in the context of infrastructure intended for use in publicly funded and privately funded research. In such cases, the incentives of public research organisations (ROs) and private companies often diverge, with public ROs seeking to disseminate research findings and private companies prioritising confidentiality. In this context, the beneficiary's ability to utilise the infrastructure effectively has emerged as both a driver and a challenge in the causal process. The beneficiary can leverage the infrastructure's potential to cover variable costs associated with its use, thereby enabling long-term sustainment, when they use ERDF funding to cover fixed costs of acquiring the infrastructure. Conversely, the beneficiary can hinder long-term sustainment if they fail to ensure the infrastructure is adequately sustained due to a lack of a viable long-term strategy for its use.

4.4.2. ERDF has facilitated the production and diffusion of knowledge, as evidenced by the nearly 79,000 publications resulting from ERDF RTDI beneficiaries

It is widely accepted that knowledge creation is the primary driver of innovation and, consequently, competitive advantage.[106] The traditional indicator used to measure knowledge production activities is the number of scientific publications. The EU has a solid research base and ranks second globally in scientific output (Section ERDF RTDI support: funding allocation and expenditure analysis), excelling in less technological domains, while China leads in several top-cited publications. The 2024 Science, Research, and Innovation Performance Report shows that the EU ranks second globally in scientific output. With an 18.1% share of all publications registered in the Scopus database, the EU outperforms other regions, particularly in less technological domains. China leads in a number of top-cited publications with 27% of all scientific publications.[107] Collectively, the four largest EU countries (Germany, Italy, Spain, and France) produced 56% of these Scopus-registered publications within the EU. Nevertheless, there have been considerable alterations in the shares between 2002 and 2022. The countries with the most pronounced absolute increases in their shares during this period were Spain, Italy, Poland and Portugal. Conversely, the countries with the highest growth rates in terms of publication shares were those with a relatively low overall publication volume. These included Luxembourg (+843%), Malta (+618%), and Cyprus (+452%).

A comparison of publication activities across EU regions reveals a relatively dispersed pattern, with indications of convergence across regions.[108] Many lagging regions, predominantly in Eastern Europe (Poland, Latvia, Slovakia) and Southern Europe (Portugal, Spain, Italy), have demonstrated an improvement in publication activities over the 2010-2020 period. Should the positive trend in the quantity of scientific publications translate into higher quality, there is a possibility of catching up in the future. However, this catching-up

[106] Nico Pintar and Thomas Scherngell, (2022), *The complex nature of regional knowledge production: Evidence on European regions*, Research Policy, 51, (8).

[107] European Commission (2024). Science, Research and Innovation performance of the EU 2024 report. Available online.

[108] DG Research and Innovation – Common R&I Strategy and Foresight Service – Chief Economist Unit, based on Science Metrix, using the Scopus database Stat. link: https://ec.europa.eu/assets/rtd/srip/2022/figure-6-1-3.xlsx .

process tends to take time and is contingent upon overall improvement in framework conditions for scientific production.

To deepen the understanding of the knowledge production capacity from ERDF funding RTDI 2014-2020, a novel approach was implemented by this ex-post evaluation (see Section

Methodology for more details). A micro-level database was established to identify individual scientific publications by EU researchers from academia and/or industry that acknowledge ERDF funding in the period 2014-2020 as (one of) the financing source(s). That is, a direct causal link was established between ERDF support and a resulting scientific publication for the first time in an EU-wide evaluation of RTDI support from ERDF. As a first result, the analysis of this novel publication dataset, which relies on data from Dimensions.AI and OpenAlex, has identified that **ERDF investments in RTDI played a substantial role in knowledge production and dissemination**:

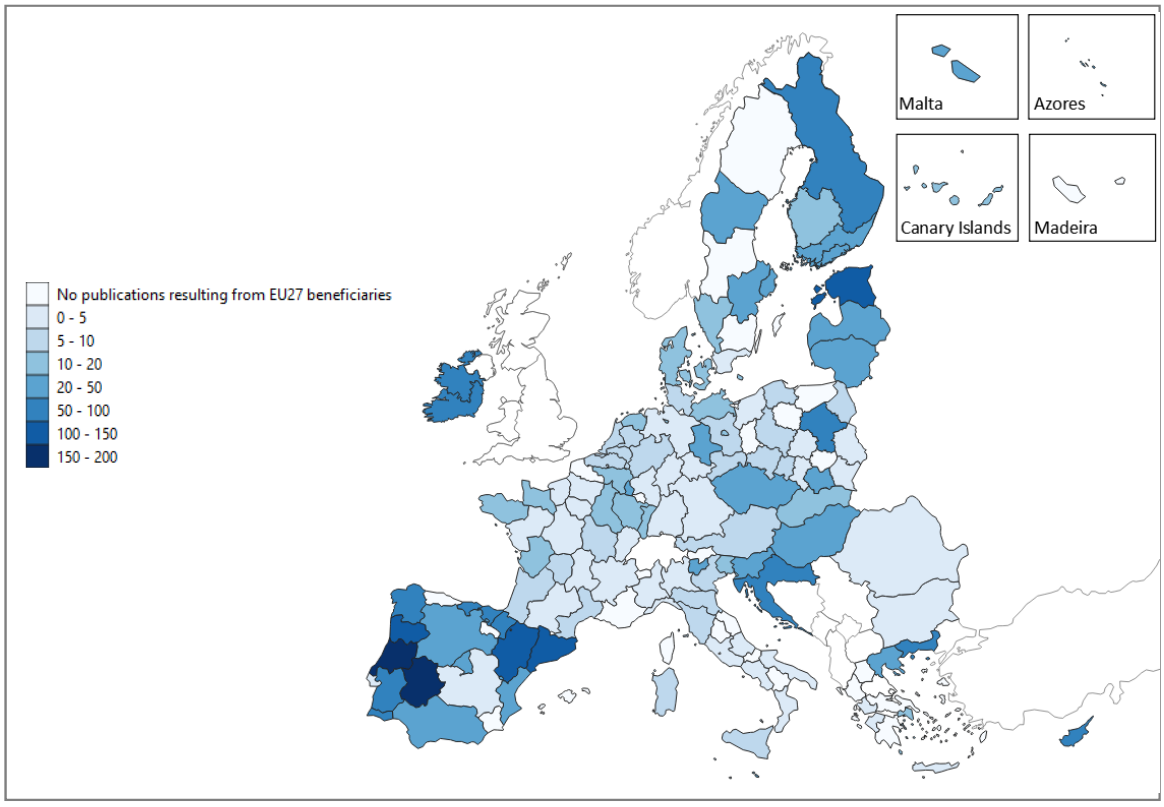
- A total of **138,600 scientific publications** in credible journals have acknowledged the receipt of ERDF support in the 2014-2020 period.
- Upon detailed examination of these 138,600 publications, **over half (57%) of them (or 78,700 in total) resulted from ERDF RTDI beneficiaries**.
- **Other ERDF funding (SMEs, Climate and environment, ICT...)** could have accounted for a further 43% of publications.

Even though the approach is successful in identifying relevant ERDF RTDI publications, some limitations should be kept in mind. These limitations include the time lag in the publication process or that potentially not all relevant publications indicate ERDF support (see also Annex IV for a full discussion of the limitations).

Regional distribution of the publications resulting from ERDF RTDI beneficiaries between 2014-2023

Figure 29 provides a **regional overview of the number of the number of publications per capita by ERDF RTDI beneficiaries between 2014-2023**. In general, the publications can be linked to almost all regions across the EU27 Member States. Nonetheless, higher concentrations of these publications are found in some Spanish regions (e.g., Catalonia and Extremadura), some Portuguese regions (e.g., Centro), in Ireland, and in Estonia.

Figure 29. Regional overview of the publications per capita resulting from ERDF RTDI beneficiaries between 2014-2023



Source: Prognos / CSIL / Visionary Analytics (2024), own publication database developed based on data from Dimensions.AI and OpenAlex. Publications are shown by 100,000 population.

This regional analysis is complemented by an assessment of the publications resulting from ERDF RTDI beneficiaries in EU14/EU13 regions[109] between 2014-2023, as well as the Cohesion Policy regional typology. A greater proportion of these publications is concentrated in the EU14 (74%) and associated with ERDF RTDI beneficiaries in more developed regions (57%), followed by less developed regions (34%) or regions in transition (9%). This, however, must be put in the context of the number of regions according to the Cohesion Policy typology. Here, almost 55% of the regions are classified as more developed, around 30% as less developed and around 15% as transition regions.

Development of publications linked to ERDF RTDI beneficiaries over the 2014-2023 period

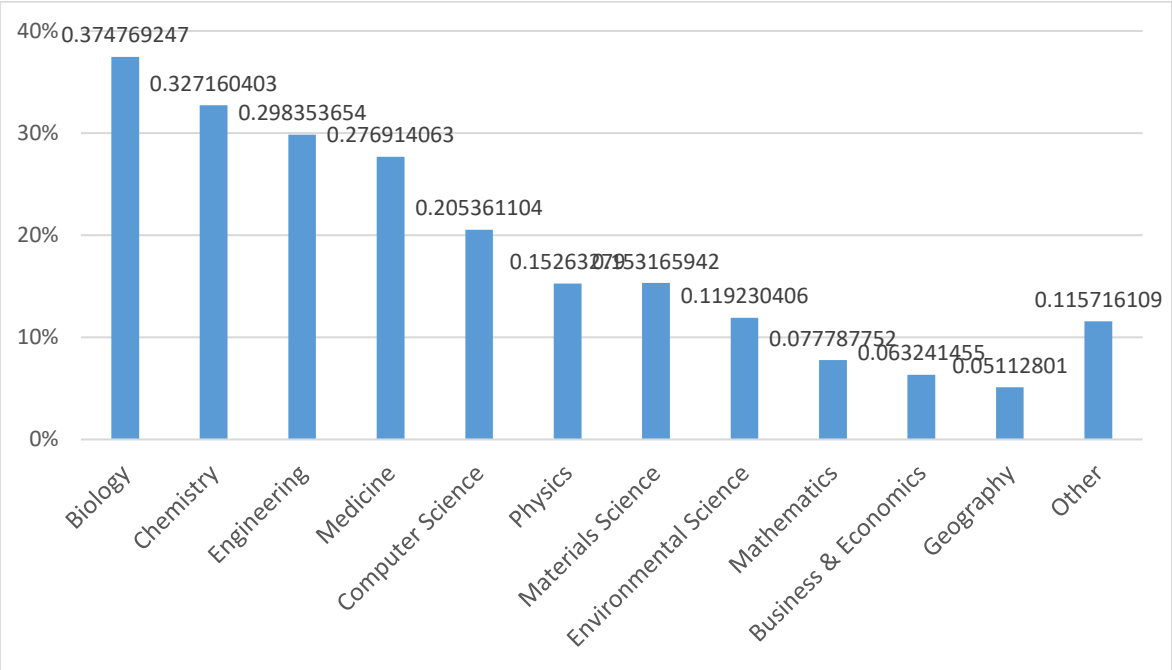
Since 2018, there has been a notable increase in the number of yearly ERDF-funded publications resulting from ERDF RTDI beneficiaries. Overall, the development of publications by ERDF RTDI beneficiaries has exhibited a relatively consistent pattern between 2014 and 2023 across all regions. In total, there was a gradual but consistent increase in these publications from approximately 3,300 in 2014 to approximately 5,250 in 2017. This was followed by a surge in yearly publications resulting from ERDF RTDI beneficiaries, reaching a peak of approximately 12,500 of these publications in 2021. **This surge reflects the typical sequence of events in the funding process and the progress of research projects**. Prior to the publication of results, a preliminary research phase is often required. This phase often necessitates substantial planning, data collection, and analysis, which can be time-consuming without producing publishable results. Following the completion of the research, the subsequent publishing process may also necessitate additional time for drafting, peer review, and rounds of revisions, particularly in the case of research articles (82% of the publications resulting from ERDF RTDI). Consequently, it is to be expected that there will be a time lag between the receipt of ERDF funding, the conduct of research, and the eventual publication of the results. **The notable surge in publications from 2018 onwards is likely to reflect the culmination of research endeavours initiated in 2014-2015.**

Thematic domains of publications resulting from ERDF RTDI beneficiaries

The large majority of identified publications address topics that are related to STEM (science, technology, engineering, and mathematics). The majority of identified publications linked to ERDF RTDI beneficiaries are located in the thematic domains of biology (37%), chemistry (33%) and engineering (33%). This suggests a strong emphasis on disciplines that contribute directly to scientific and/or technological advancement. The prominence of biology and chemistry can be attributed to their foundational roles in fundamental research and applied sciences, often supported by substantial funding for innovation and development projects under the ERDF. Engineering follows closely, reflecting its critical role in infrastructure, industrial innovation, and technological advancements that drive economic growth. Only a small percentage of publications are linked to non-STEM-related thematic domains, including business and economics (6%) and geography (5%). There is not a significant variation in these topics across the different regions (EU14/EU13 and Cohesion Regions).

[109] EU14 includes Member States that have joined the EU before 2004. These are Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden. EU13 includes Member States that have joined the EU since 2004. These are Bulgaria, Croatia, Cyprus, Czechia, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia, Slovenia

Figure 30. Publications resulting from ERDF RTDI beneficiaries between 2014-2023, by thematic domains of publications

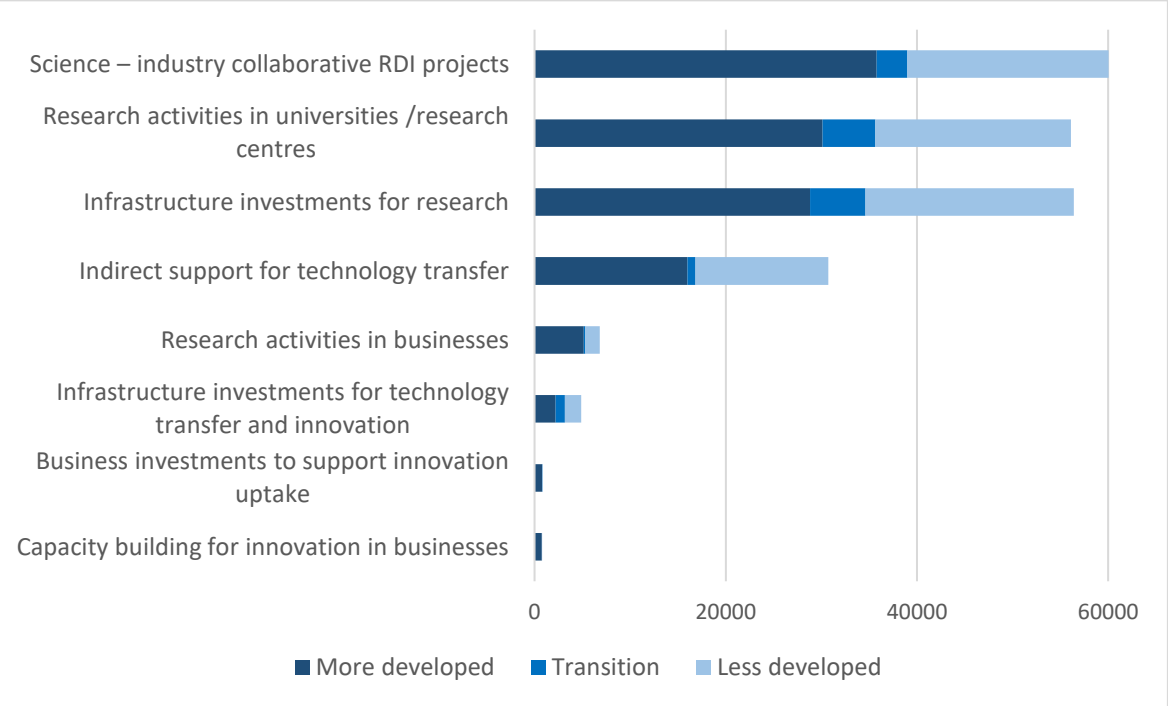


Source: Prognos / CSIL / Visionary Analytics (2024), own publication database developed based on data from Dimensions.AI and OpenAlex. n=78,714. Note: one publication can be linked to multiple thematic domains. The addressed thematic domains are provided by the publication databases.

Key policy instruments driving ERDF RTDI publications

Furthermore, the distinctive micro-level database enabled the linking of these publications to the various policy instruments analysed in this ex-post evaluation by examining the beneficiaries and their ERDF projects. Again, this goes beyond the more common assessment of publications in ERDF support schemes that rest on monitoring data. The publication can be traced to the beneficiary and project or vice versa. The assessment shows that **most publications are allocated to three policy instruments, namely "Science-industry collaborative R&D projects", "Research activities in universities/research centres" and "Infrastructure investments for research".**

Figure 31. Publications resulting from ERDF RTDI beneficiaries, by RTDI policy instruments & by Cohesion Regions



Source: Prognos / CSIL / Visionary Analytics (2024), own publication database developed based on data from Dimensions.AI and OpenAlex. Allocation of PIs to ERDF RTDI beneficiaries based on ERDF RTDI projects allocated to those beneficiaries. Note: one ERDF RTDI beneficiary can be linked to multiple PIs.

An examination of the aforementioned findings yields three primary insights.

First, it can be observed that **publications resulting from science-industry collaboration stand out by number, regardless of the type of Cohesion region.** The prevalence of science-industry collaborative R&D projects as the majority of publications in the assessment is a positive indicator of robust synergy between academic research and industrial application. This collaboration effectively leverages the strengths of both sectors, namely the innovative, exploratory nature of scientific research and the practical, market-driven focus of industry. The integration of these domains enables regions to benefit from accelerated technological advances, enhanced economic growth, and the efficient translation of research findings into real-world applications. Moreover, the pervasive involvement in these collaborative endeavours across a diverse array of regions indicates a comprehensive dedication to innovation and a balanced dissemination of technological advancement, thereby fostering regional growth and reducing disparities in economic opportunities and technological access.

Second, as demonstrated in Section Targeting investments through S3 strategies is beneficial, but only to the extent that S3s reflect the underlying economic and technological specialisations.., **ERDF investments in research activities at universities and research centres, as well as in research infrastructures have also led to an increase in the**

number of publications across all the Cohesion Regions. Additionally, it is noteworthy that **many publications resulting from business-related research activities originate from more developed countries**. This phenomenon can be attributed to a number of factors, including the tendency for such countries to possess more robust intellectual property protection and regulatory frameworks that encourage businesses to engage in and publish research.

The results of the current original qualitative research, which explored the processes of knowledge creation, have been validated by a series of detailed case studies examining the infrastructure investments for research, research activities conducted by universities and research centres, and science-industry collaboration (the latter is detailed in greater depth in Section ERDF has stimulated knowledge sharing and regional partnership creation, but there is still untapped potential for more collaborations). All three policy instruments exerted a notable influence on the growth and diffusion of knowledge, as measured by the number of published works, including those of considerable impact.

For instance, in **Spain** the support provided by the ERDF to the construction, expansion or improvement of the facilities and equipment of large research infrastructures, as evidenced by a recent evaluation[110], has positively impacted various metrics, including the number of publications in indexed journals, with a particular focus on those in Q1 indexed journals.

In **Estonia**, the ERDF was used extensively for research activities in universities and research centres (31% of the ERDF policy mix), with the structural funds accounting for a significant proportion of all research funding. The sector was perceived as relatively inefficient, particularly in terms of the dispersion of resources, networks and collaborations. A major support scheme funded by the ERDF was the *Institutional Development Programme for Research and Development Institutions and Higher Education Institutions* (ASTRA), which aimed to address this situation. Consequently, 36 projects were funded in the country, resulting in a notable increase in the country's output of high-quality academic publications. The interviewed beneficiaries of the ASTRA programme indicated that the support provided led to a more than doubling of the number of high-level publications, which they attributed to a significant enhancement in the quality and quantity of academic research. The findings were consistent with the observation of a positive shift in the performance of scientific articles among the top 10% most cited over the 2016–2023 period. In the 2023 European Innovation Scoreboard, Estonian performance demonstrated an increase of 21.5% across this period.

Knowledge dissemination

As already visible in the high share of publications resulting from science-industry collaboration projects receiving support from the ERDF 2014-2020, **knowledge diffusion is a core driver for increasing innovation capacities in regions**.

To measure knowledge diffusion from the ERDF-supported RTDI projects, citations and Altmetrics data were employed to qualify the relevance of the publications resulting from ERDF beneficiaries. While citations are a quality indicator for publications showing how publications have influenced subsequent research, Altmetric is a measure of non-traditional attention and engagement that an article has received online (by looking at online attention markers). The Altmetric score considers attention received in news articles, blog posts, tweets, policy documents, and more. [111] It is an alternative to relying solely on citations to quantify the reach and impact of published research and aims to show how research is making a difference. [112] Again, this requires detailed micro-level data.

[110] Instituto de Estudios Fiscales - IEF (2023). Evaluation of the impact of large RTDI infrastructure on RTDI projects financed by Cohesion Policy in 2014-2020, in Spain, https://ec.europa.eu/regional_policy/policy/evaluations/member-states/ese152_en .

[111] The Altmetric Attention Score: What Does It Mean and Why Should I Care? - PMC (nih.gov).

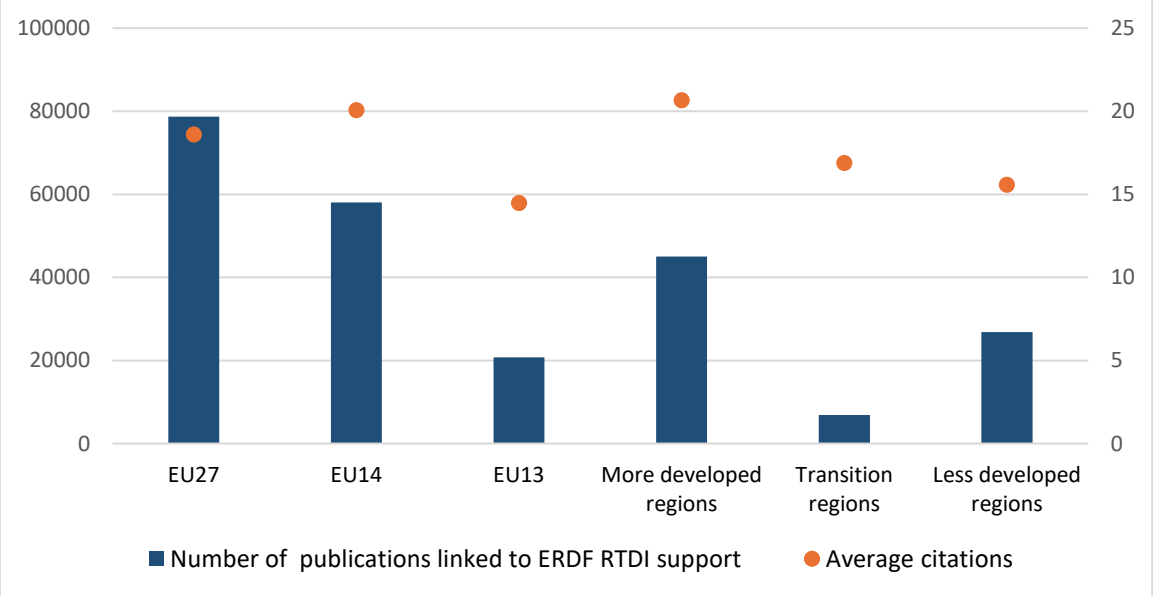
[112] For more information, please see: Understanding the Altmetrics score and your research | Wolters Kluwer.

Based on this operationalisation of knowledge diffusion, a quantitative exploration shows that **78,700 publications by ERDF RTDI beneficiaries have received an average of 19 citations each**. This is slightly higher than the average citations (18 citations) of other (non-ERDF funded) publications from the EU in the same reference period.[113] Publications from the US have on average received 22 citations in the same reference period which implies a higher scientific impact and knowledge diffusion of US publications. However, it is important to stress that a direct comparison of the average citation rate has its limitations due to the ramp-up of the publications resulting from ERDF RTDI beneficiaries (see also above under 'Development of publications linked to ERDF RTDI beneficiaries over the 2014-2023 period'). This ramp-up of the publications resulting from ERDF RTDI beneficiaries is relevant since older publications are more likely to have more citations.

Publications associated with ERDF RTDI beneficiaries from the EU14 have had a higher average of 20 citations per publication, while those from the EU13 have had an average of 14 citations per publication. This trend was consistent across different the three different Cohesion Regions. The more developed regions average 21 citations per publication, the transition regions 17 citations, and the less developed regions 16 citations.

As an additional angle, publications with more than 50 or 100 citations are examined to account for publications with a high scientific impact. Here, among the publications resulting from ERDF RTDI beneficiaries, 7.4% (5,840) have received over 50 citations, and 2.3% (1,810) have received over 100 citations, which may be indicative of their scientific impact. A similar regional pattern as before emerges for those publications that have received over 50 and over 100 citations since the majority of those publications are from the EU14 and more developed regions.

Figure 32. Publications resulting from ERDF RTDI beneficiaries (columns) and average citations (dots), by regions



Source: Prognos / CSIL / Visionary Analytics (2024), own publication database developed based on data from Dimensions.AI and OpenAlex.

In contrast to the time frame required for citations to accrue, the Altmetric score can be calculated relatively quickly after publication. It is important to note that the Altmetric score is relative, lacking a fixed scale. A score of 0 signifies no tracked attention, while higher scores indicate varying levels of engagement. Articles in highly regarded journals such as Science or Nature typically achieve higher scores due to their extensive readership and

[113] To account for the time lag between the start of the first RTDI projects and consecutive publications, only publications between 2016-2023 are used as a reference.

likelihood of being widely shared and discussed. While the Altmetric score is not standardised, a score of 20 or above generally indicates significant attention relative to peer publications.

The analysis of the Almetric score of the publications resulting from ERDF RTDI beneficiaries shows that **ERDF RTDI-supported publications had an average Altmetric score of 15, highlighting a relatively robust level of attention beyond traditional citations**. The average Altmetric Score for EU14 publications was higher (17), compared to 8 for EU13 publications. In the context of Cohesion Regions, publications originating from more developed regions achieved an average Altmetric Score of 19, while those from transition and less developed regions scored 15 and 8, respectively. However, higher scores in certain regions may reflect more effective dissemination strategies and greater access to resources and platforms that amplify the visibility and impact of their research, leading to higher Altmetric scores.

4.4.3. ERDF has stimulated knowledge sharing and regional partnership creation, but there is still untapped potential for more collaborations

As innovation is the result of an interactive process, cooperation and networking appear to be essential for successful innovation.[114] **Developing links and synergies between businesses, R&D centres and higher education was one of the key objectives of ERDF support for RTDI over the period 2014-2020**.

Recognising that innovation thrives at the intersection of different sectors, the ERDF aimed to develop partnerships and networks that could effectively bridge the gap between research and practical application. By supporting these collaborative structures, ERDF support for RTDI was primarily aimed at accelerating the commercialisation of research results, ensuring that breakthroughs in laboratories can be successfully translated into market-ready products and services. This is reflected by the fact that the second largest share of the budget was allocated to science-industry collaborative RDI projects (EUR 13 billion), representing around 20% of total spending on RTDI under the ERDF 2014-2020 and almost 17% of all operations. Furthermore, the above novel analysis of the publication dataset demonstrates that the majority of publications resulting from ERDF RTDI beneficiaries in the period 2016-2023 are allocated to science-industry collaborative R&D projects**,** regardless of the type of Cohesion region (see Section ERDF has supported the enhancement of R&I infrastructure and institutional capacities, although some implementation challenges occurred).

RTDI support through the ERDF 2014-2020 led to an increased number of joint projects between research and industry partners, predominantly SMEs, as evidenced by the evaluation reports and the case studies dedicated to the collaboration between academia and business. This resulted in active knowledge sharing, and the formation of collaborative partnerships, as well as technological advancement and improved knowledge in numerous enterprises that gained access to new ideas, expanded their range of expertise and became aware of new technological solutions. ERDF has also facilitated the alignment of academic research with industry needs, thereby establishing an ecosystem conducive to the testing, refinement, and efficient market introduction of innovations. Universities and research institutions contributed their cutting-edge knowledge and research capabilities, while businesses contributed practical insights, market understanding, and pathways to commercialisation.

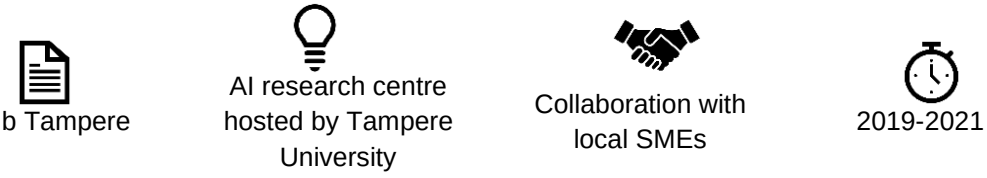
[114] Lewandowska, M., Weresa, M. & Rószkiewicz, M. (2022). *Evaluating the impact of public financial support on innovation activities of European Union enterprises: Additionality approach*. International Journal of Management and Economics. 58. 248-266.

The evaluation of Lead Market funding in the region of **North Rhine-Westphalia (DE)**, the flagship programme to support the S3 of the region, demonstrated that ERDF-supported science-industry projects made a substantial contribution to creating new technological expertise and knowledge at the regional level.[115] Approximately 90% of a survey of around 600 respondents fully or partially concurred that financed R&D projects resulted in a noteworthy gain in technological and scientific knowledge. 68% of respondents confirmed that the funded R&D projects in the lead market competition contributed to establishing a new field of research or activity. However, the motives for participating in the lead market competitions varied significantly between the main target groups: companies and academia. Companies focused on developing new products or services, while research partners participating in the project were primarily motivated by the generation of scientific publications. Also, the Lead Market funding beneficiaries interviewed within this study highlighted that the funding has led to significant scientific progress in companies and advances in the development of innovative materials.

In **Finland**, *AI Hub Tampere* project built a new Artificial Intelligence Hub for intelligent machines and boosted the AI knowledge in companies, bringing together university partners and companies. Its primary objective was to facilitate the recent advances in AI within Finnish intelligent machine companies (see the Box below).

Box 7. Mini case study example: Finland

Boosting AI knowledge through university-business collaboration in the Tampere region and beyond



AI Hub Tampere is a regional hub project funded by ERDF and the Council of Tampere Region in 2019-2021 and 2022-2023.[116] AI Hub aims at consulting local SMEs in the use and application of artificial intelligence in business development. The hub provides help and guidance in the ability to adopt the newest software and technology in the field of AI, with particular focus on intelligent machines, such as autonomous, driverless construction machines and robotics.

With the help of AI Hub Tampere, companies located in the Pirkanmaa region can advance from beginners to AI experts. The project facilitates knowledge exchange through three main modes of operation: workshops and demonstrations open to companies, helpdesk discussions to explore AI solutions, and conducting pilot projects to address specific challenges (see the picture below). In the pilot projects, technical tests and trials are performed, such as using various machine learning methods, followed by the delivery of a written analysis report to the company. This process often motivates companies to seek additional funding and advance their business operations.

[115] Prognos (2019): Evaluation of the ERDF NRW 2014-2020 OP Contribution of innovation funding to the development of the NRW lead markets. Available online.

[116] The project has also attracted over time different sources of funds. See more: About | AI Hub Tampere | Tampere Universities (tuni.fi)

Source: AI Hub Tampere website.

The AI Hub Tampere is described as a *rendez-vous* between university specialists and SMEs located in the Pirkanmaa region and beyond. It is important to note that the follow-up project *AI Hub 2.0* received funding under REACT-EU in 2022-2023.

The newly acquired knowledge from science-industry collaboration was primarily evidenced by the rise in co-publications. This aligns with our novel quantitative findings presented in Section ERDF has facilitated the production and diffusion of knowledge, as evidenced by the nearly 79,000 publications resulting from ERDF RTDI beneficiaries, which demonstrate that most publications associated with ERDF RTDI beneficiaries are attributed to science-industry collaborative R&D projects. In addition, it is confirmed by the case studies addressing collaboration between academia and enterprises.

In **Saxony (DE)**, the evaluation of the regional measure revealed that collaborative projects between academia and business resulted in a total of 905 reported publications, which constituted 91.2% of all publications.[117] This is also reflected in Saxony's increased performance over the period 2016-2023 in the Regional Innovation Scoreboard in relation to public-private co-publications. The same is true for almost all the regions included in the case study on science-industry collaborative projects[118], with the exception of North Rhine-Westphalia, where a small decline was observed in 2023 (although the region remains above the EU average).

Since 2011, the number of scientific papers with a public-private co-authorship has increased across the **EU13 countries**, from 36.2 per million people to 138.5 per million in 2023. The same trend is observed across the 2004 joiners, with the increase particularly marked in Lithuania and Latvia.[119] These improvements reflect a broader pattern of convergence, where the EU13 countries are progressively catching up in terms of knowledge co-production and collaboration.

[117] Gesellschaft für Finanz- und Regionalanalysen (GEFRA, Untiedt & Alecke GbR), JOANNEUM RESEARCH Forschungsgesellschaft mbH, Kovalis – Dr. Stefan Meyer & Institut – Leibniz-Institut für Wirtschaftsforschung an der Universität München e.V. Niederlassung Dresden (2017-2020). Laufende Evaluierung des Operationellen Programms des Freistaates Sachsen für den Europäischen Fonds für regionale Entwicklung in der Förderperiode 2014 bis 2020 sowie Ad-hoc-Analysen im Rahmen von Änderungsanträgen zum Operationellen Programm - Teil I -.

[118] Finland, Latvia, Southern and Eastern Ireland, Rhone-Alpes, Lombardy.

[119] Science Business (2024). *Ten graphs show how the research landscape in EU 2004 members has changed*. Available online.

ERDF support for RTDI has facilitated the establishment or reinforcement of predominantly regional partnerships between science and business. Firstly, a linkage-oriented indicator, 'Innovative SMEs collaborating with others', of the Regional Innovation Scoreboard shows an increase over the period 2014-2023 in the investigated regions. This increase was particularly notable in Finland as well as in the regions of Lombardy, Saxony, and Rhône-Alpes. Moreover, by the end of 2022, 75,524 enterprises had collaborated with research institutions (CO26), exceeding the target value by 115.06%.

The case studies conducted within this evaluation also provide qualitative evidence of the ERDF contribution. New partnerships were formed in **Lombardy (IT)**, where collaboration brought together actors who were not accustomed to working together, including SMEs and large enterprises. In the **Rhône-Alpes (FR) region**, partnerships were typically established through existing networks and clusters, either formed for previous projects or through the networks of various partners. Furthermore, in **Saxony (DE)**, ERDF projects played a pivotal role in the formation of collaborative partnerships, the advancement of research, and the professionalisation of existing networks. These partnerships were typically based on existing structures, such as Silicon Saxony, biosaxony e.V., and the Innovation Network Mechanical Engineering Saxony (VEMASinnovativ). In addition, ERDF support was aligned with BMWK grant-based funding and various BMBF technology-specific programmes that fostered basic and top-tier research through collaborative company-academic or research institution projects.

Furthermore, **RTDI support through the ERDF has successfully incentivized collaborative projects** through the provision of enhanced conditions. For example, Austria and Croatia implemented initiatives for research activities within businesses that provided funding premiums for collaborative projects. In Austria, for instance, a premium on aid intensities was provided for collaborations. A similar outcome was documented by the analogous incentive in Croatia, were, out of all beneficiaries, 75% initiated cooperations for the implementation of the projects.120 In Lombardy (IT), the design of the measure, which waived the requirement for a minimum investment per partner, facilitated the participation of financially unstable entities such as startups, thereby enabling them to contribute their expertise. This fostered collaboration involving young businesses and startups, enabling the leveraging of expertise without the necessity of equipment investments. These were provided by research institutions (receiving a non-repayable grant), and other financially stable beneficiary companies exempt from surety requirements. Furthermore, the call specified that up to 10% of the project investment could be sourced from research organisations outside of Lombardy. This enabled the attraction of research organisations from other Italian regions, including the Polytechnic di Torino, the Polytechnic di Bari and the CNR in Rome. Additionally, 23 companies with non-operational headquarters in Lombardy established a local office in the region during the contracting phase to participate in the call. In Southern and Eastern Ireland, the design of the Innovation Partnership Programme calls allowed applicants to apply at any time, with approval decisions made monthly. This rolling application process offered several key advantages, helping the industry adapt to rapidly changing market conditions (see the box below).

[120] Mid-term evaluation of the performance of the Operational Programme Competitiveness and Cohesion 2014-2020. PA 1 Evaluation of the effect "Strengthening the economy through the application of research and innovation" .

Box 8. Mini case study example: Southern and Eastern Ireland

Fostering knowledge sharing between science and industry through open calls and Technology Transfer Offices in S&E Ireland


Innovation Partnership Programme


2 Project partners


Research institute (1), SME(1)


2015-2017

The Innovation Partnership Programme (IPP) in the S&E Region of Ireland had a strong focus on industry, particularly SMEs. Its aim was to strengthen links between academia and business by supporting collaborative research projects that engage companies and Irish universities and institutes of technology. The programme provided non-repayable grants to research-performing organisations[121] with the aim of developing the underlying technology for new or improved products and generating new knowledge. The IPP applicants were able to apply anytime, and the approval decisions are made every month. According to the interviewed beneficiaries, this unique feature facilitated quick responses to rapid changes in the industry landscape, avoiding bureaucratic delays and making projects more relevant. Additionally, commercialisation or technology transfer offices (TTOs) that act as facilitators played a crucial role in supporting collaborative partnerships by searching for intellectual property information and licensing opportunities. All 85 projects under the measure were successfully concluded, resulting in a 100% completion rate.

ERDF funding for RTDI facilitated the formation of bilateral partnerships, particularly among previously unfamiliar partners, leading to active knowledge sharing. One illustrative example is the project *Conformal and Non-destructive Doping of High Mobility Materials*, which explored novel methods of doping materials by introducing minimal impurities. The company discovered that the conventional approach of ion implantation might not be suitable for future generations of integrated circuits, prompting the need to revisit the fundamental principles underlying this technique and explore alternative methods. The industry partner noted that the project yielded considerable insights into alternative doping methods for semiconductors, largely due to the expertise of the academic partners. The academic partner indicated that collaboration with an industry partner was beneficial for the entire research team, as it afforded the opportunity to work on cutting-edge technology and address critical issues in the technology sector. Both academic and industry interviewees concurred that this knowledge was pivotal for the development of future generations of chips. The project yielded insights into the advantages and disadvantages of the novel techniques being investigated, which informed the company's future decisions regarding the application of the technology, the evaluation of methods, and its potential use. The assessment informed decisions such as investing in the advancement of a new machine, which supported the company's future planning. Overall, this collaborative partnership was highly successful and paved the way for subsequent joint projects, which are currently ongoing.

While the ERDF support for RTDI has facilitated collaboration between RTDI actors, certain challenges remain. In **France**, specific difficulties have been encountered, including the length and complexity of setting up collaborations.[122] In **Lithuania**, businesses were reluctant to collaborate with public research organisations due to various obstacles. These included differing perceptions of the goals and results of R&D activities between business and science representatives, limited availability of public sector researchers and the internal bureaucracy of public research organisations.[123] Other systemic challenges to

[121] However, the funding structure considered the size of the company and the type of research, whether it was industrial research or experimental development.

[122] ANCT (2020). *Phase 1 : Etat des lieux et analyse de la programmation du FEDER 2014-2020 en métropole. Rapport Final. Innovation Recherche*. Available online..

[123] Visionary Analytics. (2019). 2014–2020 m. Europos sąjungos fondų investicijų veiksmų programos 1 prioriteto „Mokslinių tyrimų, eksperimentinės plėtros ir inovacijų skatinimas“ poveikio vertinimo paslaugos. Galutinė atasaita.

science-industry collaboration included a lack of convenient and one-stop information on services provided by research and education institutions and a lack of an efficient technology transfer system. The latter challenge was addressed with ERDF funds by the establishment of technology transfer centres in public research organisations.

An analysis of the national OP and the case study dedicated to science-industry collaboration show that in **North and East Finland** there was an inadequate pool of potential and actual project partners with the requisite capabilities to participate in collaborative research projects and that the relatively brief duration of financed projects had a negative impact on the accumulation of knowledge.

In addition, analysis of expenditure data reveals potential limitations in the way ERDF support contributes to the strengthening of collaboration among research and innovation actors. For instance, the breakdown of expenditure and operations by type of project and beneficiaries at the end of 2022 highlights that **75% of the ERDF RTDI funding was distributed to sole beneficiaries**, with enterprises accounting for 40% of this figure. Nevertheless, it is essential to exercise caution when interpreting this number, as the aforementioned sole beneficiaries may also be involved in collaborative projects. Conversely, 23% of expenditure was directed towards collaborative projects with the objective of fostering partnerships between various types of actors. This was also reflected in the policy mixes of several Member States, which tended to maintain gaps between science and industry and funded predominantly either the business sector or the university/public research organisation sector, with only marginal funding for science–industry collaborative projects.[124] This was particularly evident in less developed regions, where 29% of expenditure was allocated towards such projects, and in transition regions where 15% was spent on the same. However, there were some exceptions. For example, in Czechia, nearly 25% of the ERDF RTDI budget was explicitly dedicated to academia-industry collaboration[125], channelled mainly through Objective 1.2. of *the Enterprise and Innovation for Competitiveness Operational Programme*. Concretely, collaborations took the form of direct RDI projects involving companies and research centres, but also more indirect mechanisms, such as vouchers, infrastructure development and knowledge transfer partnerships. Furthermore, a survey of beneficiary companies conducted as part of the programme evaluation revealed that 70% of enterprises had initiated further joint research initiatives following the conclusion of ERDF projects.[126] This finding suggests that ERDF-supported measures in Czechia have facilitated more sustained collaborations.

[124] Marginal ERDF funding for collaboration between science and industry was allocated in Belgium (2.7%), Spain (4%) and Austria (7.5%). However, it is noteworthy that in all three aforementioned countries, government budget allocations for RTDI were considerable. To illustrate, in Spain, ERDF support for RTDI was typically used to address specific gaps and angles of policy priorities, complementing funding from the European Social Fund (ESF) and other national/regional sources. For example, the National Research Agency (AEI), the Managing Authority responsible for ERDF-funded research activities in universities and research centres, oversaw additional funding calls in parallel, sourced from other national channels. These calls provided competitive funding for collaboration platforms and partnerships between research centres and businesses.

[125] Regions differed significantly in the attributed resources with Prague strongly prioritised RDI collaborative projects, with more PROCES (2019). Evaluation of Specific Objective 1.2 of the Enterprise and Innovation for Competitiveness OP, 2014-2020 in the Czech Republic. https://ec.europa.eu/regional_policy/policy/evaluations/member-states/cze47_en than 54% of its ERDF RTDI resources. Other regions were typically in the 10-15% range.

[126] For more information, please see: PROCES (2019). *Evaluation of Specific Objective 1.2 of the Enterprise and Innovation for Competitiveness OP, 2014-2020 in the Czech Republic*. Available online.

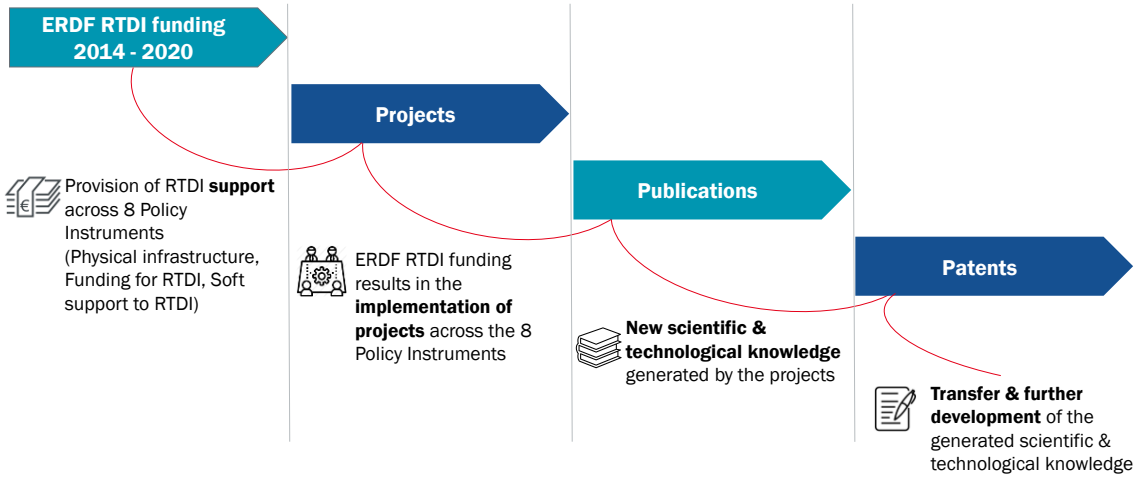
4.4.4. ERDF has positively contributed to the technological advancement of EU regions, with over 7,000 patent registrations documented

In addition to the improvement of R&I infrastructure and capacity, the generation and **dissemination of new knowledge, and increased collaboration between academia and industry**, a further step in the causal chain can be seen in technological development. Technological advancement is traditionally measured either by the number of patent applications or, even more accurately, by the number of patent registrations. This is the effect of possible transfers and further developments of these scientific findings by commercial partners. Patents serve as a robust indicator of innovation, offering valuable insights into technological advancements and inventive activities across various industries.[127] Nevertheless, despite their significance, patents also have inherent limitations that warrant careful consideration. This is exemplified, for instance, by the Ninth Report on Economic, Social and Territorial Cohesion[128] which shows that a considerable proportion of innovations emerging in the service sector, which accounts for approximately 75% of EU gross value added, remain unpatented due to their intangible or non-codifiable nature. It is thus imperative that policymakers, researchers and innovators comprehend the strengths and weaknesses of patents in order to fully leverage their potential as a means of fostering innovation and economic development.

Box 9. Tracing knowledge generated by the ERDF RTDI support from projects to patents

A novel exercise has been carried out using various matching techniques and Large-Language-Models in a multi-stage approach, which has made it possible to identify publications resulting from ERDF RTDI support between 2014 and 2020 (including their scientific impact) and to trace these publications to patents. This approach allowed for the tracing of knowledge generated by the ERDF RTDI support from projects over publications to patents (see **Figure 33.**). For more information, see Section **Mixed methods analytical approach**.

Figure 33. Schematic overview of tracing knowledge generated by the ERDF RTDI support from projects to patents



Source: Prognos / CSIL / Visionary Analytics (2024).

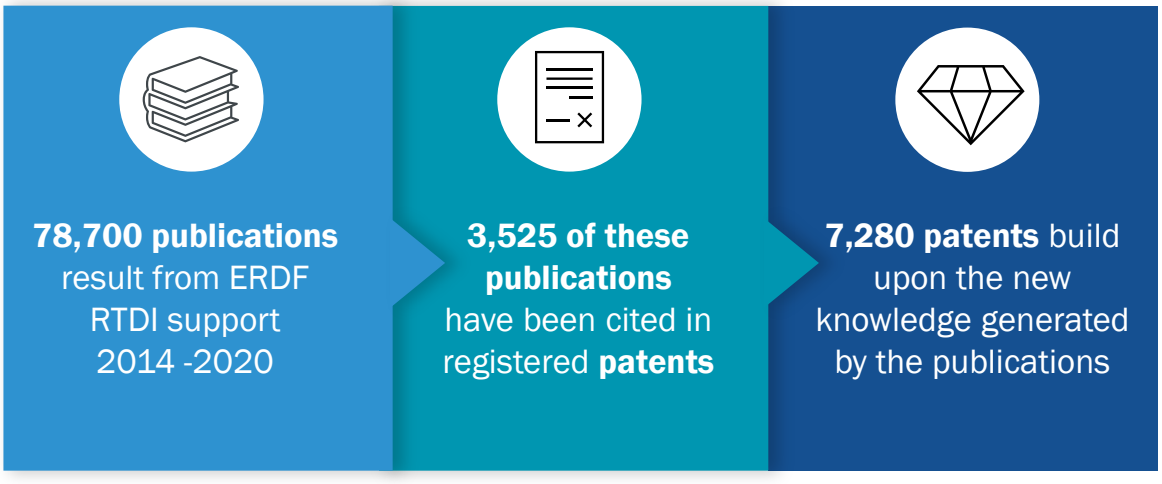
[127] Seeni, A. & Brown, Terrence B.E. (2015). Measuring Innovation Performance of Countries using Patents as Innovation Indicators.

[128] European Commission (2024). Ninth report on economic, social and territorial cohesion.

To trace the patented inventions (measured as registered patents at the European Patent Office, EPO) resulting from ERDF RTDI support 2014-2020, this ex-post evaluation has employed a number of research steps. These include the identification of publications resulting from ERDF RTDI support and the linking of these publications to registered patents through citations to non-patent literature. This was based on a novel approach that involved several matching techniques and the application of Large Language Models (see also Section Mixed methods analytical approach). Therefore, an in-depth assessment of scientific publications resulting from ERDF RTDI support was performed (see **Error! Reference source not found.** and Section ERDF has facilitated the production and diffusion of knowledge, as evidenced by the nearly 79,000 publications resulting from ERDF RTDI beneficiaries), which revealed the transmission of published research into patentable innovations over the period 2014-2023.

Based on this approach, our analysis reveals that **approximately 3,525 of the 78,700 publications (4%) linked to the ERDF RTDI support between 2014-2023 have been transformed into registered patents** (see Figure 34). Since only registered patents are considered, it is important to stress that these registered patents have undergone a qualification process. Non-successful patent applications are not considered here which means that the number of publications that have led to patent applications is likely to be higher than the number found by the analysis. Although this approach allows to trace the knowledge generated by ERDF RTDI support 2014-2020 from publications to patents, some limitations need to be kept in mind. These include, for instance, time lags due to the long publication and patent processes (see also Annex IV for more details). Moreover, it needs to be stressed that the patent activities do not directly relate to the ERDF support but that the patents build upon the knowledge generated by the ERDF RTDI support. The conversion rate from publications to patents, i.e., the 4%, is on par with the general conversion rate of European publications in the period of observation, which also reached 4%. However, this conversion rate falls below the conversion rate of publications from US innovators (6%), indicating a lower commercialisation of scientific output in the EU compared to the US.

Figure 34. From publications to patents: Tracing the knowledge generated by ERDF RTDI support 2014-2020 from research towards the market



Source: Prognos / CSIL / Visionary Analytics (2024), own publication database developed based on data from Dimensions.AI and OpenAlex.

Furthermore, our analysis demonstrates that **2,540 (35%) out of the 7,280 identified registered patents that result from ERDF RTDI publications originated in the EU27.** The vast majority (2,270 or 89%) of the registered EU27 patents that we identified are from the EU14 Member States. In addition to these novel quantitative findings, the case studies provide further qualitative evidence. In **Lombardy (IT)**, science-industry collaborative RDI

projects have successfully implemented both product and process innovations in all projects. In each case, a series of prototypes, pilot plants and tests were conducted, and in some instances, Italian or European patent applications were submitted after the conclusion of the project. In **the Netherlands**, the case study on IQ Capital, which invested in innovative startups willing to commercialise new products or processes, provides evidence that some of the projects supported by the ERDF led to patent applications after project completion.

Spatial analysis of patent registrations resulting from ERDF RTDI beneficiaries

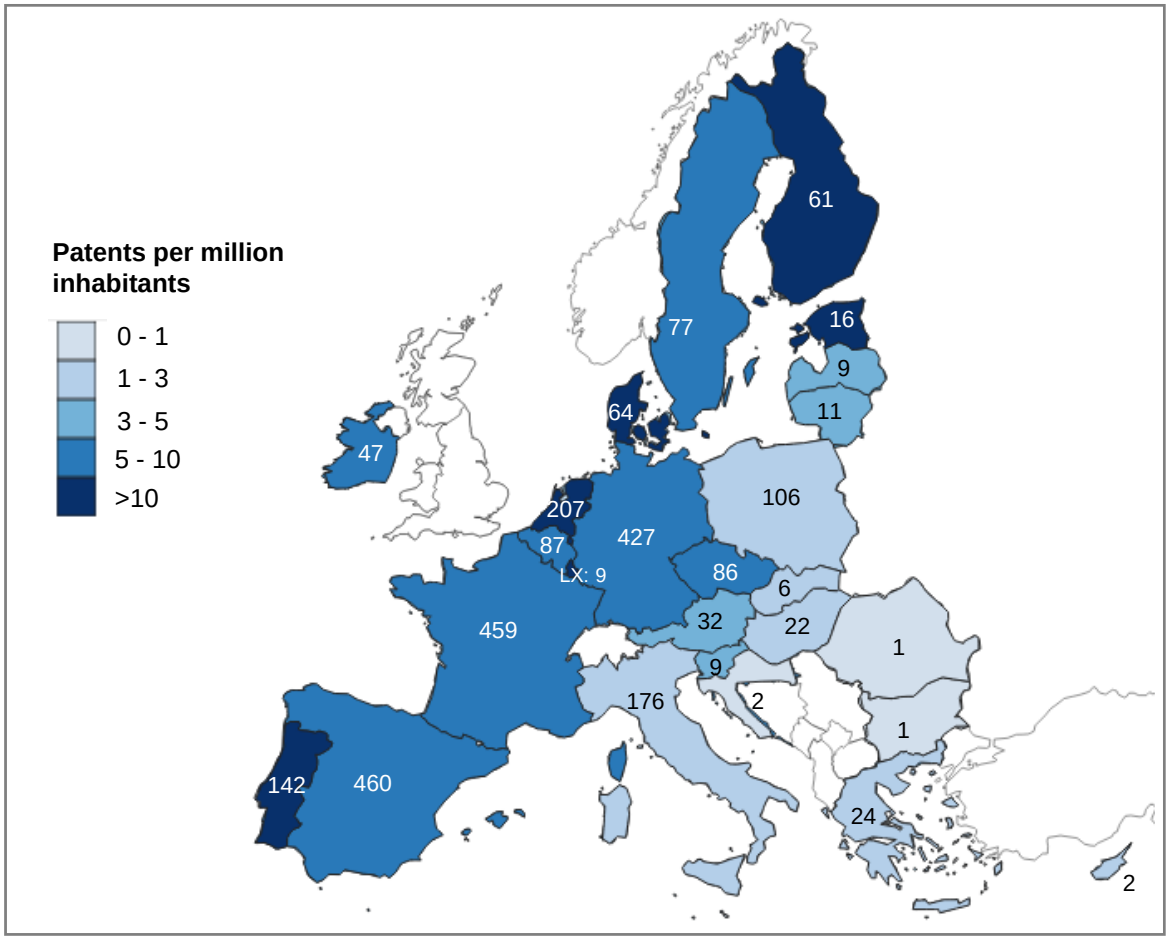
A spatial analysis of registered patents resulting from ERDF RTDI beneficiaries reveals a persistent "innovation divide" between more developed regions that are more likely to generate, import, and absorb knowledge for innovations and those that are lagging behind and are regarded as having less capacity for innovation.[129] The analysis of data at the NUTS 3 level indicates that the technological output as measured by patents is still concentrated in regions with a high share of manufacturing and with headquarters of large companies, such as southern Germany, Austria, Denmark and the Rhone-Alpes region in France or some capital city regions.[130]

Figure 35 shows a map of the EU27 for the number of registered patents resulting from ERDF RTDI projects between 2014-2023. This is based on the unique micro-level data that was gathered for this evaluation (see also Section 1.2.2.). It demonstrates that **per capita, the highest number of these patents resulting from ERDF RTDI beneficiaries are found in Western Europe (especially in Portugal and the Netherlands), the Nordic countries (especially Denmark & Finland) as well as Estonia.** In absolute figures, most patents resulting from ERDF RTDI beneficiaries are from Spain, France and Germany. This further strengthens the argument since most of those patents are originating from Western Europe.

[129] Rodríguez-Pose, A., & Ketterer, T. (2019). *Institutional change and the development of lagging regions in Europe*. Regional Studies, 54(7), 974–986. https://doi.org/10.1080/00343404.2019.1608356.

[130] SRIP 2022.

Figure 35. Regional overview of patents in the EU27 resulting from ERDF RTDI beneficiaries between 2014-2023, per capita & absolute values



Source: Prognos / CSIL / Visionary Analytics (2024), own publication & patent database developed based on data from Dimensions.AI and OpenAlex. Patent data based on Patstat. The shaded areas in the map indicate the number of patents resulting from ERDF RTDI beneficiaries between 2014-2023 per million inhabitants. The numbers in the Member States show the absolute number of patents resulting from ERDF RTDI beneficiaries between 2014-2023.

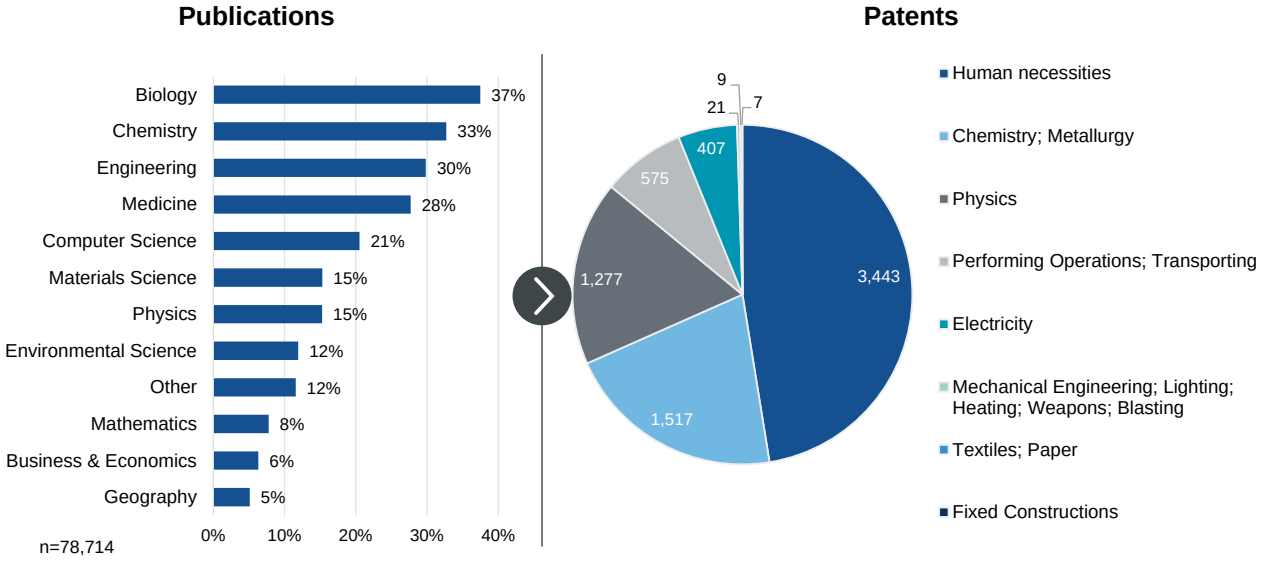
The number of registered patents citing publications resulting from ERDF RTDI beneficiaries has increased year-on-year, with a notable spike between 2018 and 2022. This trend was observed across both the EU14 and EU13 Member States. However, for the years 2023 and 2024, a considerably lower number of these patents was identified. It is crucial to consider the potential time lag between ERDF-funded projects and the subsequent dissemination of related publications and patents (see, for example, Bastianin et al., 2021). This issue was noted, for example, by the beneficiaries from **Saxony** interviewed for this evaluation study, who acknowledged the potential for commercialisation of the research results following ERDF projects but emphasised the time lag in this process.

Thematic domains of registered patents resulting from ERDF RTDI beneficiaries

Following from the assessment of publications in Section ERDF has facilitated the production and diffusion of knowledge, as evidenced by the nearly 79,000 publications resulting from ERDF RTDI beneficiaries, Figure 36. shows the publications and registered patents resulting from ERDF RTDI beneficiaries by thematic domains. As was outlined in Section ERDF has facilitated the production and diffusion of knowledge, as evidenced by the nearly 79,000 publications resulting from ERDF RTDI beneficiaries, the vast majority of the publications identified deal with topics related to STEM (Science, Technology, Engineering and Mathematics). A similar picture emerges for patents resulting from ERDF

RTDI beneficiaries. Here, **around 45% of these patents can be directly linked to STEM related domains such as "Chemistry; Metallurgy", "Physics" and "Electricity"**. As shown in Figure 36. , almost 50% of these patents are linked to the thematic domain of "Human necessities". This rather broad domain covers a wide range of technologies that have a direct impact on people's daily lives.[131] It includes patents related to food and clothing but also to medical devices. Further indirect links to STEM topics can therefore be found here. The assessment of the thematic domains in publications and patents can also be linked to the thematic domains of ERDF RTDI funded projects. As described in Section Investments in Smart Specialisation Strategies under Cohesion Policy 2014-2020, most ERDF RTDI projects linked to the S3 were directed towards the thematic domains ICT & Industry 4.0, Health & Life Science as well as Agrofood & Bioeconomy. Although it is not possible to establish a one-to-one relationship between the individual thematic domains of the projects, publications and patents, general thematic overlaps can be identified.

Figure 36. Publications & Patents resulting from ERDF RTDI beneficiaries, by thematic domains



Source: Prognos / CSIL / Visionary Analytics (2024), own publication database developed based on data from Dimensions.AI and OpenAlex. Patent data based on Patstat. Note: one publication can be linked to multiple thematic domains. The addressed thematic domains are provided by the publication databases. Thematic domains of patents according to International Patent Classification (IPC).

Patent registrations and R&D expenditure in the private sector

Our novel quantitative analysis demonstrates that ERDF RTDI beneficiaries have successfully registered over 7,000 patents. **This achievement is likely influenced by the ERDF's positive contribution to an increase in R&D expenditure in the private sector, as indicated by increased R&D spending in the private sector as a percentage of GDP in various convergence regions.** Examples are provided in the country profiles prepared for this 2014-2020 evaluation. To demonstrate, between 2014 and 2022, **Poland** experienced a notable increase of over 250% in its per capita R&D expenditures within the private sector. These expenditures began at EUR 47.3 in 2014 and gradually increased, reaching EUR 166.9 in 2022.[132] This noteworthy upward trend in private R&D expenditure

[131] For more information on the IPC domains see https://www.wipo.int/edocs/mdocs/aspac/en/wipo_reg_ip_tyo_13/wipo_reg_ip_tyo_13_t2.pdf (last access 26.06.2024)

[132] This substantial increase in expenditure on R&D in Poland is indicative of the country's investment in enhancing its R&D system, even though its per capita spending remains below the European Union average of EUR 525.3 per capita in 2022. In comparison to other countries with similar GDP, Poland's R&D spending per capita is slightly below that of Hungary (EUR 174.4 in 2022) but exceeds that of Lithuania (EUR 119.3 in 2022).

can be attributed to the effects of ERDF programmes in this area. Research activities in businesses constituted the primary focus of the ERDF dedicated to RTDI in Poland, accounting for 54% of RTDI expenditure overall and 60% of the RTDI budget of the national Smart Growth OP.

Czechia also exhibited high rates of growth in private R&D expenditure between 2014 and 2022. Expenditure in Prague accounted for approximately EUR 858 per capita in 2022; however, less developed regions grew more rapidly than Prague over the period, resulting in a narrowing of initial disparities in the rate of growth. During the 2014-2020 programming period, Czechia made extensive use of the ERDF to support RTDI activities in businesses. This was evidenced by the allocation of 22.3% of the total ERDF RTDI budget to this priority, which placed it third among national priorities. Other investments with similar objectives were also made, particularly those aimed at promoting innovation uptake. *The Enterprises and Innovation for Competitiveness* OP constituted a significant source of funding in this area, supporting industrial research and experimental development projects. A review of the OP revealed that these projects generated new knowledge necessary for developing new products, materials, technologies, and services, resulting in outputs such as working prototypes, proven technologies, software, and industrial designs.

It is crucial to acknowledge that a considerable proportion of businesses engage in innovation not only through the creation of new products but also through the optimisation of their business processes and services. In this regard, **the role of ERDF support for RTDI has been pivotal in facilitating the development of a diverse range of innovations, encompassing business process innovations and innovative services**.

The results of two ERDF RTDI output indicators demonstrate that 37,260 enterprises were assisted in the introduction of new to-the-market products (representing approximately 113.55% of the target value), while 56,959 enterprises were supported in the introduction of new to-the-firm products (approximately 100.67% of the target value). The products in question were not limited to tangible goods; they also included intangible items such as services and processes. With regard to this matter, the evaluation study identified **some positive indicators of convergence.**

In **Eastern Poland**[133], for example, the evaluation of the macro-regional measure for business investments aimed at fostering innovation uptake demonstrates that the measure has significantly contributed to accelerating investment processes in the region. It has yielded the implementation of over 200 innovations, encompassing technological process innovation, as of December 2022.[134] In terms of innovative potential, the Innovation Barometer Survey shows that approximately 78% of the surveyed beneficiary enterprises perceived their solutions as innovative on the Polish scale, 56% on a European scale, and nearly one-third on a global level.[135]

In **Estonia**, the ERDF-supported intervention for research activities in businesses was particularly focused on company development, industrial development and digitalisation. Qualitative insights from the case study dedicated to research activities in businesses confirm significant benefits for the enterprises, including productivity gains, in terms of both the development of innovations (commercialisation) and the adoption of process innovation. This case study also shows that the process innovations, induced by the support, had a “very positive” impact on the revenues of the companies. Similarly, the positive outcome of

[133] Five Polish NUTS 2 regions: Lubelskie, Podkarpackie, Podlaskie, Swietorzyskie and Warminsko-Mazurskie.

[134] Evaluation of the effects of support under priority axis I of Entrepreneurial Eastern Poland in POPW 2014-2020. Final report. Analyses based on monitoring data from the SL2014 IT system as of December 31, 2022.

[135] However, it should be noted that these declarations are difficult to verify, particularly when it comes to indicated innovations at the level of Europe or the world. This was highlighted by the evaluators in a recent evaluation of the instrument. Please see: Evaluation of the effects of support under priority axis I of Entrepreneurial Eastern Poland in POPW 2014-2020. Final report. Analyses based on monitoring data Innovation Barometer Survey. Eastern Poland Operational Programme, N=41 (final measurement, completed projects).

ERDF-backed research activities in businesses on the digitalisation of company processes and the improvement of ICT-related skills was documented in **Portugal**.[136]

Factors facilitating and impeding patenting activities

The case study on business investments to support innovation uptake (PI7) reveals that the implementation of innovative practices resulted in disparate levels of patenting across the enterprise landscape, with the exception of **Hungary**, where no patents were filed. It is noteworthy that patenting was not the primary objective of the call, as acknowledged by Hungarian Managing authorities. This lack of emphasis on patenting may explain the dearth of patenting activities observed. In **Cyprus**, patenting activities were observed in Cyprus, though not on a wide scale. According to the data collected by the Intermediate Body, grant funding was used to extend the coverage of existing patents in nearly 4% of the financed projects, while patent applications were submitted in only 5% of the supported projects. In **Poland**, slightly more than half of the beneficiary enterprises (56%) chose to protect their intellectual property in some form, with approximately 51% applying for patents.[137]

The evaluation study identified several factors that either supported or hindered patenting performance. Qualitative evidence from the case study on ERDF-funded business investments for innovation uptake in **Cyprus** demonstrated that the national measure facilitated the translation of enterprise innovation activities into the introduction of innovative products. To qualify for the grant, enterprises were required to present a prototype developed as part of a preliminary development phase. The grant was intended to provide support for the subsequent activities required to commercialise the prototype, including further development and demonstration to prospective clients. While Cypriot companies engaged in patenting activities, the impact was relatively limited. The transition from research and development to patent application proved challenging due to several factors, including the limited availability of patent attorneys, the lack of specialised innovation consultancy services, and a significant shortage of highly skilled employees.

In **France**, the explicit evidence of patents registered in some regions, such as Corsica, was found through the impact evaluation of the regional Operational Programme.[138] However, the process of moving from R&D to patent application was considered challenging due to the inherent risks of the process, e.g., technology failure, limited potential of R&D results for commercialisation, short-term financing for the projects, and disagreements between partners.

Box 10. shows insights from a novel **Impact Tracing approach to ERDF RTDI 2014-2020 project results** as a final aspect of this section. This is based on a novel approach based on Large Language Models and follows the idea of capturing information on innovation beyond patents and publications.

[136] According to national data recorded for the common output indicator CO28 - Research, Innovation: Number of enterprises supported to introduce new-to-market products, the target of 190 enterprises introducing innovation was exceeded, with a total of 226 enterprises supported. The Competitiveness and Internationalisation programme made the strongest contribution, with 139 enterprises introducing new products compared to the expected 85. In regional programmes, targets were not always fully achieved but were nearly met.

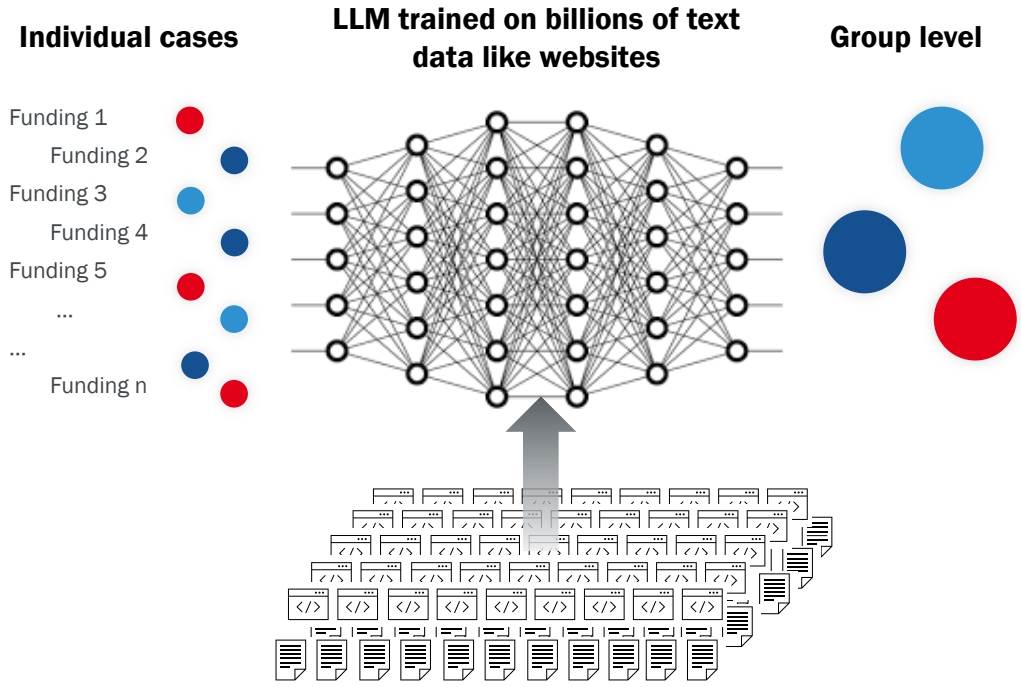
[137] Innovation Barometer study. Operational Programme Eastern Poland. The study was carried out on behalf of PARP by a consortium of entities: MCM Institute Poland Sp. z o. o., Realization Sp. z o. o., Exacto Sp. z o. o., IDEA Instytut Sp. z o. o. Warsaw, 2022

[138] Impact evaluation of research and innovation measures supported under the Corse ERDF-ESF OP, 2014-2020.

Box 10. Excursus - Impact Tracing of ERDF RTDI 2014-2020 project results from business research projects to the market

As a novel exercise, an impact tracing approach was used to examine project outcomes that are not systematically captured. The main idea is to capture information on innovation beyond the more standardized metrics of patents and publications. Recent advances in digital technologies make it possible to capture such information that is publicly available, but not available in a structured way. This study applied a **sophisticated approach based on Large Language Models (LLMs) which can tap into this unstructured data**. LLMs are based on deep learning techniques and are trained on large amounts of data. As such, LLMs can also be understood as a condensed knowledge repository that is based on a large variety of sources (websites, publications, news articles, etc). This approach allows to detect significant patterns at the group level, where the observed effects are more robust than at the individual level (see also Figure 37.).

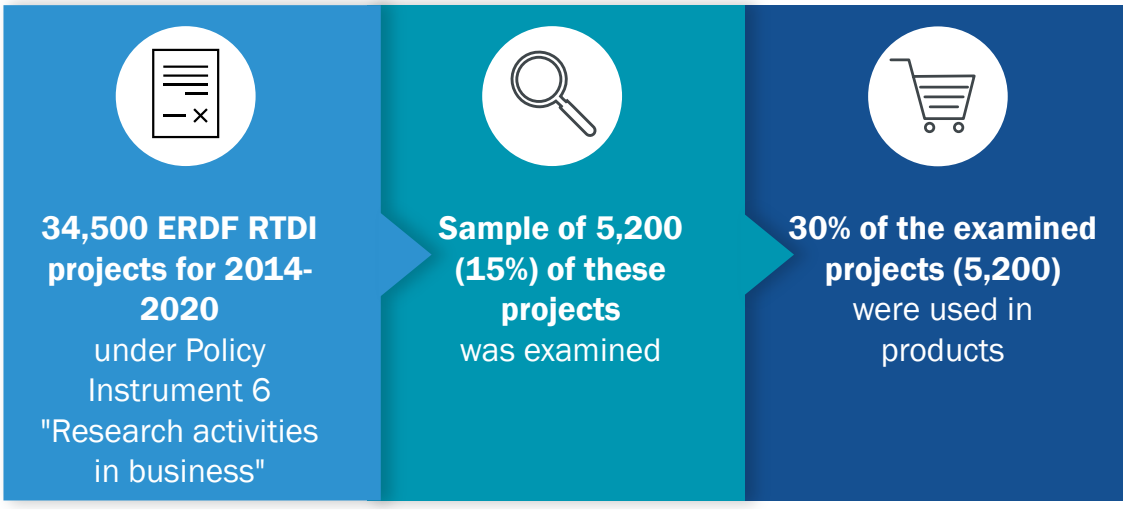
Figure 37. Schematic illustration of the Impact Tracing approach



Source: Prognos / CSIL / Visionary Analytics (2024).

This distinctive feature of LLMs is employed to initially **identify traces of projects funded by the ERDF RTDI support between 2014 and 2020**. Secondly, it is utilised to **ascertain the likelihood that the outcomes of these ERDF RTDI projects were incorporated into products**. As a pilot assessment, a random sample of 5,200 projects (15% of the total number of projects supported) under Policy Instrument 6, "Research activities in business," was used. The Policy Instrument was selected as projects receiving support are considered to be market oriented.

Figure 38. Impact tracing of ERDF RTDI 2014-2020 project results



Source: Prognos / CSIL / Visionary Analytics (2024).

Based on the ERDF RTDI projects for 2014-2020 and their descriptions, the approach suggests that approximately 30% of the examined projects (around 1,500 projects) were used in products (see Figure 38. **).** In other words, almost one-third of projects led to commercialised results, either directly as new products to the market or by adding new features to existing products. If one were to extrapolate this finding to all business research projects under investigation (approximately 34,500 projects/operations), it would be reasonable to expect around 11,385 product innovations. The results also indicate that the outcomes of a collaboration between large companies and SMEs have a slightly higher chance of reaching the market than projects in which companies work alone.

However, it needs to be underlined that this approach is novel and has not been applied in comparable evaluation studies. Hence, these examinations provide a first indication and open the door for further research.

Source: Prognos / CSIL / Visionary Analytics (2024).

4.5. ERDF contribution to the convergence in innovation performance across EU regions

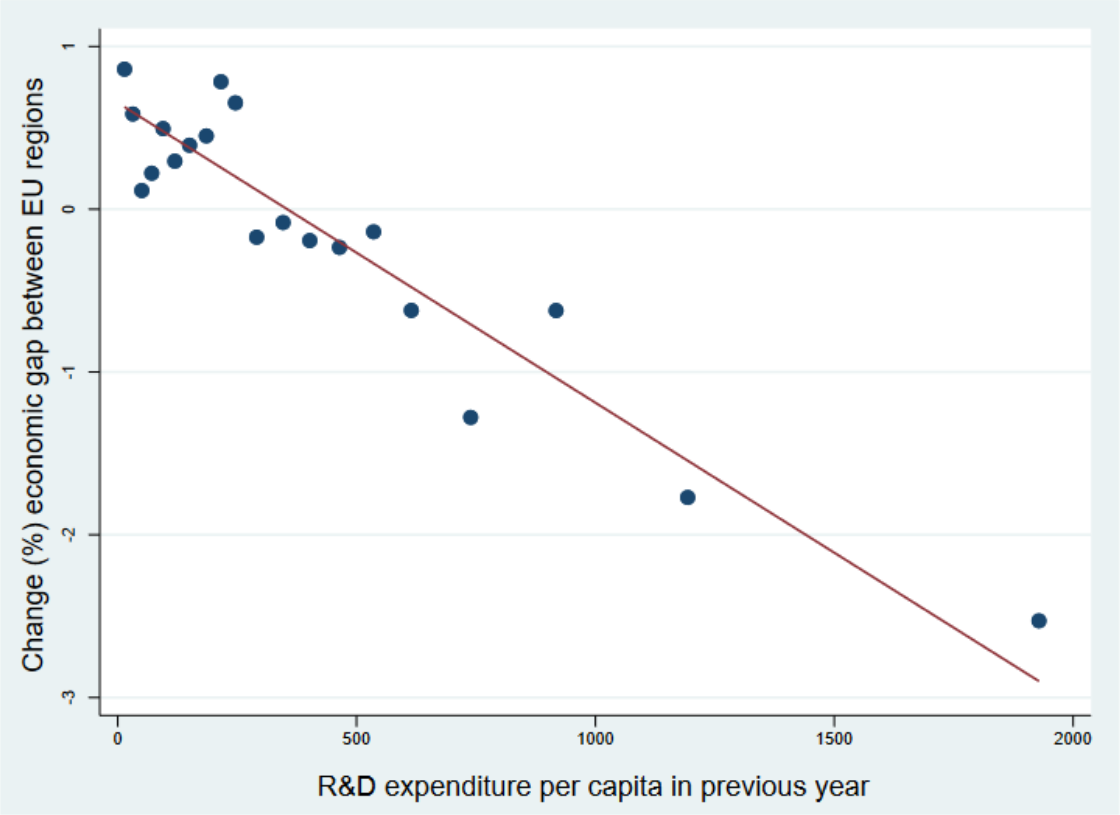
Article 176 of the Treaty on the Functioning of the European Union (TFEU) delineates the core objective of the ERDF to address significant regional disparities within the EU. This is to be achieved by providing targeted support to regions lagging in development and aiding the transformation of declining industrial areas.[139]

In the light of the above, it is worth examining the extent to which the ERDF, as one of the main sources of public investment in research and innovation, has contributed to research and innovation performance in the 2014-2020 programming period and beyond. This assessment will be made in particular with regard to the transformation of national, regional and local RTDI systems, the promotion of knowledge-based economic growth and the potential facilitation of upward convergence at EU level.

[139] Regulation (EU) No 1301/2013 of the European Parliament and of the Council of 17 December 2013 on the European Regional Development Fund and on specific provisions concerning the Investment for growth and jobs goal and repealing Regulation (EC) No 1080/2006. Regulation - 1301/2013 - EN - EUR-Lex (europa.eu)

The relationship between RTDI investments and their role in closing the innovation gap and reducing regional disparities in Europe is illustrated below. As shown in Figure 39. , there is a correlation in the EU between per capita RTDI expenditure at NUTS2 level and regional convergence over the last 20 years. The EU regions with the highest expenditure on RTDI are those that have converged more strongly economically, using the best performing EU region in terms of per capita income as a benchmark.

Figure 39. Correlation between change in economic gap between two periods (%) and R&D expenditure per capita in the previous year (in EUR), 2000-2021



Source: Santos/Conte (2024): Assessing economic divide across EU regions between 2000 and 2021

4.5.1. Expected systemic impacts and methodological limitations

According to the **Theory of Change (ToC) for ERDF support in the field of RTDI 2014-2020**, as presented in Section Baseline situation: Performance of regional innovation ecosystems across the EU in 2014, the funding shall lead to a number of immediate and intermediate outcomes and several (systemic) impacts that reduce the innovation divide and increase the competitiveness of all EU regions. These include, for example, increased R&D activity, new skills or capabilities of innovation system actors, enhanced knowledge transfer capacities, and so forth, ultimately leading to increased international competitiveness, regional diversification and contribution to employment growth and societal challenges. However, some broader contextual factors (preconditions, enablers, risks) need to be considered to contribute to the achievement of the desired outcomes and long-term policy goals. These include the maturity of the innovation system, institutional and governance capacity, the combination of complementary measures within the RTDI policy mix, and the availability of skilled labour or absorptive capacity within firms.

Hence, **the evaluation of the systemic effects of ERDF RTDI interventions in the 2014-2020 remains challenging due to several factors.** Firstly, **the long-term nature of outcomes** introduces a time lag between RDI policy instruments and their effects. For

example, the recent literature confirms[140] that quantifiable outcome additionality occurs for a minimum of three years after receiving RTDI grants, which for many projects under consideration in this evaluation does not apply. Only input and behavioral additional effects may appear earlier, which are rather qualitative in nature and observable in case studies etc. This time lag complicates impact evaluations, particularly regarding broader societal and economic effects. Additionally, as pointed out in the ToC, the outcomes of research and innovation activities are influenced by **numerous external factors, including economic conditions, policy changes, market dynamics, and technological advancements**, making it difficult to disentangle the specific contributions of ERDF interventions**.** Attribution is further complicated by **the presence of multiple funding sources and initiatives**, necessitating sophisticated evaluation techniques to identify the unique (dose-response) impact of ERDF funding. The complexity of ERDF interventions, which include a wide range of activities from infrastructure development to capacity building and technology transfer to public-private collaboration, also makes it difficult to isolate the specific impact on the broader system. Generally, **causality poses a significant methodological challenge for regional and systemic changes**, as direct measures alone are insufficient to estimate wider economic and societal impacts and spillover effects, which involve multiple, complex pathways that are often not thoroughly discussed in the sources analyzed.

In light of the aforementioned considerations, this evaluation cannot provide a definitive answer to the question about the systemic impacts of ERDF support at this point in time, as the funding period and last projects just ended at the end of 2023.

4.5.2. Evaluation findings on systemic impacts

Despite the outlined methodological challenges, the evidence collated throughout the assessment can help to shed light on the transformative aspects and offer some initial indications on the system effects of support. The discussion draws on the description of the evolution of the RTDI capacities of EU regions in the period under examination in comparison to the baseline situation in 2014, as presented in Section Baseline situation: Performance of regional innovation ecosystems across the EU in 2014. It then considers how the ERDF may have contributed to observed trends based on the available evidence regarding its role in transforming regional innovation landscapes. Building upon that, several illustrations from the case studies are presented, that offer helpful in-depth empirical insights. To start with, however, we draw upon the findings of the ex-post evaluation of RTDI support in the 2007-2013 period, which was conducted with a longer time-lag between the end of the funding period and the evaluation (between 2020-2021).

Econometric findings of the ex-post evaluation on ERDF RTDI support 2007-2013

Firstly, the ex-post evaluation of ERDF RTDI support in the previous programming period[141] shows that there are **positive and statistically significant correlations between ERDF investment in 2007-2013 and the growth rates of several key characteristics in EU regions:**

- **Positive impact on R&D personnel growth:** The ERDF instrument “Expenditure in infrastructure for research and individual R&D projects in HEIs” significantly contributed to the growth rate of R&D personnel and researchers between 2007 and 2017, regardless of whether the region was lagging or not.

[140] Dimos, C., Fai, F. M., & Tomlinson, P. R. (2021). THE TEMPORAL EFFECTS OF R&D SUBSIDIES ON R&D, INNOVATION AND INNOVATION BEHAVIOUR: EVIDENCE FROM UK FIRMS. Paper presented at 81st Annual Meeting of the Academy of Management 2021: Bringing the Manager Back in Management, AoM 2021. Available online.

[141] CSIL, Prognos and Technopolis (2021). Evaluation of investments in Research and Technological Development (RTD) infrastructures & activities supported by the ERDF in the period 2007-2013. Final Report.

- **Increased scientific publications in EU13 regions:** A positive and statistically significant relationship was observed between ERDF investments and the growth rate in scientific publications from 2007 to 2017, with EU13 regions experiencing a higher growth rate than EU15 regions. This may suggest that ERDF investments played a role in the catching-up process for EU13 regions, although other factors likely contributed as well.
- **Positive correlation with tertiary education growth:** ERDF investments in educational infrastructure positively correlated with the growth rate of tertiary-educated individuals across regions from 2007 to 2017, supporting the role of ERDF in enhancing educational outcomes.
- **Mixed results on innovation outcomes:** While there was no significant relationship between ERDF investments and the growth in patent applications (a "hard" innovation outcome), there was a positive and significant correlation between ERDF investments and the growth rate of EUTM applications (a "soft" innovation outcome), highlighting the differentiated impact of ERDF on various innovation measures.

Interestingly, there was no impact identified on scientific excellence. More precisely, there was no observed relationship between ERDF investments and the growth in scientific excellence, as measured by the share of top-cited publications, indicating that scientific excellence is primarily driven by long-term public R&D investments.

Evolution over time in the Regional Competitiveness Index & Regional Innovation Scoreboard

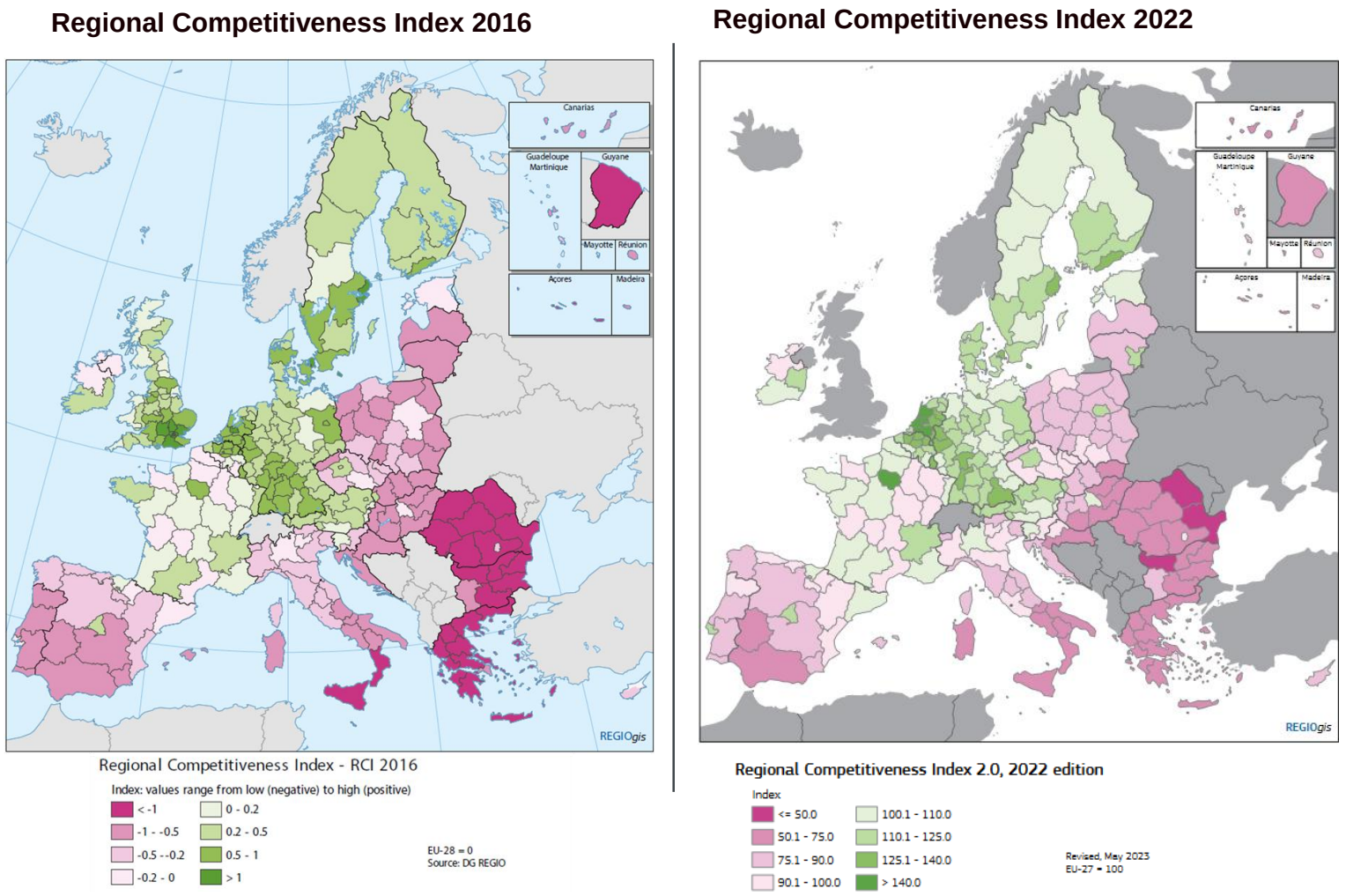
Building upon these econometric findings, this evaluation can add both comparative statistical analysis and qualitative case studies insights, which substantiate our understanding of system impacts.

As a starting point and based on the assessment of the 2016 **Regional Competitiveness Index**[142] in Section Baseline situation: Performance of regional innovation ecosystems across the EU in 2014, Figure 40. compares the performance of European regions in the 2016 and 2022 Regional Competitiveness Index. This serves to provide a comparison of regional competitiveness over time on an overarching level. Some changes in the methodology of the Regional Innovation Index as well as changes in regional structure are some challenges that limit the comparison of individual regions over time. Overall, the Regional Competitiveness Index 2022 demonstrates a heterogeneous performance of regional competitiveness across the EU in 2022. This is consistent with the assessment of the Regional Competitiveness Index 2016, which also revealed a relatively similar distribution of regions exhibiting varying degrees of competitiveness. The Regional Competitiveness Index for both 2016 and 2022 shows that the most competitive regions are concentrated in regions in northern (Denmark, Finland, Sweden) and western Europe (e.g., Austria, Benelux, Germany). Likewise, the less competitive regions are mostly found in southern and eastern European regions. Although it must be stressed that the comparison over time is limited due to methodological differences, it can be observed that **the competitiveness of the less developed regions improved between 2016 and 2022**.[143] For the transition regions, the development of their competitiveness between 2016 and 2022 is mixed, pointing to a heterogeneity of dynamics that must be considered when assessing each region's development trajectory.

[142] We refer to the RCI 2016 because this edition mostly draws on empirical data from the years 2013 or 2014, i.e. it resembles the baseline situation at the starting point of the funding period. The same logic applies to the RIS below.

[143] European Commission (2023): EU Regional Competitiveness Index 2.0. Available online: https://ec.europa.eu/regional_policy/sources/work/rci_2022/eu-rci2_0-2022_en.pdf (last access 31.07.2024)

Figure 40. Comparison of the performance of European regions in the Regional Competitiveness Index 2016 and 2022



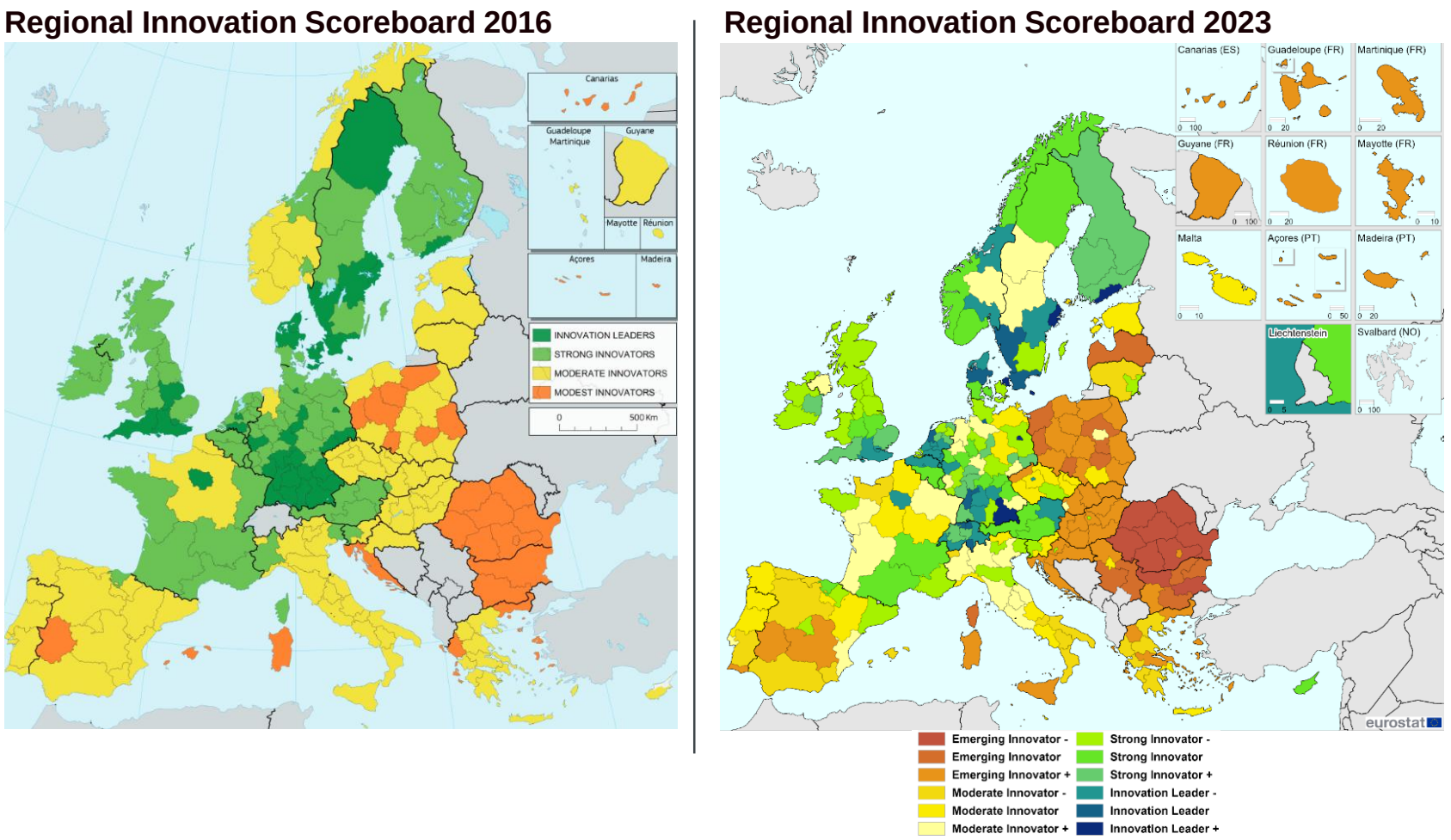
Source: Prognos / CSIL / Visionary Analytics (2024) based on Regional Competitiveness Index (2016 & 2022).

Due to the importance of the maturity and capacity of regional innovation ecosystems, a second comparative assessment was undertaken based on the **Regional Innovation Scoreboard**. The analysis of the Regional Innovation Scoreboard 2016 vs. 2023, reveals that almost a decade after the launch of the 2014-2020 programming period, **94% of emerging innovators (60 out of 64 regions) and 84% of moderate innovators (58 out of 69 regions) have increased the performance of their regional innovation ecosystems** (see **Error! Reference source not found.**).[144] The same limitations regarding changes in the methodology of the Regional Innovation Scoreboard as well as changes in the structure of some regions that were outlined in the context of the Regional Competitiveness Index above also need to be considered here (see also Annex IV). Overall, the performance of the EU increased by 8.5% points over the 8-year reference period (2016 to 2023). In comparison to the EU, 53% of regions (126 out of 239), improved their performance by more than 8.5%, while 47% of regions (113) exhibited a decline in performance relative to the EU. **Compared to the EU average, RTDI performance improved for more than half of the moderate innovators and emerging innovators.** All regions in Belgium, Czechia, Greece, and Lithuania, and all but one region in Croatia, Denmark, Finland, and Italy, demonstrated an increase in performance relative to the EU. Conversely, all regions in Bulgaria, France, Ireland, Romania, and Slovenia, and all but one region in Austria, Slovakia, and Sweden, exhibited a decline in performance relative to the EU.[145]

[144] The Regional Innovation scores used are for 2016 and 2023, but there is a 2-year lag on the data.

[145] European Commission (2023). Regional Innovation Scoreboard 2023. Available online: https://op.europa.eu/en/publication-detail/-/publication/c849333f-25db-11ee-a2d3-01aa75ed71a1/language-en/format-PDF/source-289680093 (last access 31.07.2024)

Figure 41. Comparison of the performance of European regions in the Regional Innovation Scoreboard 2016 and 2023

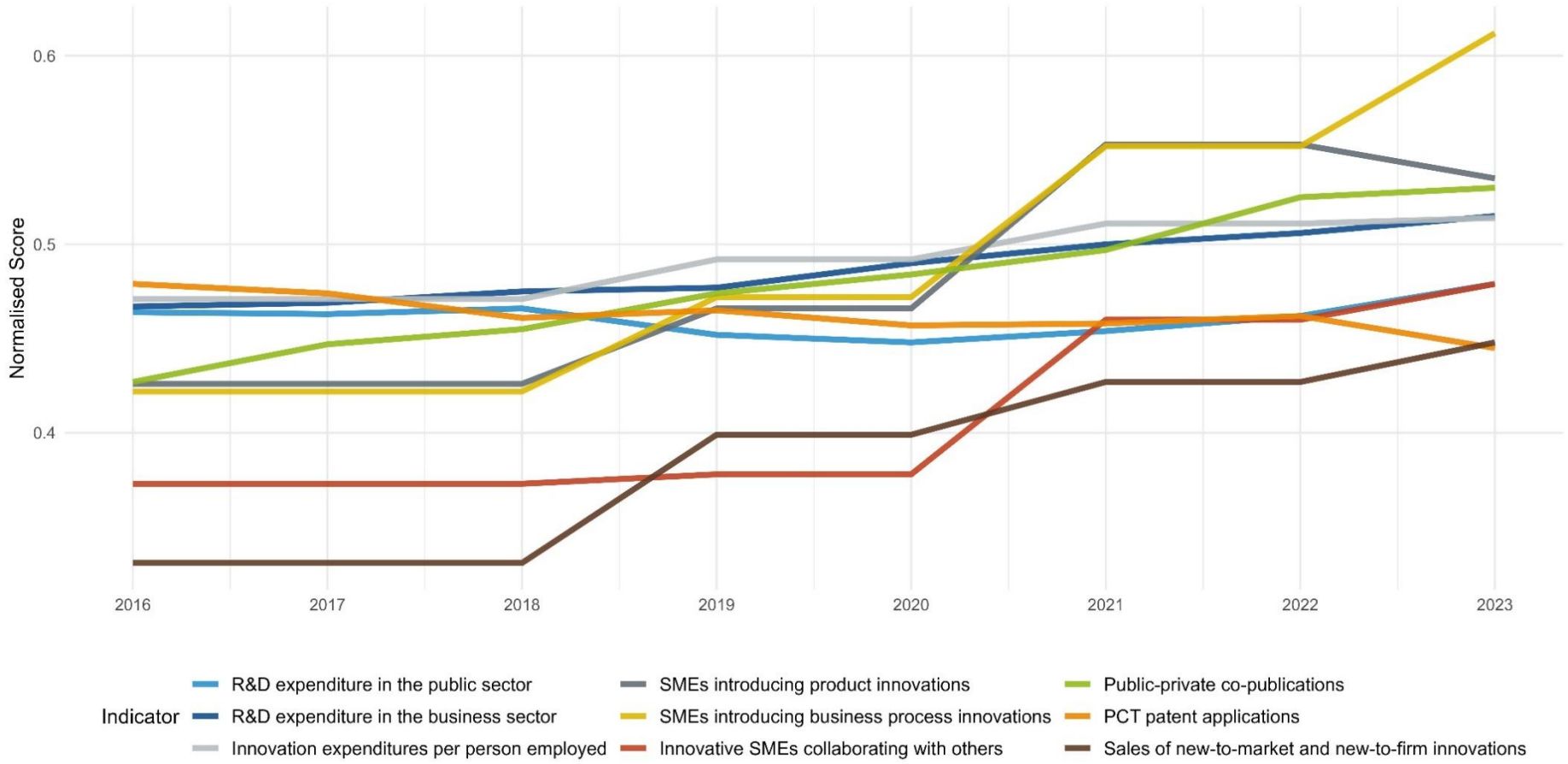


Source: Prognos / CSIL / Visionary Analytics (2024) based on the Regional Innovation Scoreboard 2016 and Regional Innovation Scoreboard 2023.

A more detailed analysis of the EU's performance across a range of key R&I indicators[146] reveals that collaboration indicators, including public-private co-publications and innovative SMEs collaborating with others, demonstrated overall growth during the 2016-2023 period (**Error! Reference source not found.**). Furthermore, there was a notable increase in the number of SMEs introducing business process innovations, sales of new-to-market and new-to-firm product innovations, and a slight rise in R&D expenditures in the business sector. However, there was a noticeable decline in PCT patent applications. The increase in collaboration, business process innovations, and product innovations signals a growing culture of innovation and partnership within the EU. Nevertheless, the decline in PCT patent applications may indicate difficulties in transforming innovations into internationally recognised intellectual property, which could potentially impact the EU's competitive advantage in global markets.

[146] For the purposes of this analysis, nine specific indicators (with standardised scores) were selected. The identified indicators are: 1) R&D expenditures in the public sector as a percentage of GDP, 2) R&D expenditures in the business sector as a percentage of GDP, 3) Innovation expenditures per person employed in innovative SMEs, 4) SMEs introducing product innovations as a percentage of all SMEs, 5) Innovative SMEs collaborating with others as a percentage of all SMEs, 6) Public-private co-publications per million population, 7) PCT patent applications per billion regional GDP, 8) Sales of new-to-market and new-to-firm product innovations in SMEs as a percentage of turnover, 9) SMEs introducing business innovations as a percentage of SMEs. A further detailed overview of each of the nine RIS indicators, including their definitions, rationale, and data sources can be found in the Annex. RIS and RCI data preparation and limitations are also described in detail there.

Figure 42. RTDI indicator trends in the 2016-2023 period



Source: Prognos / CSIL / Visionary Analytics (2024) based on Regional Innovation Scoreboard data and ERDF list of regions eligible for funding. Number of regions by cohesion group: less developed – 68, transition – 27 and more developed – 127.

To enable a more in-depth understanding of the regions[147] within each cohesion group, Figure 43. **displays the top 10 regions with the greatest overall progress in RTDI[148] in the period of 2016-2023**. For each region, the one indicator that has seen the greatest increase is highlighted. For instance, under less developed regions Ipeiros made the most overall progress from 2016 to 2023 and Sales of new-to-market and new-to-firm innovations were an indicator with the highest increase.

Figure 43. Top 10 regions with the most overall progress in selected RTDI indicators in 2016-2023 period; by cohesion region

	Less Developed		Transition		More Developed	
	Region	Indicator with the most progress	Region	Indicator with the most progress	Region	Indicator with the most progress
1	Ipeiros	Sales of new-to-market and new-to-firm innovations	Peloponnisos	Innovative SMEs collaborating with others	Attiki	SMEs introducing product innovations
2	Thessalia	Sales of new-to-market and new-to-firm innovations	Sterea Ellada	SMEs introducing product innovations	Marche	SMEs introducing business process innovations
3	Grad Zagreb	Sales of new-to-market and new-to-firm innovations	Abruzzo	SMEs introducing business process innovations	Nordjylland	SMEs introducing business process innovations
4	Kentriki Makedonia	SMEs introducing product innovations	Dytiki Makedonia	SMEs introducing product innovations	Praha	SMEs introducing business process innovations
5	Anatoliki Makedonia, Thraki	SMEs introducing product innovations	Algarve	Sales of new-to-market and new-to-firm innovations	Notio Aigaio	SMEs introducing product innovations
6	Dytiki Ellada	SMEs introducing product innovations	Ionia Nisia	Sales of new-to-market and new-to-firm innovations	Etelä-Suomi	Sales of new-to-market and new-to-firm innovations
7	Střední Čechy	SMEs introducing business process innovations	Région wallonne	Sales of new-to-market and new-to-firm innovations	Emilia-Romagna	SMEs introducing business process innovations
8	Calabria	Innovation expenditures per person employed	Molise	Public-private co-publications	Oberbayern	SMEs introducing business process innovations
9	Moravskoslezsko	SMEs introducing business process innovations	Kriti	SMEs introducing product innovations	Västsverige	Innovation expenditures per person employed
10	Campania	SMEs introducing product innovations	Sachsen-Anhalt	SMEs introducing business process innovations	Liguria	Innovative SMEs collaborating with others

Source: Prognos / CSIL / Visionary Analytics (2024) based on Regional Innovation Scoreboard data and ERDF list of regions eligible for funding. Number of regions by cohesion group: less developed – 68, transition – 27 and more developed – 127.

Figure 43. additionally highlights two significant trends in RTDI performance. First, regions in Greece showed the most overall progress between 2016 and 2023, followed closely by regions in Italy. Notably, 12 out of 13 regions in Greece and 7 out of 21 regions in Italy ranked among the top 10 for overall RTDI progress. Second, **the overall progress across all Cohesion Regions is largely driven by SME activities, with the greatest positive changes seen in indicators such as innovative SMEs collaborating with others and SMEs introducing business process or product innovations**. This observation is in line with the 2024 Science, Research and Innovation Performance report, which indicates that SMEs located in emerging and moderately performing regions seem to have improved their R&I performance, while SMEs in strong and leading regions have experienced a decline in terms of the R&I performance indicators.

Role and significance of ERDF RTDI support in the national policy mix

The significance of the ERDF RTDI support, particularly in certain territories, can be fully understood when viewed in the context of its contribution to the overall country RTDI funding. In several countries, including Poland, Latvia, Lithuania, Estonia, Hungary,

[147] It is important to mention that the presented NUTS 2 level regions do not always correspond with the NUTS level of the operational programmes.

[148] The overall progress was calculated by adding the differences in the normalised scores between each year for each indicator and then adding the scores for all nine indicators into an overall progress score. In this way, a positive score indicates overall growth in the period of 2016-2023 and a negative score indicates overall decline in RTDI systems for the same period.

Bulgaria and Portugal, the ERDF support for RTDI during the 2014-2020 period exceeded 20% of the total RTDI funding (compare Section ERDF RTDI support: funding allocation and expenditure analysis). For instance, in Portugal, by the end of 2023, the ERDF had committed EUR 2.5 billion to RTDI, representing approximately 20% of the total ERDF budget and nearly 21% of the overall RTDI spending in the country. The multiregional Operational Programme *Competitiveness and Internationalisation*, which provided funding exclusively to Portuguese less developed regions in the RTDI field, had a significantly larger budget than regional programmes. Approximately 30% of the programme budget was allocated to research and innovation, accounting for 60.1% of the total ERDF RTDI funds in Portugal. This example shows that the RTDI investments of the aforementioned territories remain heavily dependent on Cohesion Policy funds.

However, it is also important to note that RTDI investments alone do not yield equal returns across all regions. This is due to several factors, including the cost of technology accessibility in different areas, proximity to the technological forefront, the quality of local institutions and hindered knowledge sharing.[149] Recent studies indicate that the effectiveness of such investments depends on a well-tailored, region-specific mix of investments, supported by a robust institutional and macroeconomic framework. Innovation is crucial for sustained economic growth at the regional level, yet the innovation divide within European regions has widened.[150] This gap is worsened by feeble innovation and insufficient spillovers of human capital resulting from international trade relations and value chains in numerous less developed and transition regions. Despite substantial foreign direct investment (FDI) and exports, several regions are unable to leverage the benefits for local businesses and workers. Inadequate uptake of digital technologies, management practices, and industry 4.0 technologies in both the business and public sectors renders several regions ill-equipped to avail themselves of new opportunities, thereby exposing them to possible reshoring as supply chains change.

Qualitative evidence on system effects from the case studies

A closer look at the RTDI performance of these EU regions between 2016 and 2023 in conjunction with in-depth insights from the case studies, reveals promising indications of convergence. For instance, the RIS 2023 indicates that **some Polish regions** have demonstrated an improvement in RTDI performance, including Warszawski Stołeczny, Małopolskie, and Podlaskie. The case study on business investments to support innovation uptake (PI7) shows that the investigated submeasure 1.3.1, which concerns the implementation of innovation by SMEs in **Eastern Poland**[151], has had a beneficial impact on other innovation support policies. These include the national Smart Growth Operational Programme (POIR) and other activities under the entire Eastern Poland Programme (POPW). This is corroborated by macroeconomic studies which demonstrate that both POIR and POPW had a positive impact on the value of R&D expenditure and investments in this area. Simulations based on the VESPA3 model[152] indicate that the base effect is of great importance in the case of R&D expenditure. In Eastern Poland, where the starting point is smaller, the impact of the intervention is significantly greater. Consequently, the impact on R&D is considerably more pronounced in Eastern Poland than in the rest of the country, with tangible results emerging sooner. The assessment of ERDF support for RTDI

[149] European Commission, Science, Research and Innovation Performance Report 2020. Available online.

[150] Inforegio - Eighth Report on Economic, Social and Territorial Cohesion (europa.eu)

[151] Encompassing five Polish NUTS 2 regions: Lubelskie, Podkarpackie, Podlaskie, Swietorzyskie and Warminsko-Mazurskie.

[152] Analysis of selected POIR and POPW measures at the sectoral and macroeconomic level using a macroeconomic model Final report. Research commissioned by the Polish Agency for Enterprise Development by the consortium: WiseEuropa - Warsaw Institute of Economic and European Studies Foundation and Ecorys Polska Spółka z o.o. Warsaw 2022.

in the 2007-2013 period also reveals a notable enhancement in research capabilities and expertise across Polish regions.[153]

Lithuania also exhibits a relatively optimistic trajectory, where ERDF resources have played a pivotal role in financing research and innovation activities. By the conclusion of 2023, 20% of the total ERDF budget in Lithuania had been allocated to RTDI, representing 32% of the country's total RTDI expenditure. As indicated by the European Innovation Scoreboard 2024, all regions in Lithuania demonstrated enhanced performance in comparison to the EU average, with the country's overall performance increasing by over 10%.[154] It is noteworthy that Lithuania has made considerable progress in venture capital expenditure, becoming the foremost Moderate Innovator in this field, reaching 137.6% of the EU level in 2024, representing a striking increase of 92.7 percentage points since 2017. Nevertheless, the country is deficient in terms of direct and indirect government support for business R&D, ranking last among Moderate Innovators in this category. As evidenced in the European Semester Report 2024, the country's relatively low level of support for business R&D is attributed to complex procurement procedures and tax incentives that fall below the EU average.[155]

The **eight convergence regions in Southern Italy**, which were the subject of the case study on investments in research infrastructures and where ERDF support was a key source of funding for RTDI, have demonstrated improvements in their performance according to the Regional Innovation Scoreboard 2023. The regions in question were Abruzzo (+26%), Campania (+23.3%), Puglia (+19.2%), Basilicata (+19.8%), Calabria (+20.4%), Sicily (+15.5%), Sardinia (+12.3%), and Molise (+16.8%). It is worth noting that Abruzzo, Molise and Sardinia have seen a significant increase in public-private co-publications and international scientific co-publications since 2016. The case study indicates that the investigated regions have developed enhanced research infrastructures. However, the improvements in these collaboration indicators cannot be directly attributed to the analysed ERDF-supported policy instrument. This is due to both the strategic design of the measure and the findings from the OP evaluation, which concluded that the collaborations between beneficiaries and private companies remain "limited and contingent." Furthermore, the recently established infrastructures have not yet fulfilled the pivot role originally intended by the measure's design, with many indicating a need to hire managerial figures to foster relationships with the private sector.

The ERDF in Slovenia has a strong potential to facilitate systemic outcomes in terms of collaboration and partnerships. One of the main objectives for the 2014-2020 period has been the formation of partnerships between research institutions and the industrial sector. To this end, 15.9% of the ERDF's RTDI budget has been allocated to science-industry collaborative R&D projects. A cluster approach to RDI development, in line with the Smart Specialisation Strategy (S4), was developed in 2015 to foster science-industry collaborations. In line with this strategy, nine Strategic Research and Innovation Partnerships (SRIPs) have been established, aligned with the S4 priorities. These partnerships, known as the 'four spirals of innovation', facilitated collaboration among their members through activities such as networking, joint R&D projects, and human resource development. The number of SRIP members has grown significantly over time, with membership rising from 783 in 2018 to 919 in 2022, representing a 24% increase since the establishment of SRIPs. A case study on this intervention indicated that SRIPs have been instrumental in fostering new connections between companies and knowledge institutions, with successful cooperation models emerging. By the end of 2022, the number of

[153] CSIL, Prognos and Technopolis (2021). Evaluation of investments in Research and Technological Development (RTD) infrastructures & activities supported by the ERDF in the period 2007-2013. Final Report.

[154] https://ec.europa.eu/assets/rtd/eis/2024/ec_rtd_eis-country-profile-lt.pdf.

[155] https://economy-finance.ec.europa.eu/document/download/b2eea0d9-a516-4153-82ac-66d150d1ce7e_en?filename=SWD_2024_615_1_EN_Lithuania.pdf.

enterprises cooperating with research institutions funded by the ERDF exceeded the planned target value. Furthermore, SRIPs have indirectly enhanced access to research infrastructure for members, through cooperation between public research organisations and private entities.

Furthermore, Croatia displays encouraging indications of systemic influence resulting from ERDF RTDI support. The magnitude and geographical dispersion of this funding demonstrate that Croatia has attained systemic-level advantages from ERDF interventions in business R&D. These investments have played a pivotal role in stimulating private sector R&D activities, augmenting overall R&D expenditures, and fostering collaboration across the innovation ecosystem, particularly in the Zagreb region. For more details, please see the information provided in Box 11. below.

Box 11. Mini case study example: Systemic outcomes of ERDF-supported research activities within the context of Croatia's innovation ecosystem.

Baseline situation: Prior to the commencement of the 2014-2020 programming period, Croatia was classified as a moderate innovator, with notable challenges present within its R&D ecosystem. There was a distinct regional disparity, with the Zagreb region outperforming the rest of the country in terms of R&D activities. Furthermore, Croatia faced low levels of business expenditure on R&D and a shortage of human capital due to the ongoing emigration of highly educated individuals. A distinctive factor exacerbating these challenges was Croatia's lack of a structured approach to innovation support. The country largely relied on EU funding, particularly from the ERDF, to drive private sector R&D activities.

Challenges in the R&D ecosystem: The Croatian R&D ecosystem reflected the characteristics of a transitioning economy. Many companies lacked established R&D departments, allocated minimal spending to innovation, and were reluctant to pursue active collaborations, despite having significant untapped potential. Furthermore, there was a lack of national-level initiatives to support business R&D without relying on ERDF interventions.

ERDF interventions 2014-2020: During the programming period, Croatia made use of the ERDF to provide significant support for R&D activities in businesses. In fact, 46.3% of the total ERDF RTDI budget was allocated to this priority. The ERDF funding played a crucial role in financing industrial and experimental R&D projects at various stages of the innovation cycle, from initial prototypes to commercialisation. It is crucial to acknowledge that no comparable national measures existed in the country.

Scale of support and outputs: The Croatian measure “Increasing the development of new products and services resulting from research and development activities” provided support to private enterprises under the forms of non-refundable grants. As a result, 80 received support for the introduction of products that are new to the market (CO27), and private investment, corresponding to EUR 99.5 million was triggered because of the grants. The measure met with great demand since it covered a gap in the policy mix: **no** alternative (national) support for RTDI activities existed in Croatia at the beginning of the programming period.

Systemic outcomes: The ERDF interventions in Croatia have positively contributed to the Croatian RTDI ecosystem. From 2014 to 2021, the country's overall R&D expenditure as a percentage of GDP increased from 0.7% to 1.27%. This growth was in line with the improved R&D performance in the Zagreb region, where many ERDF-supported beneficiaries were based. Furthermore, 75% of the beneficiaries of ERDF support set up collaborations as part of the funded projects, demonstrating an increase in innovation-focused partnerships. The successful implementation of ERDF-funded projects prompted private investments, helping to bridge the gap in R&D activities outside Zagreb and contributing to broader innovation ecosystem development across Croatia.

On a final note, it is important to point out that the recent completion of ERDF projects means that many regions are only now beginning to see the full outcomes of these investments. This leads to a time lag between the initial R&D investment and the manifestation of tangible results, such as increased innovation capacity and economic expansion. This time lag made it difficult to assess the immediate effectiveness of RTDI investments from the ERDF 2014-2020 and underlines the need to take a longer-term view to gain a fuller understanding of their impact.

5. Policy assessment

This chapter offers a comprehensive examination of essential policy elements in accordance with key evaluation criteria. To start with, Figure 44. provides a synthetic assessment by evaluation criteria and policy instruments. The following then give a detailed assessment by evaluation criteria. Section Relevance examines the relevance of ERDF-supported RTDI measures, with a particular focus on their alignment with identified needs and objectives. Section Effectiveness evaluates the effectiveness of these interventions, assessing their success in achieving the desired outcomes. Section Efficiency addresses the efficiency of resource utilisation, while Section Coherence discusses external and internal coherence, ensuring policy consistency across various RTDI activities. Lastly, Section EU added value explores the added value of ERDF-supported RTDI measures, including their scale, leverage effects, continuity of funding, strategic impact, and contributions to capacity building, synergy improvement, market integration, and territorial cohesion.

The main conclusions from this chapter are outlined in the box below.

KEY TAKEAWAYS

Relevance

- The analysis of weaknesses highlighted **consistent deficiencies in regional innovation systems** across the EU, such as inadequate interaction between business and science, infrastructure failures, and underinvestment in RTDI, particularly in Central and Southern Europe.
- Horizontal analysis of Operational Programmes and case studies found that **policy instruments were largely relevant**, with 30 out of 34 case studies evaluating the interventions as highly relevant and the remaining four as having medium relevance.
- Some investment strategies were specifically designed **to mitigate the challenges associated with the regional innovation paradox**. For example, in line with literature findings, lessons from previous funding periods, and analysis of local challenges, regions recognised as modest and moderate innovators prioritised investments in basic research and education infrastructure and were more likely to incorporate capacity building for innovation and training into their RTDI policy mix.
- However, **most EU regions and Member States generally opted for a broad mix of strategies and policy instruments to address the multiple needs of their innovation systems**. As Section Effectiveness illustrates, positive outcomes were often achieved by combining a range of measures that span different stages of research and innovation.
- Although the interventions are expected to have positive impacts, **evaluating their relevance for jobs, growth, and cohesion presents certain difficulties**. This is largely due to the recent conclusion of the financed projects and the relatively modest scale of the implemented measures.
- The **pandemic affected the relevance and funding of policy instruments differently,** with increased emphasis placed on those instruments strengthening resilience against COVID-19, and negative impacts on programmes dependent on mobility and collaboration.

- The **strategic approach of the ERDF programmes remained stable**, focusing on addressing beneficiary needs and efficient fund utilisation, with adjustments made based on demand and the ability of institutions to use funds effectively.

Effectiveness

- The **total ERDF RTDI funding allocated to the 11 FOIs after the 2023 period was EUR 59 billion**, with ERDF contributing EUR 40 billion, a substantial increase in comparison to the preceding programming period. Despite the mixed achievement values of output indicators, the assessment through the case studies of the effectiveness of ERDF-supported policy instruments for RTDI was largely favourable. Of the 34 specific cases, 22 were rated as highly effective, and 12 as moderately effective. This assessment was made possible by the relatively high average completion rate for most policy instruments (over 85%). However, infrastructure investments for research encountered significant implementation challenges. By November 2023, only 46% of projects had been completed, largely due to difficulties in adapting them to the changing environment resulting from the pandemic and the ongoing conflict in Ukraine.
- The **ERDF support led to enhanced institutional R&I capacities**, and **increased collaboration between academia and industry, and promoted business investments** in research and innovation, though evaluating broader impacts remains challenging as many projects have only recently been completed.
- **The success of RTDI support hinges on the establishment of a transparent, long-term strategy at both the regional and beneficiary levels. Effective use and integration of developed infrastructure into strategic plans are essential,** especially for universities and large public beneficiaries. Case studies demonstrate the importance of regional and national alignment, synergies between funding sources, and leveraging a mix of funding instruments to optimise resources. The quality of the collaborative ecosystem and a robust selection system, as exemplified by regions like Flanders and Cyprus, significantly influence the effectiveness of RTDI interventions.
- **The overall effectiveness of ERDF-supported measures was impeded by a number of factors, including the presence of complex administrative procedures, workforce shortages, and delays associated with COVID-19 pandemic**. The imposition of additional national requirements beyond EU regulations, known as 'gold-plating', added further administrative burdens, particularly in public procurement and audit practices. Case studies revealed that these challenges were especially pronounced in infrastructure investments for technology transfer, with beneficiaries in Bulgaria, Flanders, and Czechia struggling to navigate evolving rules and complex procedures. Additionally, the availability of skilled labour and broader economic factors, such as market fluctuations and the COVID-19 pandemic, significantly influenced the success of these initiatives.

Efficiency

- The **efficient implementation of RTDI measures is primarily dependent on the presence of sufficient expertise and experience among both Managing Authorities and beneficiaries**, as well as the presence of a clear long-term RTDI strategy within coherent national or regional frameworks. Even for the most experienced beneficiaries, there is still a need to reduce administrative burdens and provide more guidelines on compliance with State Aid rules.

- **Building on existing partnerships and networks can facilitate project adoption**, ensure seamless communication within the local ecosystem, and foster long-term strategic planning. Specifically, in the context of ERDF, these networks are vital for ensuring that resources are used optimally and that project goals align with regional development priorities.
- **The COVID-19 pandemic and the war in Ukraine have impacted project efficiency by causing delays and increased costs**. However, these challenges have also led to increased flexibility, such as changes in eligibility rules and project timelines, and an enhanced use of digital tools in public administration.
- **Grants were generally used to fund the early stages of innovation**, whereas financial instruments, such as loans and guarantees, offered more flexibility and options for funding innovations at later stages.
- **In terms of financial instruments, loans and guarantees were noted for their faster re-flows in the assessed measures**, with guarantees showing significant leverage effects. Financial instruments implemented through funds of funds were found to provide potential benefits, including enhanced flexibility and the ability to achieve greater scale, which can attract investors. The efficiency of different management structures—whether multi-layered or single-tier funds of funds—largely depends on the Managing Authorities' ability to establish them promptly.

Coherence

- The analysis shows **considerable coherence between ERDF support and other EU interventions at strategic and operational levels**, particularly with Horizon 2020, where complementarities were observed in university research activities, science-industry collaborative RDI projects and infrastructure investments. Synergies between Horizon 2020 and ERDF were highest in more developed regions.
- **Synergies were also observed at project leve**l, with almost 20% of ERDF projects related to R&I capacity building and almost 11% of innovations in the Innovation Radar benefiting from ERDF and other EU funding sources (downstream synergies).
- **The mechanisms that facilitated high degrees of coherence varied**. In some instances, external coherence resulted from policy design and was planned beforehand. In other cases, particularly in Central and Eastern Europe, synergies were achieved unintentionally, largely due to the limited availability of other funding sources apart from the EU.

EU added value

- **ERDF added value had a critical quantitative dimension in different cases**: when the ERDF was the primary funding source in countries and regions suffering from a lack of fiscal resources, when co-funding rates were high (for policy instruments like infrastructures and in EU13 regions), and when the ERDF occupied a specific, well-defined position on a broader policy mix (generally in EU14+UK). The quantitative dimension of ERDF added value also covered ERDF's capacity to leverage additional private investments (e.g., in the case of venture capital funds)
- **As a stable, if finite, funding source, the ERDF made it possible to adopt a strategic approach to RTDI support**, experiment with good practices and foster behavioural change. The ERDF provided room for developing and consolidating practices like collaborations and networking in ecosystems where these remained an exception to the norm. Instead, there was **little evidence that local policy**

makers, used the ERDF support to implement innovative policy practices (e.g., experimental approaches, stakeholders involvement, etc.).

- **Effective demarcation of ERDF with other national/regional RTDI funding sources was achieved**. There is also evidence of synergies with other EU sources of funding.
- From the perspective of stakeholders engaged on the ground, **the effect of the ERDF support to RTDI on the reduction of territorial disparity was limited and indirect**. Eventually, policymakers remained focused on the objective of competitiveness.

Figure 44. Synthetic assessment by evaluation criteria and policy instruments

	Relevance	Effectiveness	Efficiency	Coherence	EU added value
Infrastructure investments for research (PI1)	High	High	Moderate	High	High
Infrastructure investments for technology transfer and innovation (PI2)	High	High/ moderate	High/ moderate	High/ moderate	High/ moderate
Research activities in universities and research centres (PI3)	Moderate	Moderate/ high	Moderate/ high	Moderate/ high	Moderate/ high
Science-industry collaborative RDI projects (PI4)	High	Moderate/ high	Moderate/ high	Moderate/ high	High
Indirect support for technology transfer (PI5)	Moderate/ high	Moderate/ high	Moderate	Moderate/ high	High
Research activities in businesses (PI6)	High	Moderate	High	High	Moderate
Business investments to support innovation uptake (PI7)	Moderate/ high	High	Moderate/ high	High	Moderate
Capacity building for innovation in businesses (PI8)	Moderate	Moderate/ high	Moderate/ high	Moderate/ high	High

Source: Prognos / CSIL / Visionary Analytics (2024). Please see Full text of the policy instrument fiches are presented as self-standing document accompanying this report.

Table 10. in the Annex for a detailed overview & further description of the assessment.

5.1. Relevance

The analysis of weaknesses **reveals similar needs and deficiencies faced by regional innovation systems across the EU**. These were predominantly lack of interaction between business and science, infrastructure failures and underinvestment in research areas with innovation potential. Despite progress in some regions and areas, these needs remained relatively stable during 2014-2020. Additionally, regions faced territorial-specific needs limiting RTDI development, such as research and innovation infrastructure failures, particularly in countries that are modest and moderate innovators in Central and Southern Europe. The choice of policy instruments varied across different territories, reflecting specific regional needs and the place-based approach of ERDF programmes.

The horizontal analysis of operational programmes, along with case studies, indicates that **the policy instruments and the overall strategic approach were largely relevant** to addressing the needs of beneficiaries throughout the entire programming period. Specifically, in 30 out of 34 case studies, the interventions were evaluated as highly relevant, while in the remaining 4 cases, they were deemed of medium relevance.

There is also evidence suggesting that **some investment strategies were specifically designed to address the region's unique position on the innovation ladder and to mitigate the challenges associated with the regional innovation paradox**. The term 'regional innovation paradox' refers to a well-documented phenomenon in which firms in developing regions struggle to fully exploit available innovation opportunities due to their innovation systems' limited capacity to absorb public financial investments in research and innovation. This limited absorptive capacity highlights the inability to utilise knowledge generated through research, leading to the failure to retain and capitalise on the insights gained from RTDI funds. The conversion of knowledge into innovation is a process deeply connected to territorial conditions. Key elements essential to this process include a robust system for knowledge dissemination, a skilled and educated workforce, and effective collaboration between academia, industry, and government.[156]

For example, in line with literature findings, lessons from previous funding periods, and analysis of local challenges, **regions recognised as modest and moderate innovators**:

- **Prioritised investments in basic research and education infrastructure**: regions such as Czechia, Hungary, Slovenia, Cyprus, Greece, and some areas in Italy focused on these areas. More advanced regions (e.g., in Flanders, Germany), while also investing significantly in infrastructure, were more likely to concentrate on advanced research infrastructure and infrastructure for technology transfer.
- **Were more likely to incorporate capacity building for innovation and training into their RTDI policy mix**: specifically, these countries had a higher proportion of operations involving capacity building for innovation in business (7% compared to 1% in other countries). However, the total expenditure on capacity building for innovation was still relatively low, even though access to skills and knowledge proved essential for the effectiveness of RTDI interventions (see Section Effectiveness).

However, most EU regions and Member States **generally opted for a broad mix of strategies and policy instruments to address the multiple needs of their innovation systems**. Across the EU, the median number of instruments applied within a single OP was six. Only a few regions, such as Austria, Cyprus, Denmark, and Estonia, chose to

[156] Paliokaitė, A. (2019). *An innovation policy framework for upgrading firm absorptive capacities in the context of catching-up economies*. Journal of Entrepreneurship, Management, and Innovation, 15(3), pp. 103-130; Capello, R., and Lenzi, C. (2016). *Persistence in regional learning paradigms and trajectories: consequences for innovation policy design. European Planning Studies*, *24*(9), 1587–1604. https://doi.org/10.1080/09654313.2016.1177493.

concentrate their resources on just one or two policy measures. As Section Effectiveness illustrates, positive outcomes were often achieved by combining a range of measures that span different stages of research and innovation. This approach was particularly important for the investigated science-industry collaborative projects, particularly concerning technology transfer, the uptake of RTDI project results, and the transition towards the commercialisation phase.

Although the interventions are expected to have positive impacts, **evaluating their relevance for jobs, growth and cohesion presents certain difficulties**. This is largely due to the recent conclusion of the financed projects and the relatively modest scale of the implemented measures (see Section Effectiveness).

The **pandemic impacted the relevance and funding of each policy instrument differently**, leading to changes in focus and planning. The pandemic increased the importance of those RTDI policy instruments and priorities that have simultaneously contributed to strengthening regional and national resilience against COVID-19, specifically aiming to improve capabilities, research, and healthcare infrastructure. Conversely, the pandemic diminished the uptake and relevance of funding allocated to instruments and programmes vulnerable to challenges such as social distancing measures, mobility restrictions, supply chain disruptions, and increased costs. Programmes centred on international and interinstitutional collaboration, knowledge transfer, and infrastructure development were primarily affected.

In certain instances, the pandemic negatively affected the relevance of financial instruments, though these effects were minor and limited to specific instruments. In some cases, financial instruments supporting RTDI were perceived as less relevant compared to immediate economic needs, and their relevance decreased due to crowding-out effects and changing economic circumstances, such as decreasing interest rates or inflation. In contrast, there was increased use of financial instruments aimed at providing companies with extra liquidity towards the end of the programming period, as examined within Work Package 6 on SME support. However, case studies suggested that the pandemic primarily affected the planning and execution of ERDF-supported operations rather than their relevance.

The overall strategic approach underlying the policy mix remained relatively stable throughout the period. Addressing the genuine requirements of intended beneficiaries and consequently enhancing efficient fund utilisation was a primary motivation behind reprogramming choices. The levels of demand and uptake observed for various policy instruments were treated as indicators reflecting beneficiaries' needs. When demand was limited, policy instruments were either eliminated, their funding significantly decreased, or funds redistributed to other instruments with higher demand. Similarly, resources were rerouted towards institutions that had demonstrated superior capability to effectively utilise funds in the preceding period.

The strategic approach and policy instruments of the ERDF OPs have largely been successful in addressing beneficiary needs, albeit with some regional disparities. The pandemic's impact necessitated adjustments, underscoring the importance of flexibility and responsiveness in policy implementation to maintain relevance and efficacy, but did not significantly change the overall strategic approach or the composition of PIs on the aggregate level.

Most OPs across the EU consisted of coherent and complementary policy instruments, creating synergies, particularly in more developed regions with higher innovation potential. 80% of sampled OPs across the EU consisted of coherent and complementary policy instruments, out of which 65% also reported synergies arising between them. However, some EU regions and Member States, primarily those falling below the EU average in innovation performance, exhibited a lack of coherence and complementarities in the policy mix. This issue is consistent with countries having relatively

weak or underdeveloped business ecosystem infrastructures, hindering coherent implementation and limiting the capacity to absorb or utilise ERDF policy instrument resources. Consequently, this leads to inefficient resource allocation, limited access to funding, or a lack of clarity for companies applying for funding for the first time.

In the face of new megatrends and challenges, new questions related to the relevance of RTDI investments arise:

- Is the ERDF/S3 mechanism suitable for orienting RTDI policies toward solving issues related to climate disruption?
- Should success be judged solely through the lens of 'competitiveness/growth'?
- To what extent and in what ways do ERDF and RTDI policies consider social or socio-technical innovation as opposed to solely technological/performance-based innovation?

These questions are outside the scope of the current study. However, some recent initiatives have already begun to address them. For example, the 2023 study 'Aligning Smart Specialisation with Transformative Innovation Policy' highlights how S3 strategies have been adapted to support transformative innovation, particularly in the context of climate challenges. Similarly, a 2024 report, 'Research and Innovation for Climate Neutrality by 2050,' explores ways to move beyond a focus on individual technologies to consider the broader social and economic impacts of innovation.

5.2. Effectiveness

The criterion for evaluating effectiveness considers the extent to which policy instruments have achieved or progressed toward their stated objectives. According to the aggregated figures of ERDF expenditure supporting RTDI, the total funding allocated to the 11 FOIs **at the end of 2023 was EUR 59 billion, with ERDF funding covering EUR 40 billion**.[157] Despite the slight decline compared to a total of EUR 63.5 billion allocated at the start of the 2014-2020 period, the ERDF resources dedicated to RTDI during this time represent **a significant amount compared to the previous programming period (approx. EUR 17 billion of ERDF resources) and other currently available sources of funding for RTDI.** The output indicators reported in the Cohesion Data Platform at the end of 2022 indicate that the degree of achievement was mixed. Some output indicators met their target values, including CO26 (number of enterprises cooperating with research institutions), CO28 and CO29 (number of enterprises supported to introduce new-to-the-market products and new-to-the-firm products), while others demonstrated an underachievement, namely CO24 and CO25 (number of new researchers and researchers working in improved research infrastructure facilities) and CO27 (private investment matching public support in innovation or R&D projects). Nevertheless, as observed in earlier evaluation studies, monitoring indicators are only an initial source of information for evaluating the effectiveness of RTDI support.[158]

The evidence collected by the case studies indicates **a broadly positive assessment of the effectiveness of ERDF support for RTDI**, as indicated by high or medium scores given by country experts. In 22 of the 34 specific cases, the measures were evaluated as highly effective in achieving their objectives. The remaining 12 were deemed to be moderately effective. The assessment of policy instrument effectiveness was closely tied to their

[157] Figures based on ESIF 2014-2020 categorisation ERDF-ESF-CF planned vs implemented considering the variable "Planned_Total_Amount_(National)" and "EU_amount_planned" and the year 2023.

[158] In particular: they are generally not available at the level of individual projects or policy instruments, or in terms of categories of expenditure; the target indicators can be flawed, making the comparison with the actual achievement indicators not fully reliable; it is not possible to compare the programme-specific indicators across different OPs; finally, being focused on the programme outputs and results, the achievement indicators are not sufficient for a complete evaluation of effectiveness

relatively high completion rate, which indicates the level of execution and enables an evaluation of the effects achieved by the measures under examination. While most policy instruments exhibited high implementation rates (exceeding 85%), the implementation rate for infrastructure investments for research was only 46% by November 2023. This suggests that there were significant challenges in the implementation of infrastructure investments.[159] These challenges included difficulties in modifying the original project when circumstances required such modifications, such as during the COVID-19 pandemic and the war in Ukraine.

As outlined in Section Moving from projects to tangible and intangible outcomes of RTDI support for beneficiaries, **ERDF support for RTDI has yielded a range of outcomes aligned with its investment priorities.** These include enhanced institutional R&I capacities, facilitated knowledge creation and sharing (nearly 79,000 publications resulting from ERDF RTDI beneficiaries), increased collaboration between academia and industry, technology development (more than 7,000 patents registrations documented), and the promotion of business investments in research and innovation. These anticipated outcomes have been largely realised at the beneficiary level. Nevertheless, evaluating the broader impacts presents certain difficulties, largely due to the recent conclusion of the financed projects and the relatively modest scale of the implemented measures. While long-term effects are anticipated, confirming these projections necessitates evaluations that extend beyond the implementation phase, as shown by the evaluation of the programming period.[160] The examined measures presented mixed evidence regarding their contribution to reducing regional disparities. Some regions experienced significant benefits, while others, particularly those with a concentration of R&D activities in metropolitan areas (capitals), such as Riga, Lisbon, Dublin, Zagreb, or Prague, witnessed an apparent intensification of disparities.

The qualitative evidence from the case studies, in conjunction with existing evaluations and literature findings[161], indicates that **the successful implementation of RTDI interventions is contingent upon the existence of a clearly defined long-term strategy at both the level of the Member State/region and the beneficiary.** This factor, along with implementing comprehensive initiatives, particularly affects the effectiveness of ERDF-backed infrastructure investments for research (PI1), infrastructure investments to facilitate technology transfer and innovation (PI2), research activities conducted at universities and research centres (PI3), and science-industry collaboration (PI4), as evidenced by the case studies. As indicated in Section ERDF has supported the enhancement of R&I infrastructure and institutional capacities, although some implementation challenges occurred, it is of paramount importance that the developed infrastructure be effectively utilised and integrated into the long-term strategic plans of the region and beneficiary. Universities and large public beneficiaries frequently encounter difficulties in systematically ensuring this outcome, particularly in the case of infrastructure utilised in research funded by a combination of public and private sources. Furthermore, the capacity to leverage funding to cover initial costs and ongoing expenses is crucial for the long-term sustainability of the infrastructure. Positive outcomes are frequently achieved by combining a range of measures that span different stages of research and innovation. This was particularly important for the investigated science-industry collaborative projects, particularly

[159] Research infrastructures had to reorganise their operating procedures, rapidly setting new priorities and balancing their resources to address the pandemic with continuing support for the science base as a whole. See: OECD and Science Europe (2021). *Workshop on "Research Infrastructure mobilisation in response to COVID-19: lessons learned*". Draft summary. Available online.

[160] CSIL, Prognos and Technopolis (2021). Evaluation of investments in Research and Technological Development (RTD) infrastructures & activities supported by the ERDF in the period 2007-2013. Final Report. Available online.

[161] *Ibi*dem.

concerning technology transfer, the uptake of RTDI project results, and the transition toward the commercialisation phase.

Furthermore, the case studies illustrate **the importance of regional and national alignment**, as well as the exploitation of synergies with other funding sources, for the achievement of RTDI objectives. The effective coordination and collaboration between various funding sources have been crucial in regions such as Eastern Poland and Northern Portugal, where European funding played a key role in compensating for the lack of similar national instruments. The strategic adoption of mixed funding instruments, including non-reimbursable grants, repayable funding, and guaranteed loans, has optimized the application of resources and improved the position of SMEs in the credit market. The quality of the collaborative ecosystem significantly influences the effectiveness of RTDI policy instruments. This is evidenced by the Flemish R&D ecosystem, which benefits from established partnerships and government-encouraged collaboration. Conversely, inadequate collaboration and networking can limit the scope and impact of research activities, as evidenced by the cases of Greece and Brittany, where measures have been implemented to enhance visibility and awareness of networking opportunities. A strong selection system aligned with the instrument's objectives, as exemplified by the case of Cyprus, ensures that support is directed towards companies with proven innovation capacity, which is crucial for increasing technology readiness levels and successful commercialisation.

The overall effectiveness was hindered by several factors, including administrative procedures, workforce availability, and delays related to the ongoing pandemic. The administrative burden was primarily due to additional requirements imposed on beneficiaries by national and sub-national authorities, known as **gold-plating**.[162] However, the main causes of gold-plating were rooted in excessive and complex EU regulations, state aid and public procurement compliance, and audit practices, which highlights the need for simplification and better use of the existing regulatory framework.

The case study on infrastructure investments for technology transfer and innovation (PI2) demonstrates that challenges were encountered in all three assessed territories as a result of **public procurement rules**. In Bulgaria, it was the first time that such complex procedures, including different eligible expenditures (e.g. procurement of research equipment, software, construction of infrastructures, staff costs, mobility, external services, protection of IPRs, etc.), were contracted to public RTDI institutions. Therefore, the Managing Authority developed numerous rules throughout the project implementation process. This resulted in a number of challenges for beneficiaries, who had to dedicate significant time and resources to adapting to evolving requirements. To address this challenge, the MA provided guidance materials on the public procurement rules. Nevertheless, beneficiaries reported that instead of focusing on the primary research work, they found themselves drawn into the complexities of administrative project management, reporting, procurement, and technical details. Similarly, in Flanders, these procedures were found to be excessively complex even by most experienced beneficiaries (such as those having previous experience with ERDF funding) and often led companies to decline to respond to public calls. In Czechia, beneficiaries found the extended duration of the selection process, frequent procedural changes (e.g. eligible expenditure, VAT), and the use of the MS2014+ interface (specifically developed for monitoring EU funds) to be onerous. With regard to **state aid,** the case studies concluded that, except for infrastructure investments in Bulgaria, where the obligation to comply with the state aid framework was perceived as an additional burden, hindering collaboration with enterprises, state aid regulations were not a significant barrier to implementing the measures.

[162] https://ec.europa.eu/futurium/en/system/files/ged/hlg_16_0008_00_conclusions_and_recomendations_on_goldplating_final.pdf.

Furthermore, it was observed that in several regions, there were **instances of multiple and disproportionate audit practices.** As an illustration, the Managing Authority in Rhone-Alpes (FR) has indicated that there have been a greater number of audits conducted under ERDF support than under regional support, particularly in relation to larger projects. This has resulted in a considerable administrative burden. Furthermore, beneficiaries highlighted an excessive administrative burden under ERDF support, particularly in relation to expense justification. In Cyprus (PI7), beneficiaries perceived the financial audits required by the call as a significant and disproportionate burden on companies, with delays in these audits negatively impacting cash flow. In Lombardy (IT), national regulations such as Antimafia and DURC introduced additional controls.

The qualitative data collected during the case studies provides evidence to support the assertion that **the availability and supply of skilled labour** has a significant impact on how effective policy instruments were. This finding is supported by the existing literature[163] and has been observed in many regions, including Finland, Spain, Greece, Italy, Bulgaria, Lithuania, the Czech Republic, and Cyprus. In addition, the broader economic context, encompassing **market fluctuations and macro-level occurrences**, exerts an influence on the effectiveness of RTDI policy instruments. For instance, Hungarian enterprises have been impacted by fluctuations in foreign exchange rates, while Spain and Greece have endeavoured to reinvigorate their research ecosystems in the context of fiscal consolidation. Furthermore, the collective impact of **the COVID-19 pandemic and the conflict in Ukraine** had a notable effect on investments in RTDI across diverse sectors (see Section Efficiency).

5.3. Efficiency

The presence of **sufficient expertise** for project implementation across all actors positively affected the successful implementation of the RTDI measures. On the one hand, **efficient and experienced Managing Authorities/ Intermediate Bodies** played a crucial role in clarifying procedures to beneficiaries and guiding them through the exploitation of synergies and complementarity with other programmes. Dedicated project staff acted as a help desk for beneficiaries and supported them in addressing unexpected challenges (such as the pandemic) and their lack of experience with EU funded projects (e.g. suggesting complementary funding opportunities, clarifying the interpretation of rules). Effective central management by intermediary organisations facilitated the ease implementation of project supporting the capacity building for innovation in business (PI8) and the indirect support to technological transfer (PI5). Institutional know-how and experience in managing research funding and projects in universities and research centres (PI3) ensured smooth operations despite administrative bottlenecks. On the other hand, **beneficiaries with substantial experience** - in absorbing public funds, managing public procurement, intellectual property rights, and technology transfer processes – and **a clear long-term strategy** demonstrated better performance and achieved better outcomes than those lacking experience and expertise who encountered more difficulties in navigating administrative processes. Among the types of beneficiaries, SMEs faced more challenges than public research entities and large enterprises, which often had dedicated human resources to manage the administrative aspects of collaborative projects, particularly in public procurement and intellectual property matters.

Even for more experienced beneficiaries and where efficient Managing Authorities are in place, the evidence suggests a **continued need to reduce administrative burdens** related to public procurement and compliance with State Aid regulations to minimise project delays. Managing Authorities play a crucial role by providing guidelines to support the implementation phase and, through dedicated project staff, to provide a help desk for beneficiaries. Some effective measures for streamlining project implementation include

[163] e.g., Tingvall, P. G. and J. Videnord (2018). "Regional differences in effects of publicly sponsored R&D grants on SME performance." Small Business Economics 54 (2018): 951 - 969.

integrating State Aid constraints and other relevant regulations into the design of the call. This approach helps beneficiaries align project activities with the regulatory framework and minimizes the need for post-hoc adjustments.

Strategies that **leverage existing partnerships and networking** have led to greater efficiency in achieving effective communication with the local ecosystem, promoting the uptake of project results and encouraging long-term strategic planning. This was a key facilitator for science-industry collaborative projects (PI4), projects supporting innovation capacity building for businesses (PI8), and technology transfer and innovation (PI2 and PI5).

In addition to the programme-specific factors mentioned above, several **contextual factors** were identified as crucial for ensuring the efficiency of RTDI measures. One key enabling factor is **the availability of a national or regional framework supporting RTDI investments**. Strategic alignment with national and regional RTDI frameworks – including S3 strategies - has proven beneficial for collaborative RDI between science and industry (PI4), research activities in businesses (PI6), research and for technology transfer and innovation (PI2). This alignment ensured that policy measures were seamlessly integrated into broader and well-aligned innovation strategies. It provided beneficiaries with a sense of clarity and predictability, paving the way for smoother project execution. The evidence collected also underscores the importance of **long-term funding commitments for infrastructural projects** that extend beyond their integration into national or regional strategies. Without such commitment, there is a risk that only physical structures will be provided, neglecting the effective exploitation and achievement of commercial products. Conversely, the availability of qualified human capital and companies that are capable and motivated to push the technological frontier forward is crucial for fully capitalizing on the opportunities presented by supported interventions.

The **COVID-19 pandemic and the conflict in Ukraine** presented both challenges and opportunities for supported RTDI projects. They resulted in delays, particularly in equipment procurement and construction works, and imposed mobility restrictions on researchers and testing activities as well as caused an increase of project costs. However, these circumstances also prompted greater flexibility in project implementation, such as extensions of project timelines, adjustments to eligibility rules and an expanded use of digital tools within public administration.

Additional barriers to the efficient implementation of RTDI projects **were mostly country or policy instrument specific**, including the lack of flexibility in project's modifications (under PI1), limited availability of funding (e.g. Czechia), lack of clear communication between Managing Authorities and beneficiaries (PI1 and PI5), the absence of pre-financing by the ERDF and delays in obtaining ERDF funding (PI3).

Regarding the mode of financing, **non-repayable grants** were found to be more efficient for funding early stages of innovation and for covering the high costs associated with infrastructure investments, particularly due to the uncertainty surrounding their returns.

The key features of **financial instruments**, such as mobilisation of additional capital and capital re-flows, offer more options for funding innovations at later stages. Amongst the different types of financial instruments, **loans and guarantees** were found to have faster re-flows, already amounting to up to almost 60%. The case studies suggest that capital flows from financial instruments will continue to increase as the financial instruments live their full span and projects are completed. Financial instruments implemented through **fund of funds** showed potential benefits, especially in terms of enhanced flexibility and achieving a greater scale, which may help attract investors. On the other hand, funds of funds imply an additional layer of costs, as well, as they may be seen as potentially reducing the capacity of the Managing Authority to steer implementation. For national-level programmes, the **multi-layered structure of fund of funds** seems to be a more rational choice, whereas regional-level programmes generally use a single-tier structure. Nevertheless, the efficiency

of the different structures – multilayered versus single-tier – mostly depends on **the ability of Managing Authorities to establish them promptly**.

5.4. Coherence

The analysis of the internal and external coherence was largely addressed in the preceding Chapter (Targeting investments through S3 strategies is beneficial, but only to the extent that S3s reflect the underlying economic and technological specialisations. and Articulation of the policy mix: Improving strategic policy planning with better utilisation of synergistic funding approaches.). To complement, the analysis of OPs and case studies suggests a considerable **coherence between ERDF support and other EU interventions with similar objectives at the strategic and operational levels.** The support was well-aligned towards overarching goals across funding programmes to address Europe's challenges cohesively and harmonise application and implementation processes across programmes to simplify access to funding.

- **This coherence is most frequently observed between ERDF and Horizon 2020**. At the OP level, complementarities between Horizon 2020 and ERDF policy instruments supporting research activities in universities were observed in 83% of OPs. Similarly, complementarities between ERDF policy instruments for science-industry collaborative RDI projects and infrastructure investments for research were noted in 73% and 64% of OPs, respectively. Synergies between Horizon 2020 and ERDF were highest in more developed regions, with a greater concentration of R&D capabilities necessary for obtaining Horizon 2020 grants.
- Complementarities between **ERDF and instruments other than Horizon 2020** (such as LIFE, COSME, Connecting Europe Facility, EAFRD, EMFF, and EFSI) are lower, yet they reach up to 40-50% for the aforementioned policy instruments at the OP level.

The **synergies at the project level were more limited**. Regarding upstream synergies, around 17% of ERDF projects were directly related to R&I capacity building. In relation to downstream synergies, nearly 11% of innovations in the Innovation Radar (June 2024) benefited from ERDF funding and other EU funding source.

In the majority of cases, **ERDF support and other EU instruments were either alternative** (e.g., ERDF-funded operations that had not received funding from Horizon 2020, relying on the Seal of Excellence) **or consecutive** (e.g., funding from ERDF enabled successive funding from Horizon 2020 or vice versa).

The mechanisms that facilitated high degrees of coherence varied. In some instances, external coherence resulted from policy design and was planned beforehand. In other cases, particularly in Central and Eastern Europe, synergies were achieved unintentionally, largely due to the limited availability of other funding sources apart from the EU.

5.5. EU added value

The analysis of EU added value investigates the overall value, or benefit, deriving from providing support at the EU level instead of at national or regional level. The EU added value criterion is closely linked to the principle of subsidiarity (Article 5 of the Treaty on the European Union), which establishes that the EU should act only when the objectives can be better achieved by the Union action rather than action by the Member States or at the regional or local level.

A quasi-absolute majority of stakeholders interviewed or reviewed recognised some form of added value to ERDF interventions. They generally agree that without ERDF support, RTDI projects would have not been implemented, these would have had a smaller budget, been less ambitious and/or they would have taken place later – this can be linked

back to the rationale of public intervention in RTDI, i.e. market and system failures (see Chapter Rationale and policy context). In more detail, ERDF added value covers different dimensions. The evidence collected shows that the three most important dimensions have to do with the long-term perspective of ERDF planning, a catalyst effect and a scale advantage.

The following paragraphs elaborate on the different dimensions of the added value associated with the ERDF.[164]

5.5.1. Scale and leverage effects

The **quantitative dimension of ERDF added value was widely acknowledged** by the stakeholders reviewed. The scale effect enabled by ERDF funds was a significant value added in 68% of the programmes reviewed. ERDF funding allowed for more significant and wide investments, and in some cases, it enabled investment in the RTDI sector that would not have found space at all. The evidence gathered through interviews highlighted MAs' views that taking advantage of additional ERDF funding made it possible for beneficiaries to sustain more ambitious, innovative and riskier investments.

Box 12. Examples of ERDF scale effects

In the Polish Smart Growth OP, an evaluation, including counterfactual analyses, indicated that support under the SG OP had a significant impact on the engagement in R&D of companies who were beneficiaries of the support. Without the programme's support, it was determined that many projects would not have been implemented or would have been implemented to a lesser extent, later, or with a detrimental effect on the level of innovation of the implemented solutions. A positive and significant impact of the intervention on investment implementation involving the deployment of R&D results was also established.

Source: Prognos / Visionary / CSIL (2024).

The **intensity of the ERDF scale effect** differed depending on the countries/regions concerned and the type of investment supported. Managing Authorities from the EU13 acknowledged the quantitative dimension of ERDF added value. Of the 18 MA from EU13 consulted, 16 considered scale effects to be the most relevant component of EU added value, far above any other types of effects. The quantitative dimension of ERDF added value was documented when the ERDF was the main or even sole source of funding. This happened in countries and regions suffering from a lack of financial resources due to more or less structural reasons (e.g., fiscal consolidation or systemic limited financial resources in Greece, Spain / Castilla y Leon, Poland).

Scale effects were especially at work in the case of large-scale infrastructure projects and applied research projects. In the case of some infrastructures, for example, very high co-funding rates[165] suggest that projects might have been impossible without ERDF interventions.

In principle, the quantitative dimension of ERDF added value also covers the capacity of the ERDF to leverage additional funding and investment. Findings were mixed in this respect. A quantitative analysis of monitoring indicators shows that the ERDF failed to attract the expected levels of private co-funding (see Section From projects and operations to tangible outputs of RTDI support). At the same time, evidence from the case studies shows the potential of the ERDF in this effect. A direct leverage effect was documented in

[164] D. Tibor (2020). EU added value — a categorical imperative for EU action? Example of various EU actions with their main proponent. European Court of Auditors. Available online.

[165] For example up to 85% in eastern Poland or an average of 80% of all expenditure on science-industry collaborative projects in Latvia and Germany - Saxony.

the case of venture capital funds, for example. In the Netherlands (West Netherlands OP), the contribution of ERDF support was decisive in ensuring the revolving nature of the venture capital fund targeted.[166] Another example is a measure in Latvia which attracted significantly more private funding than initially planned for R&I investments by SMEs and other companies.[167]

Indirect leverage effects were also reported. Benefiting from ERDF support had a positive reputational implication that strengthened the credibility of beneficiaries when seeking further or complementing funding opportunities.

In short, the ERDF provided initial investment, supported the ambitious financial goals of projects, and attracted private investment through its leverage effect. However, the MAs from two Baltic countries highlighted one possible drawback - the risk of overreliance and dependence on ERDF resources (Latvia and Lithuania).

5.5.2. Continuity of funding, long-term strategic perspective

According to the stakeholders consulted, **the ERDF offered a unique opportunity to plan and commit RTDI resources over the long term**. This feature is remarkably acknowledged equally by EU 14+UK and EU13 stakeholders.

Continuity of funding was particularly relevant for RTDI projects, which are inherently uncertain due to the random character of the research process. From the perspective of MA, the ERDF offered a reliable funding framework making possible long-term planning and encouraging strategic thinking. Even when the ERDF funding allocation was low, MAs appreciated the “ring-fencing” effect of the ERDF against political turmoil that can threaten the stability of budgets dedicated to RTDI.

Continuity of funding is also identified by beneficiaries as a major asset of the ERDF. Either alone or in combination with other funding sources within a well-defined policy mix, the ERDF was seen as providing continuous support and addressing the different stages of technology and product development over a significant time period (7 years) and even sometimes across programming periods (e.g., Flanders, Czechia).

The label effect described above (see section 5.5.1) also contributed to forging the sustainability of ERDF funding.

5.5.3. Catalyst and targeting effects

ERDF funding acted as a catalyst for new initiatives and projects, stimulating companies to engage in RTDI activities in strategic areas. Stakeholders acknowledged the ERDF for compelling strategic attention to specific needs particularly those identified in the S3 (see also Section Targeting investments through S3 strategies is beneficial, but only to the extent that S3s reflect the underlying economic and technological specialisations.). Focusing on regional specialisations enabled the concentration of funding on specific thematic areas, ensuring targeted support for priority sectors and types of beneficiaries. For example, in Poland, the Smart Growth OP concentrated on SMEs while in Denmark, the ERDF was mobilised to support technology transfer in favour of SMEs, which no other national or regional policy addressed.

ERDF funding catalysed companies and research partners to engage in new RTDI activities and fostered new practices. There was evidence, for example, that the ERDF support triggered organisational changes to facilitate project management and technology transfer in Ireland. Also, the ERDF developed and consolidated collaborative and

[166] The ERDF envelope made it possible for the IQ Capital fund to build on critical size from the start, which is an important factor for initiating a virtuous capitalisation process.

[167] EUR 52 million, exceeding the planned EUR 15 million.

networking practices in EU 13 ecosystems where they were an exception to the norm (e.g., in RO, SL). For example, under PI5, the ERDF contributed to anchoring behavioural changes by supporting networking activities in S3 priority areas in Slovenia. For PI6, evidence also suggests that European support induced more extensive and numerous collaborations compared to existing national support. Thus, the ERDF support triggered behavioural changes within beneficiaries, with an expected transformative effect in time.

In more developed regions, this dimension of ERDF added value was less important. Networking practices were not so new and, anyway, it was debated whether ERDF funding could diffuse these practices to transform RTDI ecosystems without critical mass. Indeed, some MAs from more developed regions highlighted no added value with respect to leveraging/catalyst/targeting aspects, citing a lack of sufficient amounts of funding for a significant effect that could transform the RTDI ecosystem. It was also argued that ERDF priorities did not differ much from those of other plans and strategies defined at regional and national levels in the areas. Finally, the evidence reviewed did not highlight significant evidence of new policy practices implemented by local policy makers and MA in the context of the ERDF support (for example more intense stakeholders' involvement as per the territorial approach fostered by the S3 and its "Entrepreneurial Discovery Process") as an added value of the latter.

5.5.4. Capacity building

Administrative capacity building did not rank high among the ERDF added value acknowledged by MAs overall, even if MAs from the EU 13 tended to give more importance to this aspect due to a lower starting point and more significant needs. Yet, strong skills are needed to manage and make the most of ERDF, combine it with other policies and instruments, adapt it to the local specificities, etc. The hypothesis is that (policy) learning occurred tacitly as a by-product of ERDF programmes but was not an explicit strategic objective.

Capacity-building effects resulting from ERDF support were also expected to materialise at the beneficiary level. The ERDF financed Capacity-building initiatives (as documented in the PI6 case study for example). Beneficiaries' capacity-building took place as testified by the internalisation of new practices such as networking and related behavioural changes.

5.5.5. Efficiency and better synergies

Stakeholders did <u>not</u> strongly value the added value of ERDF in terms of improved efficiency of the policy delivery proves and synergies. If at all, this effect was identified by EU14+UK stakeholders (16 OP out of 38) rather than by EU13 stakeholders (3 OP out of 18). Yet, developing a comparative advantage in contexts that lag behind in terms of R&D performance requires multiple lines of effort that seek to mitigate, to the extent possible, every structural factor that acts as a barrier to R&D activity.

The prevailing focus often appears to be on establishing demarcation with other funding sources rather than actively seeking opportunities for synergies and efficiency gains. In different cases, the ERDF occupied a specific, well-defined position on a broader policy mix that no other national or regional measures filled. A good example was documented in Denmark where the ERDF exclusively supported SMEs' technology transfer which did not benefited from other lines of support.

Often, excessive administrative complexity was invoked by MA as a serious obstacle to the expected ERDF efficiency gains.

5.5.6. Integration of EU markets

ERDF's added value in terms of integration with EU markets is potentially significant in the field of RTDI, as one can expect that ERDF projects contribute to improved integration with the European Research Area, synergies with other EU RTDI funding, etc. There were cases illustrating this ERDF effect. For example, in Hungary, ERDF funding helped conform to the international standards of R&D and reach international relevance in research outputs and the commercial viability of innovations. Dedicated support to the internationalisation of activities, intellectual property management, mobility of researchers, cooperation and internationalisation of research teams all point toward ERDF effect on enhancing integration with the EU market. Another example were measures in Brittany which aimed at supporting researchers to penetrate European research networks and funding streams – with the objective of increasing visibility and integrating into the European ecosystem. Also, an increase in national and international standing of ERDF beneficiaries were documented in Finland and Lombardy.

5.5.7. Territorial cohesion

Territorial cohesion is a concern in some of the OPs reviewed and/or analysed through in-depth case studies (in Austria, Czech Republic, Italy, Spain - Castilla y Leon, Estonia, Germany - Saxony Anhalt, Croatia). However, **the evidence collected does not show strong results in this respect.** This is either because of difficulty in reaching the objective or because of a dilemma between using the ERDF to reduce territorial imbalances and to foster competitiveness, with a tendency for the latter option to prevail.

For example, in the case of a policy instrument such as research infrastructures which can be expected to reduce territorial disparities, there was no systematic evidence that the latter were successful in endorsing this role. In Germany (Saxony Anhalt) ERDF support to research infrastructures clearly improved territorial cohesion, and similarly, in Italy, the national network of infrastructures strengthened research collaboration in less developed regions. However, in the other two cases reviewed for the same policy instrument (Romania and Lithuania), research infrastructures did not seek or did not manage to reduce regional disparities.

In some other cases, the objective of territorial balance is adopted from a negative perspective rather than as a proactive approach. In Italy, Estonia and Spain – Castilla y Leon for example, the attention was on how not to exacerbate disparities (PI6).

In other cases, like Spain and Croatia, ERDF support to RTDI policy instruments were found to have increased territorial disparities. In Spain, the ERDF support to research activity in universities and public research centres was part of a multiregional OP which recorded an uneven capacity to absorb funds across regions. The adoption of a system of competitive calls prevented from offsetting this imbalance and closing the gaps between more and less developed regions in the country.

Overall, local policymakers and stakeholders often downplay the effect of the ERDF on the reduction of territorial disparity and remain focused on the objective of competitiveness. This fits with an alternative approach where territorial cohesion is best assessed in aggregate terms at EU level, with single regions pursuing competitiveness goals (rather than aiming at intra-regional territorial cohesion). The Czech standpoint collected during the consultation is an illustration of this view.

In conclusion, there is a consensus about the quantitative dimension of EU added value. This is clear in the case of EU13 countries where ERDF support to RTDI is often of considerable critical magnitude. But it is also true for the EU14 as the ERDF can be used in a carefully designed policy mix to fill gaps or to pursue a specific mission. In a context of budget restriction, ERDF support is generally welcome irrespective of its size.

This is even more so since ERDF support also brings about qualitative benefits in terms of funding continuity and catalyst effects. This is widely acknowledged by the stakeholders reviewed and documented especially as concerns beneficiaries. The ERDF promoted innovative practices and behavioural change such as networking and partnering. The timeframe of the support encouraged riskier and more ambitious investments and facilitated the access to further funding opportunities of different kinds (private, public, EU).

On the downside, there is little evidence that local authorities used the ERDF as a testing bed to experiment new approaches and innovative policies. While offering funding security over a relevant timeframe, the ERDF replicated existing intervention logics and reinforced budget where needed rather than departing from mainstream interventions and innovating. Neither did local authorities seem to acknowledge and make the most of the ERDF potential in strengthening capacity building.

Also, the indications that the objective of competitiveness prevails in different occasions suggests that Cohesion policy misses the opportunity to affirm the added value expected in the field of territorial cohesion – being the only EU policy pursuing this objective.

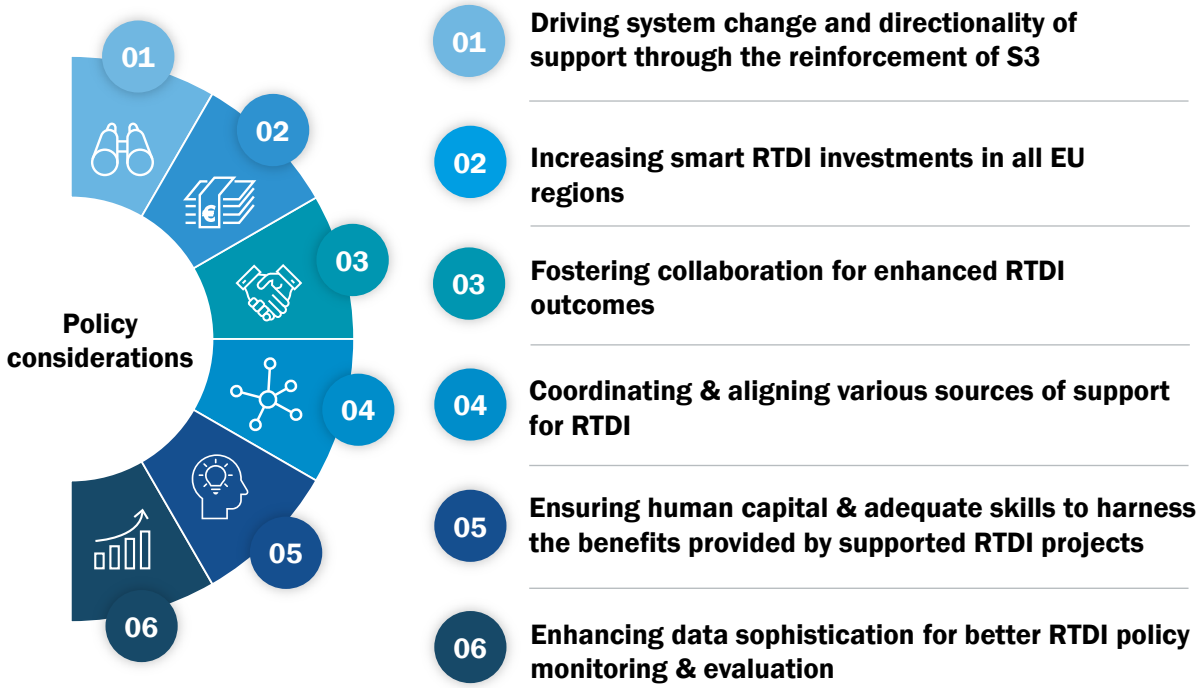
Finally, it should be stressed that the *conditions* for the ERDF added value to materialise are tough to meet. They are the same as those guaranteeing the effectiveness and efficiency of Cohesion policy, in short: adequate administrative capacity to deal with complex requirements and to adopt a strategic approach as well as beneficiaries' absorption capacity. The MAs interviewed confirmed that the added value of ERDF depends on regional absorption capacity and the quality of planned interventions. Furthermore, the added value had been affected by more complex implementation, tendering, reporting, and auditing procedures compared to national or regional funding sources.

6. Lessons learned, current policy context and policy considerations

Chapter 6 presents the main lessons learned based on the findings of the evaluation study. At the same time, we outline the policy implications. These were first discussed at a seminar with key stakeholders from Managing Authorities, RTDI institutions, intermediate bodies, the European Commission and academic experts involved in the evaluation.

The **policy implications are grouped into six overarching areas**, as presented in Figure 45. . These implications are particularly relevant in the context of the ongoing discussion concerning the future direction of the Cohesion Policy[168].

Figure 45. Policy considerations based on the lessons learned from the evaluation



Source: Prognos / CSIL / Visionary Analytics (2024).

[168] Cohesion for a competitive and inclusive Europe: report of the High-Level Group on the Future of Cohesion Policy, February 2024. Available online: Forging a sustainable future together - Publications Office of the EU (europa.eu).

6.1. Driving system change and directionality of support through the reinforcement of Smart Specialisation Strategies

6.1.1. Lessons learned from the evaluation

Smart Specialisation Strategies (S3) is a strategic framework for targeting ERDF RTDI investments within regions. The evaluation confirmed that **the directionality inherent in the S3 paradigm (i.e., the selection of priority areas) has enabled MAs to channel ERDF funding towards pre-identified innovation goals** (incl. so-called “transformational activities” of the S3 paradigm). This is in itself an important finding, to the extent that it confirms that a vehicle for targeting investments exists and that enjoys significant uptake. Targeting investments through S3 strategies is beneficial, but only to the extent that S3s reflect the underlying economic and technological specialisations.

The evaluation examined the extent to which investments made under the ERDF 2014-2020 period were aligned with national and regional Smart Specialisation Strategies. Overall, **approximately 64% of ERDF RTDI projects were thematically aligned with S3 priority areas**, with a strong focus on thematic domains such as ICT and Industry 4.0, Health and Life Sciences, and Agrifood and Bioeconomy. These areas reflect the EU's strategic vision for innovation-driven growth, sustainability, and digital transformation.

In regions with well-developed S3 frameworks, the effective allocation of resources was evident, as Managing Authorities successfully tailored investments to their region’s distinctive economic and technological strengths. However, the analysis in Section 4.1.1 revealed that **approximately 32% of the regions studied (55 out of 162) lacked sufficiently developed S3s.** These regions often relied on existing production assets with low relatedness and faced limited opportunities for upgrading to more advanced technological areas, resulting in what has been termed a "Dead-End Strategy." This represents a significant shortcoming, considering the strategic importance of these frameworks for regional innovation and development. This issue is compounded by inconsistencies in how ERDF calls for proposals are aligned with S3 requirements. The evaluations also shows that a number of calls lack specificity, featuring broad conditions that aim to attract a wide range of applicants. While inclusivity is important, overly generalized calls dilute the strategic focus of S3, undermining its intent to channel investments into prioritized, high-impact areas.

These shortcomings highlight the need for a more refined approach to S3 management. A structured, performance-based system could ensure that S3 strategies are more effectively designed and implemented. Such a framework would prioritize alignment with regional strengths, emphasize measurable outcomes, and establish clear criteria for ERDF funding to ensure it supports targeted areas of innovation and development. This would reinforce the directionality and impact of S3, enabling regions to better leverage their unique capacities while contributing to broader EU objectives like digital transformation, sustainability, and economic resilience.

6.1.2. Current policy context

The prevailing policy context for Smart Specialisation Strategies places an emphasis on fostering **innovation-led economic transformation** within the EU. The overarching goal of S3 is to attract advanced projects with a high Technology Readiness Level (TRL) and facilitate regional transformation. Consequently, S3 plays a pivotal role in the ERDF’s objective of fostering a "Smarter Europe," with a heightened emphasis on integrating innovation into regional development strategies. These strategies prioritize thematic areas

such as green technologies, digitalisation, energy, health, and manufacturing, aligning with the New European Innovation Agenda.[169]

In order to facilitate the exchange of best practices and the design of robust implementation frameworks, the European Commission has introduced initiatives such as the **S3 Community of Practice (CoP)**. [170] This collaborative platform is intended to bring together policymakers, researchers, and stakeholders from across the EU. Furthermore, Thematic Smart Specialisation Partnerships (TSSPs)[171] facilitate collaboration between regions with the objective of developing new value chains in areas of strategic importance, in alignment with their smart specialisation strategies. These partnerships prioritise domains that offer significant benefits in terms of technology, society and the environment, at both regional and EU levels, with a particular emphasis on alignment with shared strategic priorities. TSSPs are open to regional authorities and quadruple helix actors, and require a clear connection to the regional smart specialisation strategy, as well as authorisation from regional authorities.

6.1.3. Future policy considerations

In light of the above, the following policy considerations regarding greater **system change and directionality through S3** can be made:

- **Develop a performance-based approach to implementing S3 strategies.** A performance-based approach to implementing S3 strategies would provide for significant efficiencies. It should establish a link between the strategies' implementation and the structural reforms that are necessary to improve regional innovation ecosystem and create the foundations for innovation success. The link can be made through establishing milestones realised through reforms in critical areas of the innovation environment. The aim is to reduce innovation-inhibiting factors and thereby further the implementation of the S3 strategy. For example, innovation-inhibiting factor include limited knowledge valorisation from universities due to burdensome regulations, ineffective processes for attracting international talent to substantiate the position in priority domains. Some of these reforms cannot be implemented at the country or regional level alone. Such a milestone system must therefore be accompanied by a suitable EU-level definition process that validates the proposed milestones. In designing the new approach, policymakers should bear in mind that targeting ERDF investments through an S3 is only effective to the extent that the underlying strategy intercepts and directs investments towards a region's more promising innovation fields, i.e. its priority domains. Policy makers should therefore place even more emphasis on ensuring that the priority areas of the S3 are neither too broad nor too general.
- **Transform the S3 into a more forward-looking mechanism.** To enhance the forward-looking capacity of S3 strategies, it is essential to position them as dynamic mechanisms that facilitate the transition from mid-tech to high-tech activities. This requires deliberate efforts to align opportunities at the EU level with the identified strengths of regional ecosystems. The overarching objective should be to attract and support higher TRL projects that drive innovation and economic growth. S3 should focus on specific transformational activities within its priority sectors, using them as cornerstones for technological advancement and economic restructuring. This requires Managing Authorities to actively engage stakeholders through robust consultations to accurately identify their needs and ensure targeted support. By fostering innovation ecosystems that enable regions to move up the technology

[169] The New European Innovation Agenda - European Commission.

[170] For reference, see https://ec.europa.eu/regional_policy/policy/communities-and-networks/s3-community-of-practice_en

[171] Inforegio - Thematic Smart Specialisation Platforms

spectrum and focusing on high-tech outputs, S3 can act as a catalyst for cutting-edge industries and strengthen regional competitiveness in global markets..

- **Further improve S3 calls and competitive procedures by adequate policy engineering and experimentation.** The evaluation has documented that, in many instances, ERDF RTDI calls feature broad conditions that are designed to attract a diverse range of applicants. Consequently, these calls must necessarily incorporate only generic requirements, which limits the degree of directionality that can be achieved. This is where the untapped potential of Smart Specialisation Strategies for targeting ERDF RTDI support lies. Promoting adequate policy engineering for S3 implementation is the important improvement that should be pursued in future programming periods. This implies choosing policy instruments that structure beneficiary incentives in a way that is adequate for the transformational activity in question, and designing calls that solve the trade-off between specific requirements and broad enough beneficiary pools. In this sense, specific S3 capacity-building efforts targeted towards Managing Authorities can be beneficial.

6.2. Increasing smart RTDI investments in all EU regions

Over the past two decades, the EU has increased its RTDI investments. However, there remains a discrepancy in comparison to some of its main competitors. In 2021, the EU's R&D intensity (2.3%) was below that of the US (3.5%), Japan (3.3%), South Korea (4.9%), and slightly below China (2.4%).[172] Furthermore, the European Investment Bank (EIB) demonstrates that the insufficient RTDI investments contribute to the innovation divide within the EU and limit its overall competitiveness on a global stage.[173] Less developed regions tend to invest more in transport, energy and infrastructure, but considerably less in research and innovation. To narrow the existing gap in R&D intensity between the EU and key global competitors and enhance competitiveness, **the EU requires to continue to increase R&D investments in all regions combined with the implementation of strategic policy reforms.**

6.2.1. Lessons learned from the evaluation

The evaluation highlights that **ERDF RTDI funding remains a vital source of support for enhancing innovation capacity**, which refers to developing and commercializing new products, services or processes over extended periods of time.[174] The qualitative evidence collected for the purpose of the study demonstrates that, in the absence of ERDF, the implementation of numerous RTDI projects would have been unfeasible, or would have entailed reduced budgets, less ambitious objectives or delays.

The evaluation shows that **this support is particularly significant for EU13 countries.** As of 2023, the proportion of ERDF funding relative to total RTDI expenditure from national sources was substantially higher in EU13 countries than in EU14 countries. With the exception of Portugal, ERDF funding in EU14 countries accounted for less than 3% of total RTDI expenditure. In contrast, in EU13 countries, it consistently surpassed 10%, and in Lithuania, Poland, and Latvia, it reached approximately one-third (30%) of total RTDI funding. Additionally, recent reports indicate that ERDF support, which is concentrated in regions with comparatively weaker R&I performance, also serves to offset their limited

[172] European Commission (2024). Science, Research and Innovation performance of the EU 2024 report. Available online.

[173] European Investment Bank (2023). EIB Group activities in EU cohesion regions, 2022. Available online.

[174] Natário, M.M.S., de Almeida Couto, J.P. (2023). Capacity of Innovation. In: Idowu, S.O., Schmidpeter, R., Capaldi, N., Zu, L., Del Baldo, M., Abreu, R. (eds) Encyclopedia of Sustainable Management. Springer, Cham. https://doi.org/10.1007/978-3-031-25984-5_799.

ability to access EU Framework Programme funding for R&I as an additional source of innovation stimuli and funding. [175]

ERDF support operates within the framework of state aid rules, which inherently limit public funding to projects by requiring leverage or private co-financing. Any assessment of the ERDF's success in mobilizing private support must consider these constraints. Despite these challenges, **the evaluation showcases various instances in which the ERDF successfully mobilised supplementary private investments.** In the Netherlands, for instance, venture capital funds were successfully attracted, while in Latvia, the ERDF-supported measure promoting science-industry collaboration attracted three times more private funding than initially planned. Furthermore, the ERDF's focus on co-financing RTDI infrastructure, such as clusters managing open-access facilities for knowledge valorization, has fostered private investment. In Flanders (Belgium), for example, the ERDF played a key role in securing co-financing for infrastructure projects, underscoring its substantial impact on stimulating private investment in the RTDI sector. This highlights the vital importance for the EU to continue mobilising private investments to complement public-sector investment.

However, the evaluation also reveals that **the ERDF support for RTDI during the 2014-2020 period did not attract the anticipated level of private funding.** As of December 2022, the ERDF output indicator for mobilising private investments (CO27) fell short of expectations, achieving 77% of the target, with EUR 7.6 billion raised (out of 9.9 billion planned). This suggests that Managing Authorities were less successful in attracting private investment than anticipated, even after targets were revised during the programming period. To some extent, this shortfall can be attributed to the impact of the COVID-19 pandemic, which significantly reduced private R&D spending, compounded by the war in Ukraine.[176]

In addition, the evaluation demonstrates **the ERDF's contribution to technological advancement, as evidenced by over 7,000 patent registrations.** A quantitative analysis of downstream synergies identified 840 innovations supported by ERDF funding, representing 10.7% of the 7,801 innovations included in the Innovation Radar as of June 2024. Of these, nearly half are still in the exploratory phase, and only 1.2% are business-ready, indicating a limited impact in terms of scaling innovation. While this data can only serve as a proxy for the innovation dynamics, it indicates that the ERDF generates a considerable number of outputs and immediate outcomes that are not yet market-ready and have untapped commercialisation potential, despite enhancing firms' knowledge capital. It also highlights the necessity to reinforce financial resources to bridge the gap in innovation implementation across EU regions. In the absence of sufficient funding to overcome this gap, increased R&D efforts could exacerbate existing structural weaknesses. **To address this issue, more targeted funding for projects close to market readiness, including via interregional collaboration for pan-EU value chains, is essential**.

6.2.2. Current policy context

The Smart Specialisation Strategies in the current programming period emphasize innovation-driven regional transformation by prioritizing high TRL projects. These initiatives focus on applied research and near-market innovations, enabling regions to capitalize on their unique strengths and build competitive advantages in specific domains, fostering economic diversification and sustainable growth.

A critical element of this framework is investment in shared smart specialisation areas, where multiple regions converge on common priorities. By fostering cross-regional collaboration, S3 aims to create synergies that enhance transnational value chains,

[175] European Commission (2024). Science, Research and Innovation performance of the EU 2024 report. Available online.

[176] Trunschke, M. Peters, B., Czarnitzki, D., and Ch. Rammer (2023). Pandemic effects: Do innovation activities of firms suffer from long-Covid? ZEW Discussion Papers, No. 23-014. Available online.

optimize resource utilization, and promote the sharing of expertise and infrastructure. Key focus areas typically include high-impact domains such as Industry 4.0, renewable energy, agrifood, health technologies, and digital transformation, closely aligning with EU-wide initiatives like the European Green Deal and the Digital Strategy.

This policy approach prioritizes high TRL projects to ensure the swift transition of innovations into practical applications, delivering immediate societal and economic benefits. It plays a crucial role in narrowing the innovation gap between developed and less-developed regions, thereby promoting cohesion and reducing regional disparities within the EU. The overarching aim aligns with broader EU goals of achieving a sustainable, knowledge-driven economy while enhancing global competitiveness, making S3 a cornerstone of the EU's transformative and inclusive growth strategy.

A number of EU initiatives have been established in the current programming period under Cohesion Policy with the objective of providing enhanced support for smart RTDI investments and the transformative potential of S3s. For instance, the **Interregional Innovation Investments (I3) Instrument**, part of the ERDF, provides support for interregional innovation projects during their commercialisation and scale-up phases.[177] The purpose is to assist projects in overcoming regulatory and other obstacles to reach the investment stage. By fostering stronger interregional cooperation and linking regional ecosystems in shared S3 areas, the I3 instrument accelerates the market uptake of research results and stimulates innovation. The initiative is focused on testing, demonstration, piloting, large-scale product validation, market replication and adaptation of existing prototypes, particularly in the areas of digital transition, green transition and smart manufacturing. It provides support for activities that are close to market, specifically at TRLs 6-9. In addition, the Vanguard Initiative, through its new VInnovate Call 2024, has set up an instrument designed to fund industry-led, strategic interregional projects by supporting post-prototyping activities at TRLs from 6 to 8.[178]

Furthermore, to drive investment in the uptake of technologies, the **Strategic Technologies for Europe Platform (STEP)** facilitates the allocation and direction of funding across 11 EU programmes, including the ERDF, towards three target investment areas, namely digital technologies and deep-tech innovation, clean and resource-efficient technologies, and biotechnologies. In August 2024, the Commission approved the first two amendments to Cohesion Policy programmes, which redirected resources in support of the objectives of the Strategic Technologies for Europe Platform (STEP).[179] This decision may have implications for future ERDF support for RTDI.

In order to address the dearth of **private capital for RTDI**, the financing landscape of the EU is receiving high level attention. For instance, public procurement has emerged as a key instrument for fostering innovation and the creation of bespoke solutions to address regional challenges.[180] Additionally, public investment banks, such as the European Investment Bank (EIB), play a pivotal role in financing large-scale, high-risk projects that the private sector may be reluctant to undertake. By co-financing projects, these institutions not only support strategic sectors but also help attract private capital by sharing investment risks.

[177] https://eismea.ec.europa.eu/programmes/interregional-innovation-investments-i3-instrument_en.

[178] For reference, see: https://www.s3vanguardinitiative.eu/multipurpose-page/vinnovate-call-2024.

[179] For reference, see: Strategic Technologies for Europe Platform - European Union (europa.eu).

[180] For reference, see: Benchmarking of innovation procurement investments and policy frameworks across Europe (europa.eu)

6.2.3. Future policy considerations

Considering the aforementioned lessons, the following policy considerations regarding increasing **smart RTDI investments under the ERDF in all EU regions** emerge as pivotal:

- **Encourage risk-taking in innovation.** Develop funding instruments within the ERDF that actively support high-risk, high-reward projects, especially those targeting breakthrough or disruptive technologies. Establish safeguards, such as incremental funding tied to milestone achievements, to mitigate risks while encouraging bold initiatives. Regions should be incentivized to include such forward-looking projects in their S3s.
- **Establish dedicated funding lines to support high-risk and experimental projects.** The aforementioned lines would facilitate the financing of innovative and risky ventures by implementing evaluation and funding criteria that are tailored to their unique nature. This approach guarantees that the funding body can efficiently monitor and substantiate the disbursement of funds. For instance, preliminary funding could be allocated for concept development, market research, and preliminary studies, with the possibility of augmented funding for subsequent stages contingent on project advancement. An exemplar of this approach is Business Finland's provision of supplementary incentives for industrial research projects, which exemplifies the value of scaling funding in alignment with project development.[181]
- **Foster ecosystems for disruptive innovation**. Create supportive ecosystems by encouraging collaborations between startups, research institutions, and established industry players within the S3 framework. Introduce tailored ERDF-funded measures to support incubators, accelerators, and innovation hubs, fostering an environment where disruptive ideas can scale and thrive.
- **Invest in emerging technologies**. Prioritize funding for RTDI in cutting-edge areas such as artificial intelligence, quantum computing, advanced biotechnology, and green energy innovations. Integrate these focus areas into the thematic priorities of S3 strategies to ensure alignment with EU strategic objectives, such as the twin transitions of digitalization and sustainability.
- **Develop incentive mechanisms with the objective of encouraging a greater utilisation of innovative public procurement**. Innovative public procurement has the potential to significantly enhance the competitiveness of companies. By employing this strategy, the public sector can engage with businesses to develop bespoke solutions for regional challenges, addressing needs that cannot be met by conventional market products and services. Nevertheless, the implementation of innovative procurement processes continues to encounter considerable obstacles. To this end, the ERDF should incorporate additional incentive mechanisms from 2028 onward, with the objective of motivating procurers to adopt these innovative tools. In designing their operational programmes, federal states should assess the specific needs of local authorities regarding innovative procurement processes and create strategies to overcome existing obstacles. It would be beneficial to introduce a funding guideline that allows the public sector to address its requirements for non-commercial solutions to transformation challenges. Such a funding guideline could help mitigate risk aversion in public administrations, initiate modernisation and skill development processes, and ultimately provide the necessary momentum for innovation development.

[181] Changes to many of our funding services - Business Finland.

6.3. Fostering collaboration for enhanced RTDI outcomes

The formation of innovation partnerships offers a multitude of advantages. They can offset the R&D costs, add a valuable dimension of expertise and flexibility, and help foster the creation of new markets. Furthermore, they can also accelerate innovation and commercialisation timelines. This can be a particularly crucial function, given the length of time that is often required to achieve breakthroughs and subsequently commercialise them, with this process often spanning decades. It is for these reasons that 94% of those working within the technology sector view innovation partnerships as a fundamental strategic tool.[182]

6.3.1. Lessons learned from the evaluation

The evaluation underscores the pivotal contribution of ERDF support for RTDI in fostering collaboration between public research institutions and private enterprises, especially within EU regions. Firstly, based on the assessment of output indicators, the ERDF instruments supported collaborations of over 75,500 enterprises and research institutions by the end of 2022, exceeding the target by 115%. Secondly, these collaborations, primarily driven by problem-solving and demand-side needs, facilitated the generation and dissemination of knowledge. The analysis of a novel publication dataset shows that the majority of publications from ERDF RTDI beneficiaries during the period 2016-2023 originated from science-industry collaborative RDI projects, irrespective of the type of Cohesion Region. Thirdly, the case studies of science-industry collaborative RDI projects and indirect support for technology transfer demonstrates that ERDF-supported partnerships have resulted in behavioral shifts, including researchers adopting a more business-focused perspective and enterprises becoming more interested in pursuing innovation strategies. The funding provided by the ERDF has significantly enhanced the knowledge and capabilities of the beneficiaries, enabling private enterprises to access cutting-edge infrastructure or knowledge and become aware of emerging technologies. To illustrate, in Finland, an ERDF-funded project established a new Artificial Intelligence Hub, which facilitated the advancement of AI knowledge within companies by fostering connections between academic institutions and private enterprises. The AI Hub sought to assist local SMEs in applying artificial intelligence to business development. Concurrently, research institutions acquired a more profound comprehension of business requirements and developed the competencies essential for industrially oriented and applied R&D through collaboration with industry partners. Ultimately, the key RTDI indicators from the Regional Innovation Scoreboard show a general increase in collaboration metrics, including public-private co-publications and innovative SMEs collaborating with others, over the 2016-2023 period.

A variety of approaches to boost collaborations between RTDI actors were identified across the examined ERDF-supported measures. For instance, in Austria and Croatia, a special funding premium for collaborative research activities in businesses (PI6) was included in the measures' design. At the Enterprise Ireland, Intermediary Body for science-industry collaboration (PI4), dedicated Development Advisors offered tailored support to companies, helping them pursue sustainable growth plans and adopt sector-aligned strategies, together with guiding them through available funding opportunities. Furthermore, Technology Transfer Offices (TTOs) at Irish universities have played a crucial role in the formation of partnerships between academia and enterprises by helping in managing intellectual property and licensing options. The implementation of an open rolling-call system in the examined Innovation Partnership Programme permitted applicants to submit their applications at any time, with monthly approval decisions. This approach enabled

[182] Cecchi-Dimeglio, P., Masood, T., and Ouderkirk A. (2022). What Makes Innovation Partnerships Succeed. Harvard Business Review. Available online: What Makes Innovation Partnerships Succeed (hbr.org).

industries to respond rapidly to shifts in market conditions, accelerate the absorption of funding. In Saxony (DE), a tax-based research allowance provided fiscal incentives for RTDI expenditures across companies of all sizes, sectors, and legal forms.[183] Additionally, ERDF support for science-industry collaboration was aligned with BMWK grant-based funding and various BMBF technology-specific programmes that fostered basic and top-tier research through collaborative company-academic or research institution projects. In Lombardy (IT), the measure's design waived the minimum investment requirement per partner, thus enabling financially unstable entities, such as start-ups, to participate and contribute their expertise. Furthermore, the call permitted up to 10% of project investments to originate from research organisations outside Lombardy, thereby attracting institutions from other Italian regions.

The evaluation identifies potential for enhanced collaboration under the ERDF, given that the majority of support has been directed towards individual beneficiaries. The analysis of expenditure data demonstrates that 75% of ERDF RTDI funding was allocated to sole beneficiaries, with enterprises receiving 40% of this amount. However, caution is warranted in interpreting this data, as sole beneficiaries may still be engaged in collaborative projects. **The findings of the evaluation also show that ERDF-supported partnerships are predominantly regional, which may be an insufficient approach to addressing the deficiencies of the regional RTDI ecosystems.** To overcome these limitations, it is essential to foster more interregional partnerships and linkages between RTDI actors in order to facilitate innovation, particularly in the context of complex technologies. The recent literature shows that digital technologies, such as artificial intelligence (AI), the Internet of Things (IoT), blockchain, and cybersecurity, exhibit the highest levels of inter-country collaborations, thereby underscoring the crucial role of such collaboration in advancing these complex fields.[184]

Furthermore, as discussed during the dedicated seminar on Cohesion Policy support to RTDI, it is essential to select the most appropriate form of support for collaboration. Collaboration can encompass not only science-industry collaborative projects but also staff exchange programmes that involve the temporary relocation of researchers to companies. In some instances, this method may have the potential for a more lasting impact.

6.3.2. Current policy context

The ERDF's contribution to fostering a culture of collaboration for RTDI is crucial as it can facilitate project consortia funded by other EU programmes. The majority of EU-funded projects entail collaborative endeavours among organisations from disparate EU or associated countries, organised into consortia. For instance, the Horizon Europe Framework Programme primarily provides financial support for R&I projects that facilitate collaboration between academic institutions and enterprises to address pressing societal challenges, particularly within the context of European Partnerships and six clusters under Pillar 2 of Horizon Europe. The HE clusters in this specific interpretation are collaborative projects, and the majority of calls for proposals require teams comprising a minimum of three partner organisations from three different EU or associated countries.[185] In some cases, proposals require a multi-actor approach (MAA), which involves a diverse set of

[183] Deloitte Tax-News: MOF publishes updated guidance on R&D tax incentive (deloitte-tax-news.de).

[184] Bachtrögler-Unger, J., Balland, P.A., Boschma, R., Schwab, T., (2023), Technological capabilities and the twin transition in Europe: Opportunities for regional collaboration and economic cohesion, Austrian Institute of Economic Research, Utrecht University, Artificial and Natural Intelligence Toulouse Institute, University of Stavanger.

[185] For reference, see: Horizon Europe – Who should apply - European Commission (europa.eu).

stakeholders, particularly end-users and those who will utilise the project's results (e.g., MAA is the eligibility criterion in the calls under the Horizon Europe Cluster 6 [186]).

The current funding landscape also offers a diverse range of programmes that facilitate interregional cooperation. As mentioned above, the introduction of the Interregional Innovation Investments (I3) Instrument, part of the ERDF, was an important step to enable more interregional innovation projects, especially during their commercialisation and scale-up phases.[187] Within the I3 also the innovation divide is explicitly addressed in the way that project consortia need to be designed. Overall, the Interreg programme remains a notable instrument of the EU that fosters cross-border collaboration through project funding in a range of areas, including health, the environment, research, education, transport, and sustainable energy.[188] It provides support for interregional cooperation projects by bringing together partners from different (neighbouring) regions to share and transfer knowledge on mutual development issues. More recently in April 2022, the Partnerships for Regional Innovation (PRIs) have been launched as a pilot project involving 74 EU territories (including 63 NUTS2 regions).[189] Finally, in the context of the New European Innovation Agenda, the Regional Innovation Valleys initiative has the objective of harnessing deep-tech innovation across EU territories and strengthening innovation cohesion. The agenda sets a bold target of identifying up to 100 regions that are committed to improving the coordination and direction of their research and innovation investments and policies at the regional level. As of now, 64 eligible regions have expressed their interest in becoming Regional Innovation Valleys, comprising 7 innovation leaders, 16 strong innovators, 18 moderate innovators, and 19 emerging innovators.[190]

Furthermore, there are targeted initiatives in place to foster collaboration among RTDI stakeholders. One such initiative is the European Cluster Collaboration Platform (ECCP)[191], which aims to enhance the competitiveness and sustainability of Europe's economy and industry, with a particular focus on small and medium-sized enterprises (SMEs). The ECCP serves as a European online hub for cluster stakeholders, including cluster organisations, policymakers, and other related parties, and acts as a reference point for stakeholders from third countries looking to establish partnerships with European counterparts. Another key initiative is the S3 Community of Practice (CoP)[192], which serves as a central hub for guidance, networking, support, and peer learning on Smart Specialisation Strategies. The S3 CoP covers both the conceptual development and implementation of S3 and aims to engage all quadruple-helix stakeholders interested in Smart Specialisation, fostering a collaborative environment for learning and advancement.

[186] For reference, see: ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/wp-call/2023-2024/wp-9-food-bioeconomy-natural-resources-agriculture-and-environment_horizon-2023-2024_en.pdf#page=21

[187] https://eismea.ec.europa.eu/programmes/interregional-innovation-investments-i3-instrument_en.

[188] For reference, see: About Interreg | What is Interreg and how it works • Interreg.eu

[189] For reference, see: PRI - Smart Specialisation Platform (europa.eu).

[190] According to the European Innovation Scoreboard (EIS) 2023. More information can be found here: Inforegio - Regional Innovation Valley - Matchmaking map now available (europa.eu).

[191] For reference, see: Mission of the ECCP | European Cluster Collaboration Platform

[192] For reference, see: Inforegio - S3 Community of Practice (europa.eu)

6.3.3. Future policy considerations

Enhancing collaboration between research and innovation stakeholders at the EU level can markedly bolster Europe's competitiveness, sustainability, and technological advancement. The key policy conclusions regarding **effective collaborations** are as follows:

- **Enhance collaboration through multibeneficiary projects in future ERDF programmes.** Future ERDF funding programmes should prioritize fostering greater collaboration RTDI actors by allocating more support to multi-beneficiary and collaborative projects. The current trend, where 75% of ERDF RTDI funding is directed towards sole beneficiaries limits the potential for synergies and broad-based innovation. To address this, ERDF calls should be designed to incentivize and facilitate interorganizational collaborations, ensuring that projects engage multiple stakeholders such as universities, SMEs, research institutions, and industry partners. Additionally, while recognizing that sole beneficiaries may still participate in collaborative efforts, future programmes should encourage a clearer and more structured approach to joint ventures, with specific targets or requirements for collaboration in project proposals.
- **Design specific calls that encourage collaboration in European value chains, emerging technologies and disruptive innovations while addressing sustainability and digital transformation.** In order to foster stronger collaboration in European value chains, emerging technologies, and disruptive innovations, future ERDF funding calls should be designed to specifically target projects that bring together diverse stakeholders across sectors and regions. This approach would ensure a focus on high-impact areas such as green technologies, digitalisation, and Industry 4.0, which are central to both sustainability and the European Union's digital transformation agenda.
- **Diversify collaborative formats in future ERDF programmes.** The extension of RTDI measures to encompass initiatives such as staff exchange programmes represents a potential avenue for fostering more enduring impacts. This approach may facilitate enhanced interconnectivity between academia and industry, while also enabling the transfer of knowledge through the temporary relocation of researchers to companies, thereby benefiting both sectors. Similar forms of innovative cooperation schemes between science and industry could be “shared professorships” (Professors work half time at the university and half time in industry, e.g. industry, as established at the Karlsruhe Institute of Technology, Baden-Württemberg/DE, for example), ‘industry fellowships’ (postdoctoral researchers are employed partly at the university and partly by an industry partner) or other ‘reach-out-and-return’ models (temporary transfer of researchers from the university to industry or vice versa) in order to increase the number of scientists researching, teaching and cooperating with companies. It will be essential to create suitable matching formats between stakeholders in science and industry, such as support for the temporary work of a scientist in a company in the region.
- **Implement flexible and open funding mechanisms under ERDF**. Adopting more flexible funding mechanisms, such as an open rolling-call system offered by the Enterprise Ireland, can help RTDI actors respond swiftly to market shifts and technological advancements. Another potential solution is front-loading, which can alleviate financial pressure on RTDI actors by providing necessary capital upfront. This enables them to cover initial costs and invest in resources without delay. Moreover, considering the increasing number of “non-innovating SMEs”, stronger efforts are needed to enable SMEs to enter into a more comprehensive transfer of knowledge and expertise as well as co-operative innovation management facilitated through measures with low entry barriers (such as vouchers, cascade funding, etc.).

- **Enhance technology transfer and intellectual property management support.** Strengthen TTOs at universities to play a key role in facilitating partnerships between academia and industry. Providing guidance on intellectual property management, licensing options, and alignment with sector-specific strategies will boost collaboration by ensuring smoother technology transfer processes. To enable that, framework conditions within TTOs need to be improved, including available resources for staff and infrastructure.

6.4. Coordinating and aligning various sources of support for RTDI

Synergies within Cohesion Policy funds, particularly the ERDF, are vital for enhancing the efficiency and impact of RTDI investments. The alignment of funding strategies and project goals ensures the optimal utilisation of resources, resulting in enhanced quality of outcomes and greater impact. Furthermore, they facilitate the dissemination of optimal practices and expertise across disparate funding streams, thereby fostering a more integrated and robust innovation ecosystem. Essentially, the EU needs to address multiple transformation processes at once, notably the green, digital and demographic transitions, in a complex geo-economical context. This requires maximised use of the existing resources to enhance innovation productivity and competitiveness.

6.4.1. Lessons learned from the evaluation

The evaluation study demonstrates that synergies between ERDF and other RTDI support sources, including additional ESIF funding, sometimes arose from deliberate policy design, while in other cases, they were more incidental, emerging from efforts to prevent overlap rather than from comprehensive planning. Where synergies were planned in advance, Managing Authorities employed various strategies. These included earmarking ERDF funds for specific stages of the innovation cycle (e.g., BE, DE, FR), targeting funding at beneficiaries with previous project experience (e.g., RO, LT) to ensure effective use, or combining ERDF with national funds to address identified investment priorities (e.g., DE, IT). Notable examples of such planned coherence include Flanders (BE), where the ERDF Managing Authority and the regional agency responsible for managing RTDI funding, VLAIO, integrated ERDF support into a comprehensive policy mix covering all stages of the innovation cycle. VLAIO has incorporated ESF+ resources to support researchers' employment in conjunction with ERDF-funded infrastructure and other regional initiatives targeting diverse stages of innovation. To ensure continued alignment, VLAIO has established a joint monitoring committee that meets annually to coordinate with other ESIFs, enabling beneficiaries to access the most appropriate support measures. In Spain, the National Research Agency (AEI) played a crucial role in the supervision of the ERDF measure, which aimed to address societal challenges through research. Additionally, the AEI administered a number of supplementary funding calls, encompassing a broader range of research activities. This included financial support for collaborative research projects involving partnerships between research institutions and enterprises, with the objective of fostering innovation and the practical applications of research findings in the industry.

Furthermore, the centralisation of the management of various measures within dedicated agencies has proven to be an effective strategy to foster support and leverage networks for identifying potential beneficiaries. In Castilla y León (ES), the regional public administration body, Instituto para la Competitividad Empresarial (ICE), provided beneficiaries with comprehensive information about all available public funding opportunities, directing them to the most suitable measures. The network of offices managed by the financial intermediary (IBERAVAL) was instrumental in reaching enterprises across all provinces in the region. As demonstrated by successful practices in

Eastern Poland, centralised management provides more effective guidance for beneficiaries in identifying the most appropriate support. In addition, in 2019, Poland launched an initiative called Innovation Coach[193], which provides a specialised information service for entrepreneurs who are interested in conducting research and development but lack experience raising funds for R&D&I activities. This service offers individual consultations with an innovation coach, who is an industry expert, to assist clients in developing their innovation ideas within their own companies.

A quantitative analysis of the synergies between the ERDF 2014–2020 and the Horizon 2020 programme, conducted for the purpose of this evaluation, shows that approximately 10% of ERDF RTDI beneficiaries also received Horizon 2020 funding. In order to evaluate these synergies, the assessment focused on the extent to which dual beneficiaries received support that was directly related to the development of R&I capacity. Of the 24,833 ERDF projects analysed, 17% were found to be directly related to R&I capacity building, which suggests limited upstream synergies in comparison to the findings of the European Court of Auditors (ECA) Special Report (2022), which highlighted strong upstream synergies between Horizon 2020 and ESIFs. Furthermore, there is a lack of evidence that these were pursued systematically, with no discernible fund-targeting strategies evident (see Section Articulation of the policy mix: Improving strategic policy planning with better utilisation of synergistic funding approaches for further details). With regard to downstream synergies, the evaluation identified 840 innovations that had received support from ERDF funding, representing 10.7% of the 7,801 innovations included in the Innovation Radar as of June 2024. Of these, 51% were classified as actively exploring value creation opportunities, 19% were market-ready, 18% were at an advanced stage of technological development, and 12% were business-ready, indicating strong innovation management and readiness. The case studies indicate that several challenges impeded the formation of synergies between the ERDF and the EU Framework Programme for Research and Innovation. These included misconceptions about the compatibility of the programmes, discrepancies in the legal provisions, differing objectives, and the administrative burden of managing both funding streams.

Nevertheless, strategies for fostering synergies between the ERDF and the Horizon programmes were showcased through case studies. For instance, Lombardy (IT) ensured alignment with EU funding by providing additional assistance to SMEs that had secured Horizon 2020 funding within 12 months of receiving ERDF support for a comparable project. These SMEs were awarded a further 5% of eligible costs as a non-repayable grant, based on the assumption that their involvement in Horizon 2020 demonstrated their R&D capacity and justified additional non-repayable support. In North Rhine-Westphalia (DE), downstream synergies were given priority by giving preference to market projects with clear links to Horizon 2020 applications, provided that competing projects were of comparable quality. In Northern Portugal, ERDF support for business innovation (PI8) included assistance with preparing Horizon 2020 applications.

6.4.2. Current policy context

The European Commission has acknowledged the legal and practical challenges associated with the establishment of synergies between the Horizon 2020 and the ERDF programmes, particularly those pertaining to the SoE, and has undertaken considerable efforts to address these issues in the current multiannual financial framework. To illustrate, the EU has introduced "synergies-friendly" State aid regulation, making it easier to grant aid to SMEs involved in Seal of Excellence projects.[194] Joint support initiatives, such as the Seal of Excellence Community of Practice, have been established,

[193] For reference, see: Druga ścieżka instrumentu STEP (innovationcoach.pl).

[194] For reference, see: https://errin.eu/system/files/2023-06/230608fundingsynergieseuropean-commission.pdf.

featuring regular meetings co-chaired by the Commission.[195] The legal provisions that previously hindered the creation of synergies have been revised, and the Commission Notice has been published to facilitate their implementation.[196]

Additionally, in the current funding period, new synergistic initiatives have been established. For instance, to facilitate innovation across EU regions under the Regional Innovation Valleys, the European Commission has launched two complementary calls for proposals in May 2023, offering a total of EUR 122 million under the European Innovation Ecosystems (EIE) within Horizon Europe and the Interregional Innovation Investments (I3) Instrument.[197] Also, the transfer between cohesion policy funds and Horizon Europe is one of the new possibilities available in the 2021-2027 programming period in the context of synergies between EU funding sources and Malta was the first Member States to take advantage of this.[198] In this context, one can also mention RIMA as a new network under the European Research Area (ERA) Forum that aims at ensuring synergies across relevant funding sources. [199] Moreover, also the Strategic Technologies for Europe Platform (STEP) and its STEP Seal which should support projects in accessing other funding sources.[200]

6.4.3. Future policy considerations

Based upon these lessons learned, the main policy considerations regarding the **coordination and alignment of various sources of support for RTDI** are as follows:

- **Enhance centralised management and coordination within dedicated agencies to streamline support under future ERDF programmes and improve beneficiary guidance.** By integrating various funding sources and resources, as seen in Flanders and Castilla y León, regional authorities can offer a comprehensive range of support that covers all stages of the innovation cycle. Regular coordination meetings among different funding bodies and a unified approach to information dissemination can ensure that beneficiaries access the most relevant and effective support measures. Empirical evidence strongly supports such capacity development, as it increases the quality of governance and quality of advisory services which in turn positively correlate with the quality of project proposals.
- **Promote specialised support services that assist enterprises and researchers in navigating funding opportunities and enhancing their R&D activities.** The success of initiatives like Poland's Innovation Coach demonstrates the value of providing personalized guidance and expert consultations to help clients effectively manage their innovation projects and secure appropriate funding. This could include raising awareness and promoting utilisation options for applied research at an earlier stage and increasing the application maturity of RTDI results. Examples of such activities could include “RTDI commercialisation opportunity workshops”, “business model workshops” (as used in Baden-Württemberg, DE) and establishing matchmaking and pitching offers to overcome the financing gap at an early stage.

[195] For reference, see: The Seal of Excellence Community of Practice meets online - European Commission (europa.eu).

[196] Commission Notice Synergies between Horizon Europe and ERDF programmes 2022/C 421/03 : EUR-Lex - 52022XC1104(02) - EN - EUR-Lex (europa.eu).

[197] For reference, see: Call for expression of interest for Regional Innovation Valleys is now open - European Commission (europa.eu)

[198] For reference, see: Synergies between the European Regional Development Fund (ERDF) and Horizon Europe - European Commission (europa.eu)

[199] For reference, see: https://research-and-innovation.ec.europa.eu/news/all-research-and-innovation-news/rima-new-network-brings-together-key-ri-and-cohesion-policy-actors-2023-06-13_en

[200] For reference, see: https://strategic-technologies.europa.eu/index_en

- **Develop support mechanisms in the call documentation that enhance synergies between the ERDF and Horizon programmes.** For example, regions could adopt the approach taken by Lombardy, whereby SMEs that have secured Horizon funding are awarded additional non-repayable grants to enhance their R&D capabilities. Similarly, regions could give priority to projects with strong links to Horizon applications, as demonstrated in North Rhine-Westphalia, in order to better align funding with long-term innovation objectives. Providing specialised support for preparing Horizon applications, as done in Northern Portugal, can also boost participation in both funding streams and strengthen innovation ecosystems. Furthermore, aligning the project selection process with Horizon initiatives, as Lithuania did after learning from the 2014-2020 period, can result in more competitive and synergistic ERDF project selection for the 2021-2027 programming period.
- **Strengthen the Seal of Excellence mechanism by enhancing information flow about Seal of Excellence projects and actively promoting ERDF opportunities to Horizon Europe beneficiaries.** This requires ongoing dialogue between Member States and the European Commission to explore and develop synergies between the ERDF and Horizon Europe, particularly with regard to EU-13 countries with HE widening measures (such as TEAMING, TWINNING, Pathways to Synergies, etc.). Furthermore, national and regional funders should establish dedicated funding schemes to support Seal of Excellence recipients, while also coordinating with Managing Authorities and National Contact Points[201] responsible for Horizon Programmes.
- **Establish dedicated structures - specialised offices or liaison agencies - for managing central EU programmes, such as Horizon Europe.** Examples of such structures include the Polish Science Contact Agency (POLSCA), operating as a department of the Polish Academy of Sciences (PAS), or the Czech Liaison Office for Education and Research in Brussels (CZELO), part of the Czech National Agency for International Education and Research (DZS). Similarly, the German EU Office of the Ministry of Research or the Danish Research Office in Brussels (DANRO), integrated part of the Danish Ministry of Higher Education and Science, could serve as central hubs for coordinating EU research programmes and other RTDI related initiatives.
- **Encourage more downstream synergies.** This can be achieved by encouraging public sector organisations to procure innovative products and services that utilise research outcomes funded by framework programmes. It is also crucial to provide support to Managing Authorities in designing targeted actions that foster downstream synergies with Horizon Europe, particularly with Pillar III of the Horizon Europe programme (the European Innovation Council, the European Institute of Innovation and Technology and the European Innovation Ecosystems' calls). This Innovative Europe Pillar of HE is focused on advancing disruptive and market-creating innovations while strengthening European innovation ecosystems. Furthermore, it would be beneficial to investigate funding opportunities provided by other downstream investment schemes, such as LIFE, which supports close-to-market projects with environmental or climate benefits. The Innovation Fund also offers substantial resources for demonstrating innovative low-carbon technologies.

[201] For reference, see: EU Funding & Tenders Portal (europa.eu).

6.5. Ensuring human capital and adequate skills to harness the benefits provided by supported RTDI projects

A recent analysis conducted by the Harvard Business School has demonstrated that immigrants contribute significantly to innovation, in this case in the US innovation system.[202] Despite representing only 16% of all inventors, immigrants are responsible for directly producing 23% of the total innovation output. It is more probable that they will utilise foreign technologies, engage in collaboration with foreign inventors and facilitate the dissemination of ideas across national boundaries. Furthermore, immigrants generate considerable positive spillover effects on their native-born counterparts, accounting for 36% of the total innovation output, with two-thirds of this impact derived from these externalities. [203] While these figures do not assess the situation in the EU, they clearly demonstrate the utmost importance of attracting and harnessing talent within European regions, as highlighted by the 2023 Report on the impact of demographic change and following Communication on Harnessing Talent in Europe's Regions.[204]

6.5.1. Lessons learned from the evaluation

The evaluation findings demonstrate that a shortage of human resources and specific skills significantly hinders the implementation of RTDI activities and the sustainability of their outcomes across all policy instruments. Moreover, they limit the potential of S3, if selected priority domains cannot be underscored by sufficient talent pools and more broadly, qualified staff. With the increasing demographic change, these effects are likely to worsen. For example, the brain drain has led to a shortage of researchers, severely limiting the internal capacity of Spanish and Greek universities and research centres to conduct early-stage research (PI3). As noted in Section ERDF has supported the enhancement of R&I infrastructure and institutional capacities, although some implementation challenges occurred, the lack of researchers - due to the low attractiveness of research careers - and a shortage of highly qualified professionals in specific technical fields also presented significant challenges to the sustainability of infrastructure investments for research (PI1). This issue, shared across all four examined measures in Saxony-Anhalt (DE), Italy, Lithuania, and Romania, significantly influenced the capacity of the interventions to maintain their effects over time. The lack of personnel to work in these infrastructures has resulted in their underutilization, which has further limited their effectiveness.

Additionally, **infrastructures for technology transfer and innovation (PI5) faced the risk of being unused or underutilised due to a shortage of skilled human capital and companies capable of advancing technological frontiers**. The case study on business investments to support innovation uptake (PI7) confirmed an insufficient supply of skills as a significant barrier to the uptake of innovative activities. In Cyprus, companies were facing a significant shortage of highly skilled employees due to three main factors: the establishment of numerous private universities that have attracted skilled graduates to high-status research roles, large Foreign Direct Investments (FDIs) from Ukraine, Russia, and Israel offering high-salary positions, and an insufficient supply of STEM graduates, as many young Cypriots have opted for studying finance, law, or social sciences. Consequently, Cypriot companies found it challenging to compete in the talent market and often relied on graduates from Greek universities, which still faced difficulties. In contrast, Eastern Poland

[202] Bernstein, S., Diamond R., Jiranaphawiboon A., McQuade T., and Pousada B. (2021). The Contribution of High-Skilled Immigrants to Innovation in the United States. Harvard Business School Working Paper, No. 22-065, December 2021.

[203] Ibidem.

[204] For reference, see: Inforegio - Harnessing Talent Platform (europa.eu).

did not report skills shortages as a barrier for the sub-measure "Implementation of innovation by SMEs" as having adequately skilled employees was a prerequisite for grant applications.

Some investigated regions have been successful in addressing the issue of human resources, even though the disposition remains challenging. To illustrate, the German region of Saxony-Anhalt effectively combined ERDF and ESF funding. The ERDF provided financial support for the development of research infrastructure, while ESF financed human resource costs, enabling beneficiary institutions to hire researchers. In West Flanders (BE), tax incentives constituted a key factor in attracting highly skilled researchers. This region offered tax breaks for personnel costs, as well as funding for technology transfer and innovation infrastructure and support for individual research projects. Additionally, researchers were adequately remunerated, ensuring a consistent supply of human capital.

As evidenced by this evaluation, capacity-building initiatives financed through ERDF investments have played a pivotal role in alleviating the situation, which could have been significantly more challenging in the absence of these interventions. Investments in human capital development were instrumental to business research activities (PI6), including advisory services for human capital in Portugal and Estonia. Furthermore, science-industry collaboration (PI4) measures in Latvia and Southern and Eastern Ireland enabled participating companies to recruit researchers. Similarly, collaborative doctoral funding programmes aligned with R&D activities in Lombardy (IT) led to the acquisition of high-level skills within the sector.

6.5.2. Current policy context

The existing literature demonstrates that combining training for innovative activities with EU-funded public innovation support is an effective method for firms to mitigate the risk of innovation failure.[205] Consequently, skills development for innovation has received increased attention during the 2021-2027 programming period with the introduction of the ERDF's specific objective 1.4 "Skills for smart specialisation, industrial transition, and entrepreneurship".[206] This objective highlights the significance of human capital development as a fundamental element of the smart specialisation process, vital for the long-term sustainability of regional innovation ecosystems. However, the smallest allocation to this objective has been made among the five specific objectives under PO1, with a total funding of EUR 2 billion. Furthermore, the objective has been used more intensively only in some countries, such as Italy, Slovakia, and Greece.[207] Additionally, the Harnessing Talent Platform (HTP), developed by DG REGIO, aims to help Europe's regions promote, retain, and attract the talents their economies need.[208] A dedicated Research and Innovation Working Group is focused on two subtopics: skills development in place-based innovation strategies, and knowledge transfer and talent utilisation.[209]

Other EU initiatives also focus on skills development. The Just Transition Fund (JTF) allocates EUR 3.1 billion specifically for this purpose, with an additional EUR 1.9 billion

[205] Nevertheless, the success of training-oriented strategies in reducing the failure rate of innovation depends on the ability to address information asymmetries and other obstacles in selecting and implementing the right type of training. Please see: Nebojsa S. (2024). Innovation failure, training for innovative activities and public support for innovation: Multi-annual evidence from emerging European innovation systems, Research Policy, Volume 53, Issue 8, https://doi.org/10.1016/j.respol.2024.105059.

[206] As part of Policy Objective 1 "A smarter Europe through promoting innovative and smart economic transformation" of the European Regional Development Fund in the 2021-2027 programming period. Please see the regulation: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32021R1058.

[207] Outcome of 2021-2027 programming - cohesion policy | Data | European Structural and Investment Funds (europa.eu).

[208] For reference, see: Inforegio - Harnessing Talent Platform (europa.eu).

[209] For reference, see: Inforegio - Harnessing Talent Platform Working Groups (europa.eu).

dedicated to research and innovation.[210] The European Social Fund Plus (ESF+), with a budget of EUR 142.7 billion for 2021-2027, supports employment, social, education, and skills policies.[211] The Strategic Technologies for Europe Platform (STEP) focuses on skills for critical technologies, such as digital and clean tech.[212] Horizon Europe programmes, such as the EIT Cross-KIC Strategic Education[213], Marie Skłodowska-Curie Actions (MSCA) training programmes[214], and the EIC Business Accelerations Services (BAS)[215] further enhance education, research, and entrepreneurship. Additionally, Erasmus+ programmes promote vocational training, regional development, and social inclusion.[216] Together, these efforts create a robust framework to advance skills and innovation across Europe.

6.5.3. Future policy considerations

The key policy considerations regarding **human capital and adequate skills**, drawn from the lessons learned outlined above, are as follows:

- **Facilitate the attraction of international talent.** The substantial contribution of immigrants to US innovation highlights the necessity for European regions to prioritise the attraction and retention of skilled professionals. It is imperative that initiatives such as the Harnessing Talent Platform (HTP) continue to receive support, particularly in regions that have been affected by a brain drain. The implementation of incentives, such as tax breaks and competitive remuneration, has been demonstrated to be an effective strategy for the attraction of highly skilled researchers, as evidenced by the experience of West Flanders (BE). Furthermore, the streamlining and acceleration of visa procedures for international talent– similar to the Estonian start-up visa programme[217] – can serve to enhance Europe's capacity to attract global talent.
- **Enhance public-private collaboration for skills development**. This could reduce the risk of innovation failure by ensuring that companies have access to the human capital necessary to drive technological advancements, as demonstrated by EU-supported training and advisory services in Portugal and Estonia.
- **Strengthen the funding under the ERDF specific objective 1.4 "Skills for smart specialisation, industrial transition, and entrepreneurship".** At present, this objective receives only a modest allocation of the ERDF budget, which constrains its capacity to comprehensively address the acute shortage of skilled professionals across pivotal sectors. To optimise its impact, funding for this objective should be significantly increased and combined with resources from the European Social Fund Plus (ESF+) and other EU programmes, such as Horizon Europe and Erasmus+. By aligning and pooling these resources, regions can implement more comprehensive strategies that not only focus on infrastructure development but also address the human capital challenges that are vital for sustaining growth and innovation.

[210] For reference, see: Inforegio - Just Transition Fund to ensure a smoother road to carbon-neutral regions (europa.eu).

[211] For reference, see: European Social Fund Plus (europa.eu).

[212] For reference, see: Strategic Technologies for Europe Platform - European Union (europa.eu)

[213] For reference, see: EIT Cross-KIC Strategic Education (europa.eu).

[214] For reference, see: Home - Marie Skłodowska-Curie Actions (europa.eu).

[215] For reference, see: Business Acceleration Services - European Commission (europa.eu)

[216] For reference, see: Centres of Vocational Excellence - Erasmus+ (europa. strategies eu).

[217] For reference, see: startupestonia.ee/start-up-in-estonia/startup-visa/

- **Develop a strong domestic talent pipeline.** Expanding the domestic talent pool is critical to fostering long-term innovation and entrepreneurship within Europe. To achieve this, a variety of initiatives can be implemented to foster the growth of future entrepreneurs and innovators. For instance, the establishment of spin-out incubators within universities and research institutions can facilitate the transformation of academic research into viable business ventures. These incubators would provide aspiring entrepreneurs with the resources, mentorship, and funding needed to launch successful start-ups. Additionally, integrating entrepreneurship curricula into university programmes can equip students with the knowledge and skills required to pursue entrepreneurial careers, fostering a culture of innovation from an early stage.

6.6. Enhancing data sophistication for better RTDI policy monitoring and evaluation

6.6.1. Lessons learned from the evaluation

The Study on the monitoring data on ERDF and Cohesion Fund operations, and on the monitoring systems operated in the 2014-2020 period has collated and standardised beneficiary data from regional and national systems, revealing significant gaps in data completeness across nearly all Member States. To ensure more effective policy design and implementation that addresses the needs of various RTDI actors, it is essential to identify companies that benefit indirectly through financial institutions or other intermediaries. This information is vital for understanding the impact of policy decisions and ensuring transparency and accountability. **The evaluation highlights that access to microdata on end beneficiaries, particularly those benefiting from financial instruments, is significantly limited.** Financial institutions frequently act as intermediaries, making it challenging to identify ultimate beneficiaries due to confidentiality concerns and the intricate nature of financial transactions. However, progress has been made with the ERDF regulations for the 2021-2027 period. Regulation (EU) 2021/1060 now requires Managing Authorities (MAs) to inform beneficiaries about data publication (Article 49) and to collect data on the final recipients of financial instruments within their monitoring systems. It is essential that this data is made available to evaluators.

The evaluation study demonstrates that the utilisation of AI-based techniques, such as word embedding and approximate string matching, represents a pioneering approach for evaluating funding synergies and the impact of RTDI investments. AI-enabled tools offer significant advantages in terms of rapid processing, verification, and analysis of both quantitative and qualitative data, including textual information. To illustrate, this study employed sophisticated methodologies based on Large Language Models (LLMs), which are designed to analyse unstructured data (see Section 4.4.4). LLMs, which leverage deep learning and are trained on extensive datasets, act as knowledge repositories by drawing from diverse sources like websites, publications, and news articles. This approach helps in identifying meaningful patterns at a group level, providing more reliable findings compared to individual-level analysis. However, it is important to exercise caution when interpreting results from AI-supported analysis, as this methodology is relatively new and not widely used in similar evaluations.

6.6.2. Future considerations

The key policy considerations regarding **enhancing data sophistication for better RTDI policy monitoring and evaluation**, are as follows:

- **Enhance evaluators' access to data on indirect beneficiaries of financial instruments to ensure greater transparency and accountability in assessing the impact of financial instruments.** Making this data readily available to evaluators is vital for accurate impact assessments and effective policy evaluations.
- **Further develop and test AI-enhanced tools to ensure the accuracy and reliability of these advanced analytical techniques before they are widely adopted.** The evaluation study highlights the need to exercise caution when approaching AI-supported findings due to their novelty and limited application in similar evaluations. It is crucial to conduct rigorous testing and validation to guarantee the precision and dependability of AI-supported tools.
- **Record unique identifiers, such as VAT registration or the Participation Identification Code.** To enhance the monitoring and assessment of beneficiary enterprises, it would be beneficial to record unique identifiers, such as those pertaining to VAT registration**.** Given that all businesses are already in possession of a VAT IDs, utilising these codes can lead to greater consistency in data and facilitate integration and comparison across a range of sources. This method eliminates the need for additional bureaucracy, providing an efficient and effective solution for improving data tracking and evaluation. Complementary to that, the PIC (Participant Identification Code), which is used in the centrally-managed EU programmes could be collected on a voluntary basis. This would enable better comparability and integration of funding datasets from different origins.
- **Use online platforms (dashboards) to improve the collection and management of data.** By implementing robust digital systems for data collection, it may be feasible to track RTDI beneficiaries in real time. Such systems can accurately capture data on the implemented measures and their outcomes. For instance, an integrated digital platform where RTDI beneficiaries register and report their fund usage can provide valuable insights. This platform can be designed to ensure data privacy while allowing policymakers to access aggregated data for analysis, similar to the French Tech ecosystem.[218]

[218] For reference, see: Dashboard | La French Tech ecosystem map

ANNEXES

Annex I. Evaluation matrix

Annex I.1. Effectiveness

Sub-questions	Indicators / Descriptors	Judgement criteria	Methodological tools and tasks
EQ 1. What were the intended and potentially unintended effects of different policy interventions and their combination?			
EQ 1.1. To what extent and according to which timeline were activities completed? To what extent did the policy interventions trigger the intended number of activities?	› Number of individual operations › Number of beneficiaries › Combined financial volume of individual operations › Additional qualitative information from MAs and stakeholders	The number of activities, beneficiaries and the financial volume used have been in line with targets/expectations	Tasks 1 & 3 ›Documentary analysis ›Descriptive statistical analysis ›Semi-structured interviews with MAs and stakeholders
EQ 1.2. To what extent did the funded activities lead to intended outputs?	› Number and volume of outputs specific to each policy instrument › Additional qualitative information from MAs and stakeholders	The number and quality of outputs have been in line with targets/expectations	Tasks 1 & 3 › Documentary analysis › Descriptive statistical analysis › Semi-structured interviews with MAs and stakeholders
EQ 1.3. To what extent have the activities led to the intended effects? (overlap with question 2.1)	› Outcome/ impact indicators specific to policy instruments, using e.g. Regional Innovation Scoreboard (RIS) and relevant Eurostat data ›Additional qualitative information from MAs and stakeholders	The number and quality of outcomes and impacts have been in line with targets/ expectations	Descriptive statistical analysis (tasks 1 & 3) Literature review (task 2) Semi-structured interviews with MAs and stakeholders (tasks 1 & 3)
EQ 1.4. Were there any unintended effects of the funded activities?	Qualitative information from MAs and stakeholders	The activities have led to effects (positive or negative) that were not part of the original 'idea'	Literature review (task 2) Semi-structured interviews with MAs and stakeholders (task 3)

EQ 2. To what extent were the objectives achieved?

EQ 2.1. What is the progress towards the programme objectives? (overlap with question 1.2)	›Quantitative measurement of progress using e.g. Regional Innovation Scoreboard (RIS) and relevant Eurostat data ›Additional qualitative information from MAs and stakeholders	Progress towards objectives has been in line with targets	Tasks 1& 3: ›Descriptive statistical analysis ›Documentary analysis ›Semi-structured interviews with MAs and stakeholders
EQ 2.2. To what extent can this progress be attributed to the ERDF support?	›Level of correlation between relevant ERDF investments and advancements towards objectives ›Additional qualitative information from MAs and stakeholders	The progress can, to a significant degree, be attributed to the ERDF support	Tasks 1& 3: ›Descriptive statistical analysis ›Semi-structured interviews with MAs and stakeholders

EQ 3. To what extent was the ERDF support delivered as planned? What were the main bottlenecks which may have reduced its overall effectiveness? How and to what extent did State Aid legislation impact the RTDI investments?

EQ 3.1. To what extent was the ERDF support delivered as planned?	Covered by questions 1.1, 1.2, 1.3, 1.4, 2.1, 2.2		
EQ 3.2. What were the main bottlenecks which may have reduced its overall effectiveness?	Existence and degree of, e.g.: • administrative burdens/problems, • challenges in providing matching funding, • conflicting incentives • competing initiatives • shortage of skills/personnel • shortage of materials • lack of interaction between stakeholders o highly regulated and complex markets Additional qualitative information from MAs and stakeholders	The respective factors had a significant (negative) impact on effectiveness	Tasks 1& 3: ›Documentary analysis ›Semi-structured interviews with MAs and stakeholders
EQ 3.3. How and to what extent did State Aid legislation impact the RTDI investments?	›Existence of conflicting State Aid legislation ›Degree of impact of State Aid legislation ›Additional qualitative information from MAs and stakeholders	State Aid legislation constituted a significant obstacle to RTDI investments	Tasks 1 & 3: ›Documentary analysis ›Semi-structured interviews with MAs and stakeholders

EQ 4. To what extent did ERDF support contribute to reduction of disparities between the levels of development of the various regions?			
EQ 4.1 Has ERDF support overall made relevant regions (who have used ERDF to support RTDI) more competitive in the RTDI field?	›Improvement of scoring of relevant regions in Regional Innovation Scoreboard ›Additional qualitative information from MAs and stakeholders and experts	Relevant regions have been able to catch-up/ narrow the gap with leading regions	Descriptive statistical analysis (tasks 1 & 3) Literature review (task 2) Semi-structured interviews with MAs and stakeholders (tasks 1 & 3)

Annex I.2. Efficiency

Sub-questions	Indicators / Descriptors	Judgement criteria	Methodological tools and tasks
EQ 5: What are the underlying factors and drivers which influence the implementation of the ERDF support?			
EQ 5.1. What are the contextual factors and drivers which influence the implementation of the ERDF support for RTDI investments?	›Evolution of R&D public expenditure as a percentage of GDP ›Contextual factors: description of national/regional policy strategies encouraging RTDI investments	The design and allocation of resources to RTDI investments was positively or negatively influenced by contextual factors (e.g., availability of national/regional framework for RTDI investments)	Descriptive statistical analysis (tasks 1 & 3) Literature review (task 2) Semi-structured interviews with MAs (tasks 1 & 3)
EQ 5.2. What are the programme-specific factors and drivers which influence the implementation of the ERDF support for RTDI investments?	›Administrative and managerial capacities of both programme managers and beneficiaries (e.g., previous experience with different types of RTDI investments, familiarity with procedures, et.) › Time and resources needed to select the investment (unit cost) by type of policy instrument assessed	› The design and allocation of resources to RTDI investments was positively or negatively influenced by programme specific factors. › The efficiency of the procurement processes. ›The level of technical expertise within the competent authorities. › The lack of experiences among programme managers/beneficiaries.	Literature review (task 2) Semi-structured interviews with MAs (tasks 1&3) Case studies (task 3)
EQ 5.3 Was the scale of funding such as to make a difference?	›Description of scale of support on the main policy instruments ›Relation of scale of support and degree of achievements	The funding provided by the policy instruments was such that it enabled sufficient concentration	›Documentary review (task 1 & 3) ›Literature review (task 2) ›Semi-structured interviews with MAs (tasks 1 & 3)

EQ 5.4 Were possible synergies and scale effects with other funding sources sufficiently exploited?	›Description of other existing funding sources ›Qualitative assessment of the synergies or duplication/overlapping with other sources	The funding provided by the policy instruments was such that it enabled exploited synergies avoiding overlapping and duplication	›Documentary review (task 1 & 3) ›Literature review (task 2) ›Semi-structured interviews with MAs (tasks 1 & 3)

EQ 6: Which inefficiencies and obstacles have been identified and how were they addressed?

EQ 6.1. Which inefficiencies and obstacles were faced as part of the implementation of the policy instruments?	› Comparative overview of enforcement costs by policy instrument, structured by phase and stakeholder: e.g., enforcement costs at tendering phase (for MA/ for applicants); enforcement costs at monitoring and reporting phase (for MA/for beneficiaries/for fund managers); etc.	Obstacles hindering the efficient programme implementation with regard to RTDI objectives have been identified	›Documentary review (task 1 & 3) ›Literature review (task 2) ›Semi-structured interviews with MAs and relevant stakeholders (tasks 1 & 3) ›Case studies (task 3)
EQ 6.2. How were inefficiencies and obstacles addressed?	›Description of most burdensome enforcement costs in the perception of relevant stakeholders. ›Description of methods to overcome inefficiencies and obstacles.	Different approaches were put in place by MAs and relevant stakeholders to mitigate excessive enforcement costs, inefficiencies, and obstacles. The different approaches had different degrees of success.	›Semi-structured interviews with MAs and relevant stakeholders (tasks 1 & 3) ›Case studies (task 3)

EQ7: What were the results of RTDI support through financial instruments as compared to grants?

EQ 7.1. How does the benefits/costs ratio differ between policy instruments?	›Comparative overview of benefits and costs by policy instrument. ›Systematic mapping of individual benefits and costs	The different types of policy instruments have different benefit/cost ratios.	›Documentary analysis (tasks 1, 2 & 3) ›Semi-structured interviews with MAs, stakeholders, and beneficiaries (tasks 1 & 3)
EQ 7.2. What were the results of RTDI support through financial instruments as compared to grants?	›Comparative overview of benefits and costs ›Comparative overview of enforcement costs ›Comparative overview of individual benefits and costs	Grants and financial instruments have different benefit/cost ratios	›Case studies (task 3)

EQ 8: Under which circumstances did policy instruments work best in addressing the needs of the target groups?

N/A	› Description of circumstances under which policy instruments are implemented: contextual and programme-specific influencing factors (EQ5), as well as inefficiencies, obstacles, and solutions (EQ6). › Benefits generated by policy instruments (EQ7).	Needs of target groups are translated into expected benefits. Different policy instruments are comparatively assessed by comparing these individual benefits	›Documentary analysis (tasks 1, 2 & 3) ›Semi-structured interviews with MAs, stakeholders, and beneficiaries (tasks 1 & 3)

	› Description of extent to which the policy instruments have been effective in addressing the needs of the target groups (through synoptic tables comparing whether different policy instruments achieved individual benefits that represented needs for the target groups).	(considering the different circumstances as well as the durability of effects).	›Case studies (task 3)

Annex I.3. Relevance

Sub-questions	Indicators / Descriptors	Judgement criteria	Methodological tools and tasks
EQ 9. How relevant were the investments made under the ERDF to achieve the investment in growth and jobs objective?			
N/A	›Evaluation of the mechanisms through which ERDF support promoted growth and job's objective ›Analysis of the improved competitiveness of organisations that received support ›Analysis of how ERDF support adapted to the technological and scientific progress throughout the programming period	›Number of jobs created through ERDF support. ›Improved ranking of universities that received support compared to those who did not. ›Growing number of private investments into R&I by SMEs and other companies. ›Higher academic and research output.	›Descriptive statistical analysis (tasks 1 & 3) ›Documentary analysis (tasks 1 & 3) ›Literature review (task 2) ›Case studies (task 3)
EQ 10. How did the COVID crisis impact the relevance, focus, planning and range of ERDF support?			
N/A	Comparative analysis and quantitative overview of the changes in RTDI support before and after the COVID-19 crisis started, based on Context Mechanism-Outcome (CMO) hypotheses	›Extent to which ERDF RTDI support tackled the new challenges posed by COVID-19. ›Shift in investments in terms of the types of beneficiaries and types of projects supported	›Descriptive statistical analysis (tasks 1 & 3) ›Documentary analysis (tasks 1 & 3) › Literature review (task 2) ›Case studies (task 3) ›Counterfactual analysis (task 3)
EQ 11. To what extent were the investments made under the ERDF in line with the national/regional smart specialisation strategies?			

N/A	Analysis of correspondence between ERDF RTDI investments and regional priority area	Extent to which ERDF RTDI support (number of projects & budget) is linked to regional priority areas	›Descriptive statistical analysis - link to S3 Priority Database (task 1 & 3) ›Documentary analysis (task 1 & 3) ›Literature review (task 2) ›Semi-structured interviews with MAs (task 3) ›Case studies (task 3)

Annex I.4. Coherence

Sub-questions	Indicators / Descriptors	Judgement criteria	Methodological tools and tasks
EQ 12. How did the ERDF funding fit into the national policy mix (type of support institutions, forms of support, type, and size of supported beneficiaries) of EU Member States?			
N/A	›Description of total portfolio of investment in the policy instrument and how they fit into policy mixes of MS ›Needs analysis at MS level linking to priorities at the national / regional level mix	›Identification of needs addressed through ERDF ›To what extent ERDF supported existing initiatives (e.g., initiatives supported through national funding) and to what extent it supports new ones ›To what extent relevant framework conditions of the 2014- 2020 regulatory base (e.g., ex ante conditionalities, horizontal principles or relevant Country Specific Recommendations) play in selecting projects	Task 1: ›Descriptive statistical analysis ›Documentary analysis ›Semi-structured interviews with MAs and beneficiaries Literature review (task 2)
EQ 13. To what extent was ERDF support coherent with other EU interventions having similar objectives (overlaps, complementarities) and in particular with Horizon 2020?			
N/A	›Identification of thematic overlaps of ERDF support with support from other sources. ›Analysis of synergies and complementarities existing between ERDF and other EU interventions	›Number of linkages between ERDF supported RTDI projects and projects supported through other means ›The extent to which thematic focus of ERDF support matches support through other means in different EU regions.	›Documentary analysis (task 1 & 3) ›Literature review (task 2) Task 3: › Data and text mining

		›The number of ERDF participants who are participating in projects financed	› Semi-structured interviews with MAs, EU policy officers for RTDI support and other stakeholders › Case studies

Annex I.5. EU added value

Sub-questions	Indicators / Descriptors	Judgement criteria	Methodological tools and tasks
EQ 14. What is the additional value resulting from the ERDF intervention compared to what could have been reasonably achieved by Member States acting at national and regional level?			
N/A	› Volume of ERDF investments used to support RTDI, compared to amount that was invested/ could have been invested without › Additional qualitative information from MAs and stakeholders	The ERDF support allowed the region to significantly increase the investments	Tasks 1 & 3: ›Documentary analysis ›Semi-structured interviews with MAs and stakeholders ›Seminar
EQ 15. To what extent would the objectives of the policy have been pursued in the absence of ERDF support?			
N/A	Qualitative information from MAs and stakeholders	Extent to which the objectives would have been pursued in the absence of ERDF support	›Semi-structured interviews with MAs and stakeholders (task 3)

Annex II. List of the sample of 57 Operational Programmes

The following Table presents the full list of OPs reviewed in the Task 1. The list of OPs is ranked (from the highest to the smallest) by the total volume of funding allocated to RTDI measures, i.e., in the 11 FoIs in scope.

Table 6. List of the sample of 57 OPs

	CCI	MS	Programme Title	Territorial scope	Total funds allocated to RTDI	Of which provided by ERDF		
1	2014PL16RFOP001	PL	Smart growth - PL - ERDF	National	13,290,194,471	11,229,853,253	18.05%	87.03%
2	2014ES16RFOP002	ES	Multi-regional Spain - ERDF	National	5,506,360,512	3,572,750,690	7.48%	30.50%
3	2014PT16M3OP001	PT	Competitiveness and Internationalisation - PT - ERDF/ESF/CF	National	5,295,422,313	3,491,738,744	7.19%	46.16%
4	2014CZ16RFOP001	CZ	Enterprise and Innovation for Competitiveness - CZ - ERDF	National	3,634,021,735	1,744,330,434	4.94%	41.49%
5	2014HU16M0OP001	HU	Economic Development and Innovation Programme - HU - ERDF/ESF/YEI	National	2,208,403,519	1,911,466,603	3.00%	28.95%
6	2014SK16M1OP001	SK	Integrated Infrastructure - SK - ERDF/CF	National	1,806,972,140	1,058,985,365	2.45%	34.43%
7	2014UK16RFOP001	UK	England - ERDF	Regional	1,457,304,417	821,688,831	1.98%	20.46%
8	2014CZ05M2OP001	CZ	Research Development and Education - CZ - ESF/ERDF	National	1,443,356,530	1,137,229,532	1.96%	66.02%

	CCI	MS	Programme Title	Territorial scope	Total funds allocated to RTDI	Of which provided by ERDF		
9	2014RO16RFOP001	RO	Competitiveness Programme - RO – ERDF	National	1,252,740,239	1,046,988,192	1.70%	32.21%
10	2014DE16RFOP012	DE	Sachsen – ERDF	Regional	1,248,392,248	998,713,799	1.70%	46.34%
11	2014DE16RFOP009	DE	Nordrhein-Westfalen - ERDF	Regional	1,210,030,846	615,903,107	1.64%	42.04%
12	2014HR16M1OP001	HR	Competitiveness and Cohesion - HR - ERDF/CF	National	1,195,250,755	1,024,330,940	1.62%	16.60%
13	2014LT16MAOP001	LT	EU Structural Funds Investments - LT - ERDF/ESF/CF/YEI	National	1,124,699,779	982,210,358	1.53%	19.79%
14	2014SI16MAOP001	SI	EU Cohesion Policy - SI - ERDF/ESF/CF/YEI	National	1,111,411,830	889,993,454	1.51%	36.11%
15	2014EE16M3OP001	EE	Cohesion Policy Funding - EE - ERDF/ESF/CF	National	1,066,652,247	721,648,802	1.45%	36.17%
16	2014IT16M2OP005	IT	Research and Innovation - IT - ERDF/ESF	National	1,064,486,591	830,626,665	1.45%	91.97%
17	2014GR16M2OP001	GR	Competitiveness Entrepreneurship and Innovation - GR - ERDF/ESF	National	1,033,589,315	816,608,551	1.40%	9.73%
18	2014AT16RFOP001	AT	Investments in Growth and Employment - AT - ERDF	National	881,973,208	287,665,363	1.20%	26.53%
19	2014DE16RFOP013	DE	Sachsen-Anhalt - ERDF	Regional	734,967,291	590,134,539	1.00%	37.49%
20	2014PT16M2OP001	PT	Norte - ERDF/ESF	Regional	710,150,367	556,154,823	0.96%	14.67%

	CCI	MS	Programme Title	Territorial scope	Total funds allocated to RTDI	Of which provided by ERDF		
21	2014FI16M2OP001	FI	Sustainable growth and jobs - FI - ERDF/ESF	National	694,612,190	351,181,229	0.94%	35.23%
22	2014LV16MAOP001	LV	Growth and Employment - LV - ERDF/ESF/CF/YEI	National	693,435,882	594,243,503	0.94%	19.26%
23	2014IT16RFOP014	IT	Piemonte - ERDF	Regional	685,388,807	342,694,404	0.93%	40.28%
24	2014PL16RFOP003	PL	Development of Eastern Poland - ERDF	Regional	661,871,477	562,590,755	0.90%	26.87%
25	2014DE16RFOP015	DE	Thüringen - ERDF	Regional	653,609,141	536,077,690	0.89%	32.20%
26	2014UK16RFOP005	UK	West Wales and The Valleys - ERDF	Regional	624,868,062	420,379,132	0.85%	31.19%
27	2014PL16M2OP012	PL	Śląskie Voivodeship - ERDF/ESF	Regional	619,654,790	528,193,170	0.84%	18.88%
28	2014PT16M2OP005	PT	Lisboa - ERDF/ESF	Regional	615,931,899	287,610,511	0.84%	40.07%
29	2014NL16RFOP002	NL	West Netherlands - ERDF	Regional	502,859,192	207,875,012	0.68%	61.48%
30	2014DE16RFOP004	DE	Brandenburg - ERDF	Regional	494,273,753	395,419,004	0.67%	41.03%
31	2014DE16RFOP003	DE	Berlin – ERDF	Regional	493,421,645	246,710,824	0.67%	33.48%
32	2014ES16RFOP011	ES	Cataluña - ERDF	Regional	428,353,845	214,176,923	0.58%	14.28%
33	2014IT16M2OP002	IT	Puglia - ERDF/ESF	Regional	427,355,600	341,884,479	0.58%	9.51%
34	2014FR16M0OP012	FR	Nord-Pas de Calais - ERDF/ESF/YEI	Regional	398,761,449	220,841,702	0.54%	20.64%

	CCI	MS	Programme Title	Territorial scope	Total funds allocated to RTDI	Of which provided by ERDF		
35	2014IT16RFOP003	IT	Enterprises and Competitiveness - IT - ERDF	National	391,124,157	277,852,944	0.53%	8.32%
36	2014IT16RFOP012	IT	Lombardia - ERDF	Regional	362,737,211	181,368,605	0.49%	43.77%
37	2014ES16RFOP015	ES	Galicia - ERDF	Regional	355,881,377	285,105,101	0.48%	19.04%
38	2014FR16M2OP008	FR	Pays de la Loire - ERDF/ESF	Regional	328,529,121	154,970,147	0.45%	36.24%
39	2014PL16M2OP007	PL	Mazowieckie Voivodeship - ERDF/ESF	Regional	321,159,679	256,927,745	0.44%	16.26%
40	2014BE16RFOP002	BE	Flanders - ERDF	Regional	295,022,458	145,669,942	0.40%	55.42%
41	2014FR16M2OP011	FR	Guyane - ERDF/ESF	Regional	285,652,326	168,534,872	0.39%	32.10%
42	2014ES16RFOP009	ES	Castilla y León - ERDF	Regional	277,844,494	138,922,246	0.38%	33.31%
43	2014BG05M2OP001	BG	Science and Education for Smart Growth - BG - ESF/ERDF	National	219,987,308	186,989,212	0.30%	100.00%
44	2014FR16M2OP010	FR	Rhône-Alpes - ERDF/ESF	Regional	219,087,795	110,440,274	0.30%	19.78%
45	2014PL16M2OP006	PL	Małopolskie Voivodeship - ERDF/ESF	Regional	217,181,396	184,604,186	0.29%	8.21%
46	2014FR16M2OP003	FR	Bretagne - ERDF/ESF	Regional	215,157,592	76,079,020	0.29%	30.26%
47	2014DK16RFOP001	DK	Innovation and Sustainable Growth in Businesses - DK - ERDF	National	207,917,446	107,362,398	0.28%	27.25%

	CCI	MS	Programme Title	Territorial scope	Total funds allocated to RTDI	Of which provided by ERDF		
48	2014FR16M0OP008	FR	Picardie - ERDF/ESF/YEI	Regional	198,570,641	96,395,517	0.27%	20.79%
49	2014IT16RFOP010	IT	Lazio – ERDF	Regional	178,581,171	89,290,586	0.24%	19.24%
50	2014CY16M1OP001	CY	Competitiveness and sustainable development - CY - ERDF/CF	National	164,043,197	139,436,715	0.22%	32.16%
51	2014IT16RFOP008	IT	Emilia-Romagna - ERDF	Regional	151,462,490	75,731,244	0.21%	17.88%
52	2014SE16RFOP009	SE	National fund for investments in growth and jobs - ERDF	National	102,014,293	69,421,693	0.14%	29.54%
53	2014ES16RFOP016	ES	La Rioja - ERDF	Regional	63,340,611	31,670,306	0.09%	39.00%
54	2014MT16M1OP001	MT	Fostering a competitive and sustainable economy - MT - ERDF/CF	National	62,758,236	50,206,589	0.09%	14.61%
55	2014GR16M2OP002	GR	Central Macedonia - ERDF/ESF	Regional	60,399,027	48,319,222	0.08%	4.91%
56	2014IE16RFOP002	IE	Southern & Eastern Regional Programme - IE - ERDF	Regional	44,907,492	22,453,746	0.06%	10.13%
57	2014LU16RFOP001	LU	Luxembourg - ERDF	National	24,183,851	9,673,541	0.03%	19.65%

Source: Prognos / CSIL / Visionary Analytics (2023), based on extractions from CohesionData (data as of March 2023).

Annex III. Taxonomy of policy instruments: methodology and detailed overview

The following section presents a taxonomy of policy instruments, accompanied by a methodology and a more detailed overview of the instruments in question.

The identification of ERDF policy instruments supporting RTDI in the 2014-2020 occurred through a combination of a top-down and bottom-up approach. It relied both on an in-depth analysis of ERDF expenditure data and insights from literature reviews. Specifically, the following steps were undertaken to identify the policy instruments:

1. **A preliminary literature review** (at the inception phase) informed on the types of interventions that can support RTDI, their rationale, expected types of direct and end beneficiaries and mechanisms of effectiveness.

2. **Extraction of the full list of operations and exploration.** Operations were extracted from the Single Database developed by Work Package 2 – Preparatory Study (2014-2020). The list of 11 FoIs – covered by this evaluation - was the starting point to identify the relevant operations. No other selection criteria have been set, e.g., in terms of Thematic Objective. After having extracted the full list of operations corresponding to the 11 FoI in scope (97,802 operations were initially identified), the study team started exploring the database, examining the different variables, and studying how the information included in the database could help identify coherent policy instruments. To this end, the study team reviewed samples of operations in different countries and with different FoI. As the operations data of OPs and MS were progressively reviewed, the study team refined the taxonomy of policy instruments presented in the inception report. At the inception stage, the team had relied on its knowledge of the literature and on previous experience. Thanks to this exploration, the study team was able to better specify the characteristics of the policy instruments considering the initiatives that were funded. It was an iterative approach aimed at ensuring coherence in the way policy instruments were defined across different OPs and MS.

   First-level review of the extracted database of ERDF operations and their attribution to a list of coherent policy instruments. Once the policy instruments were better defined, the study team assigned all the operations in the WP2 Single Database to one or more of the whole set of policy instruments. This initial clustering exercise was carried out in a semi-automated way, considering the Specific Objective, the title of the OP measure/action or call for proposals under which the operations are financed, the FoI and the types of beneficiaries. In some cases, when the variables mentioned above were not informative enough, the study team looked at the operations' titles and descriptions. In this first review, the study team tended to assign the operations falling under the same measure or, if available, call to the same policy instrument as the funding rationale is expected to be similar. Whilst the exercise constitutes only a basis for the following steps, it was useful to i) verify that the policy instruments are broad enough to encompass operations from different OPs and MS; ii) improve the description of the policy instruments and of the types of activities included; iii) highlight possible overlapping between policy instruments; and iv) identify operations that fit only in a very limited way under any of the policy instruments. During this review, the study team verified whether any policy instrument should have been disaggregated or, vice versa, merged into a single one

considering the number of operations classified under each of them, the intervention priority, the beneficiaries, and the ToC that were being defined based on the literature review. As a result, it was decided to merge the initial policy instruments on infrastructure investments for education and on infrastructure investments for ICT under the policy instrument on infrastructure investments for research. In most cases, indeed, the investments for the first two categories were hardly distinguishable from the third category and they would be better described as pathways of the same policy instrument.

3. **Check the coherence between the typologies of policy instruments identified under other Work Packages**. This step was aimed at identifying potential overlaps and defining clear boundaries between the policy instruments funded during the 2014-2020 programming period under different policy objectives (and, therefore under other Work Packages). This check was conducted with the team working on Work Packages that include operations supporting SMEs (Work Package 6 - SME), the uptake of Information and Communication technologies (Work Package 5 – ICT), and the protection of the environment (Work Package 7 – Climate and environment) considering the higher risk for overlaps[219]. As a result of this exchange, refinements were made to the initial list of identified operations.[220]

4. **Second-level review and fine-tuning the list of operations in scope.** The study team carried out manual checks of operations with a view to fine-tuning the classification of policy instruments. The preliminary clustering of the entire database of operations was reconsidered also in the light of a more complete reading of the title and description of operations (when available), the type of beneficiaries, and the monitoring indicators attached to operations. After this review and previous steps, the study team found that the evaluation encompassed a database of **95,237 operations**, concentrating an allocation of **EUR 66.2 billion** of total eligible expenditure. Of this, 90% was classified under TO1 “Strengthening research, technological development and innovation. The remaining funds were distributed primarily under TO3 “Enhancing the competitiveness of small and medium sized enterprises” while for a minority of share under, TO4 “Supporting the shift towards a low-carbon economy in all sectors”, TO2 “Enhancing access to, and use and quality of, information and communication technologies”, TO6 “Preserving and protecting the environment and promoting resource efficiency”, TO8 “Promoting sustainable and quality employment and supporting labour mobility”, TO9 Promoting social inclusion, combating poverty, and any discrimination, T011 Enhancing institutional capacity of public authorities and stakeholders and efficient public administration and TO12 technical assistance. This database covers all MS + UK, for a total of 211

[219] As reported by the Preparatory Study – the WP2 found that the classification of expenditure across FoIs and TOs made by the Managing Authorities is somehow discretional and may be subject to different interpretations. See the “Report on the clustering of operations and beneficiaries“: https://ec.europa.eu/regional_policy/en/policy/evaluations/ec/2014-2020/#2

[220] 3,396 operations under other FoIs were added as they were specifically addressed to support RTDI. 2,453 operations funded by the OP “Saxony” were added. These operations were not associated to any FoI. However, the priority axis and the name of the measure under which they are funded were clearly RTDI related. 37 operations funded by the OP “West Wales and the Valleys” were added. These operations were classified under the relevant FoI but the WP2 Single Database did not include them. 8,541 operations - amounting to EUR 3. 979 billion of expenditure (of which EUR 1.9 billion provided by the EU contribution) were identified as out of scope as they do not concern RTDI activities despite having a relevant FoI. These operations mainly concerned support measures for the internationalisation of SMEs, support measures to help SMEs face the COVID-19 crisis, generic financial support for SMEs that is not RTDI related.

programmes (167 national and regional programmes and 44 programmes for territorial cooperation).[221]

5. **Extensive literature review of policy instruments (Task 2)**. Findings from literature review carried out under Task 2 were used to better characterise each policy instrument in terms of their Theory of Change. This richer review was conducted in parallel to the second-level review and contributed to the fine-tuning of the taxonomy of policy instruments, their definition and, hence their attribution to particular operations.

6. **Check and validation by the country experts**. The study team shared with the country experts the list of operations for the OPs under their responsibility and asked them to check the attribution of operations into policy instrument. The country experts carried out manual checks, considering the specific logic of the measures and calls of the OPs. To facilitate this process, the checks concentrated on the operations funded by the OPs that were in the sample for the OP review (Task 1)[222]. Following the feedback from the country experts, the study team fine-tuned the classification of operations and identify potential common mistakes / misclassifications.

The table below offers a more comprehensive description of the identified policy instruments. Their theory of change has been reconstructed in the First Intermediate Report of the study and further enriched and tested in the policy instrument case studies (Second Intermediate Report).

Table 7. Overview of the ERDF policy instruments: activities funded and expected outcomes

Policy instrument for each policy goal	Typical activities funded	Expected outcomes
Infrastructure investments for research (PI1)		
Increase the ability of research institutions to conduct high level research	Construction, upgrading or modernisation of infrastructures/facilities to carry out research activities, such as: (i) Construction / upgrading of laboratories or other buildings for research purposes (ii) Construction, upgrading or modernisation of research infrastructures included in the ESFRI or national roadmaps (iii) Construction, upgrading or modernisation of centres of excellence(iv) Construction or upgrading of ICT-based infrastructures (e.g., Data centres) Purchase of equipment for research such as lab instruments, machinery, or highly specialised apparatus.	*IMMEDIATE* ✓ New and modernised spaces are available for education ✓ Capacity to use, store and make available data and IT tools is enhanced ✓ Research operating standards are enhanced ✓ Facilities and equipment to conduct research are created or upgraded *INTERMEDIATE* ✓ Moved and better qualified/ motivated students and researchers are attracted ✓ Scientific publications increase in number and quality ✓ Conferences and dissemination activities increase ✓ International research networks are enlarged and improved *IMPACT* ✓ Technological development in critical areas is improved ✓ Spin-offs are generated and patents are filed

[221] The categorisation data available on the Cohesion Data Platform shows that, as of the end of 2023, A total of 229 programmes (174 national and regional and 55 territorial cooperation programmes), allocated expenditure to support RTDI.

[222] Task 1 entailed the in-depth review of 57 OPs which altogether covered EUR 60 billion of total allocation for RTDI interventions (82% of the total), and EUR 43 billion of ERDF funds for RTDI (84% of the total).

		✓ Research innovation ecosystems grow and expand
Infrastructure investments for technology transfer and innovation (PI2)		
Increase the ability of enterprises to develop innovative projects	Construction, upgrading or modernisation of infrastructures/facilities such as competence centres, science and technology parks, incubators, technology transfer organisations	*IMMEDIATE* ✓ Improved physical spaces are available to organise networking and facilitate knowledge sharing ✓ Adequate physical spaces are available to improve the innovation skills of firms ✓ Low-cost and modern facilities and equipment to conduct test and validation are available for firms *INTERMEDIATE* ✓ More firms participate in knowledge exchange and technology transfer processes with HEI and research organisations ✓ Increase in number of patents Increased ability of enterprises to develop innovative products ✓ Increased attractiveness of the region for talents and investors *IMPACT* ✓ Likelihood of cooperation for innovation is improved ✓ Economic performance and innovative capabilities in the region are improved ✓ Research and innovation ecosystems grow and expand
Research activities in universities /research centres (PI3)		
Increase the research and technological capacity and competencies of the supported institutions in focal areas of research	✓ Early stage (foundational) and exploratory research activities in any field/sector or in a specific one. ✓ The research is led by universities and/or research centres and it may be of individual or collaborative nature. ✓ The support may also fund the purchase of equipment to be used in the project. However, this is a marginal part. ✓ The funding may be used to establish new research teams in a specific research field.	*IMMEDIATE* ✓ Enhanced scientific and technological capacity of researchers ✓ Developing new and increasing existing competences and skills in the scientific field of interest ✓ Increased number of employed researchers working on a scientific field ✓ Increase in public R&D expenditure ✓ Improved access to research infrastructure *INTERMEDIATE* ✓ New scientific and technological knowledge generated (follow-up projects, publications) ✓ Establishment of connections and networks among different researchers/ research institutions ✓ Increase in R&D activities *IMPACT* ✓ Increased research and technological capacity and competencies of the supported institutions in focal areas of research ✓ Intensified and more effective collaboration within the R&I ecosystem ✓ Increased investments in R&I activities ✓ Uptake of projects' results (follow-up patents)
Science – industry collaborative RTDI projects (PI4)		
Enhance the administrative, research and innovation capacity of the supported institutions	✓ Collaborative R&D projects carried out by consortia composed of research centres/universities, enterprises, public administrations etc. for technology transfer (e.g., co-creation activities). ✓ The projects can be led either by research centres/universities or by enterprises. ✓ Projects aimed to create platforms for data / information sharing are also in this policy instrument. ✓ Sometimes the collaborative projects under this PI target cluster participants.	*IMMEDIATE* ✓ Active knowledge exchange ✓ Formation of collaborative partnership ✓ Technological advancement and improved knowledge ✓ Prototype development and testing *INTERMEDIATE* ✓ Increased commercialisation of research outcomes ✓ Strengthened industry-academia relationships ✓ Economic and societal impacts ✓ Generating economic growth ✓ Job creation ✓ Establishment of new industries *IMPACT*

		✓ Enhanced, research and innovation capacity of the supported institutions and increased ability to participate in R&D collaborations ✓ Increased competitiveness and economic growth
Facilitate knowledge transfer capacities and mechanisms in the ecosystem	✓ Creation of RTDI ecosystems / clusters (bringing together skills and knowledge) to generate innovation in a specific field. ✓ Activities encouraging exchanges between research centres/universities and enterprises (e.g., conferences, workshops) ✓ Public procurement of innovative solutions ✓ Capacity building for IPR management ✓ Promotion of research infrastructure / activities of raising awareness	*IMMEDIATE* ✓ Innovation actors are in contact with new/ different partners ✓ New networks among different innovation actors emerge ✓ Enhanced networking among the different innovation actors ✓ Innovation actors from private/ public sector exchange/ receive new information ✓ Improved access to research infrastructure ✓ Innovation actors improve their skills & competencies ✓ Ensured critical mass to encourage R&D investment *INTERMEDIATE* ✓ Establishment of long-lasting connections and networks among different innovation actors ✓ Enhanced knowledge transfer capacities & mechanisms ✓ More individuals are seizing opportunities for starting a business ✓ Increases in start-ups and spin-off activities ✓ Enhanced knowledge transfer capacities and mechanisms *IMPACT* ✓ Intensified and more effective collaborations within the RTDI ecosystem ✓ New investment in technology, infrastructure, processes, and services ✓ Increased investments in R&D and innovation activities ✓ Improved innovative capacities of innovation actors
Increase the volume of investments in RTDI activities by private enterprises	✓ Industrial research and experimental development activities in any field/sector or in a specific one. ✓ The research aims at producing at least a prototype / validated prototype (TRL 6) to develop an innovative product/ service. ✓ Together with the research project, the support can be used to buy equipment to be used in the research project or to build laboratories / acquire equipment to be used by the enterprise for R&D. ✓ Support for innovative start-ups. ✓ The research is led by firms or groups of firms. It may be of individual nature or in collaboration with other firms. When research centres are involved, their role is in support of the business needs.	*IMMEDIATE* ✓ New investments ✓ Development of prototypes ✓ Development of industrially relevant and applicable results (e.g., new products and processes in specific fields and potentially further developed in / with companies) *INTERMEDIATE* ✓ Introduction of innovative processes in the firms and / or innovative products or services on the market ✓ Increased volume of investments in R&D and innovation activities by private enterprises *IMPACT* ✓ Increased turnover and added value ✓ New markets generated by the commercialisation of innovation products and services ✓ Increased patenting activity ✓ Increased company's competitiveness and resilience
Enhance the competitiveness of enterprises thanks to the	✓ Funding to support innovation processes in businesses. It comprises technology upgrade, process innovation, managerial	*IMMEDIATE* ✓ *New investments in tangibles undertaken* ✓ *New investments in intangibles/ license purchase undertaken*

commercialisation of innovative products/ services	and organisational innovation, and the commercialisation of innovative products. ✓ It may consist of: Purchase of tangible (e.g., new machinery and equipment, new production sites, etc.) and intangible assets (e.g., software), to modernise production processes (process or organisational innovation), and/or to introduce new products/services (product innovation, marketing innovation like e-commerce). T ✓ The purchase of assets is linked to R&D activities, already conducted or to be finalised – a prototype is already available. ✓ Innovation funds to bring highly innovative technologies to the market (commercial demonstration projects)	✓ *Companies introduce innovations* ✓ *Companies develop prototypes/ demonstrate pilots* *INTERMEDIATE* ✓ *Improved enterprises productivity* ✓ *Additionality effect – increased investments in R&D and innovation uptake Increased patenting activity* ✓ *Increased company's competitiveness and resilience* *IMPACT* ✓ *Enhanced regional and national competitiveness* ✓ *Enhanced TFP and GDP growth*
Capacity building for innovation in businesses (PI8)		
Enhance the businesses' innovation capacity	✓ Investments in capacity development including training and skills enhancement to introduce innovation in the company ✓ Purchase of consulting services for business plans, feasibility studies, etc. ✓ Financial support for enterprises to register IPR	*IMMEDIATE* ✓ Enterprises acquire new knowledge, skills, and competencies ✓ Enterprises have increased absorptive capacity *INTERMEDIATE* ✓ Companies introduce innovations ✓ Increased turnover Increased productivity (short run) ✓ Increased export volume *IMPACT* ✓ Increased productivity (long run) ✓ New investments in technology, infrastructure, processes, and services ✓ Increased patenting activities ✓ Enhanced national and international competitiveness of enterprises

Source: Prognos / CSIL / Visionary Analytics (2024).

Annex IV. Methodology of the data analysis tools

This Annex provides detailed descriptions of the different data analysis tools that were applied in this evaluation study. The different approaches and data sources as well as the respective limitations are discussed.

RTDI performance across EU regions

This section informs about the approach taken for the assessment of the baseline of the RTDI landscape (Section Baseline situation: Performance of regional innovation ecosystems across the EU in 2014) as well as its development over time (Section ERDF contribution to the convergence in innovation performance across EU regions) .Detailed overview of each of the nine RIS indicators, including their definitions, rationale, and data sources can be seen in the table below.

Table 8. Information on indicators

R&D expenditures in the public sector as percentage of GDP	
Numerator	All R&D expenditures in the government sector (GOVERD) and the higher education sector (HERD)
Denominator	Regional Gross Domestic Product
Rationale	R&D expenditure represents one of the major drivers of economic growth in a knowledge-based economy. Trends in the R&D expenditure indicator provide key indications of the future competitiveness and wealth of a region. R&D spending is essential for making the transition to a knowledge-based economy as well as for improving production technologies and stimulating growth
Data source	Eurostat, regional statistics
R&D expenditures in the business sector as percentage of GDP	
Numerator	All R&D expenditures in the business sector (BERD)
Denominator	Regional Gross Domestic Product
Rationale	The indicator captures the formal creation of new knowledge within firms. It is particularly important in the science-based sector (pharmaceuticals, chemicals and some areas of electronics), where most new knowledge is created in or near R&D laboratories
Data source	Eurostat, regional statistics
Innovation expenditures per person employed in innovative SMEs	
Numerator	Sum of total innovation expenditure by enterprises in all size classes in Purchasing Power Standards (PPS)
Denominator	Total employment in innovative enterprises SMEs
Rationale	The indicator measures the monetary input directly related to innovation activities.
Data source	Community Innovation Survey: Eurostat and National Statistical Offices
SMEs introducing product innovations as percentage of SMEs	
Numerator	Number of Small and medium-sized enterprises (SMEs) who introduced at least one product innovation. A product innovation is the market introduction of a new or significantly improved good or service with respect to its capabilities, user friendliness, components, or sub-systems
Denominator	Total number of SMEs
Rationale	Product innovation is a key ingredient to innovation as they can create new markers and improve competitiveness. Higher shares of product innovators reflect a higher level of innovation activities
Data source	Community Innovation Survey: Eurostat and National Statistical Offices
Innovative SMEs collaborating with others as percentage of SMEs	
Numerator	Number of SMEs with innovation co-operation activities. Firms with co-operation activities are those that have had any co-operation agreements on innovation activities with other enterprises or institutions
Denominator	Total number of SMEs
Rationale	This indicator measures the degree to which SMEs are involved in innovation co-operation. Complex innovations often depend on companies' ability to draw on diverse sources of information and knowledge, or to collaborate on the development of an innovation. The indicator measures the flow of knowledge between public research institutions and firms, and between firms and other firms. The indicator is limited to SMEs, because almost all large firms are involved in innovation co-operation
Data source	Community Innovation Survey: Eurostat and National Statistical Offices
Public-private co-publications per million population	

Numerator	Number of public-private co-authored research publications with both domestic and foreign collaborators. The definition of the "private sector" excludes the private medical and health sector
Denominator	Total population
Rationale	This indicator captures public-private research linkages and active collaboration activities between business sector researchers and public sector researchers resulting in academic publications
Data source	Numerator: Scopus. Data calculated by Science-Metrix as part of a contract to the EC Denominator: Eurostat
PCT patent applications per billion regional GDP	
Numerator	Number of patents applied for at the European Patent Office (EPO), by year of filing. The regional distribution of the patent applications is assigned according to the address of the inventor
Denominator	Gross Domestic Product in Purchasing Power Standard
Rationale	The capacity of firms to develop new products determines their competitive advantage. One indicator of the rate of new product innovation is the number of patent applications
Data source	Numerator: OECD, REGPAT. Denominator: Eurostat
Sales of new-to-market and new-to-firm product innovations in SMEs as percentage of turnover	
Numerator	Sum of total turnover of new or significantly improved products for SMEs
Denominator	Total turnover for SMEs
Rationale	This indicator measures the turnover of new or significantly improved products and includes both products which are only new to the firm and products which are also new to the market. The indicator thus captures both the creation of state-of-the-art technologies (new to market products) and the diffusion of these technologies (new to firm products)
Data source	Community Innovation Survey: Eurostat and National Statistical Offices
SMEs introducing business process innovations as percentage of SMEs	
Numerator	Number of Small and medium-sized enterprises (SMEs) who introduced at least one business process innovation either new to the enterprise or new to their market
Denominator	Total number of SMEs
Rationale	Many firms innovate not by improving new products but by improving their business processes. Business process innovations include process, marketing and organisational innovations.
Data source	Community Innovation Survey: Eurostat and National Statistical Offices

Source: Prognos / CSIL / Visionary Analytics (2024) based on Regional Innovation Scoreboard Methodology Report 2021.

Data Preparation

Regional Innovation Scoreboard

To be able to present RIS analysis in terms of cohesion regions, we assigned each region in RIS to less developed, transition or more developed group. The assignment was based on the original list of NUTS 2 regions eligible for ERDF funding.[223] As 47 out of 222 analysed regions in the RIS are at the NUTS 1 level and original assignment was only available at the NUTS 2 level, the following assignment rules were applied:

1) if all NUTS 2 regions that composed the corresponding NUTS 1 region were in the same cohesion group, this NUTS 1 region was assigned under the same cohesion group as the NUTS 2 regions. For instance, if AT21 and AT22 were more developed regions, then AT2 would also be assigned to a more developed group.

2) if NUTS 2 regions that composed the corresponding NUTS 1 region had different cohesion region labels, then the label to NUTS 1 region was assigned based on the population size of the regions. For instance, if AT11 was transition and AT12 and AT13 more developed regions, then AT1 would be assigned to more developed group due to the larger population size of AT12 and AT13 regions in comparison to AT11.

[223] The original list of regions that are eligible for ERDF funding can be found in the commission implementing decision of 18 February 2014 - EUR-Lex - 32014D0099 - EN - EUR-Lex (europa.eu).

Limitations

Regional Innovation Scoreboard

Due to the confidentiality of the Community Innovation Survey[224] data, on which a big part of RIS is based, not all raw indicators are available for the analysis. The following four indicators are available only as normalised scores: *innovation expenditures per person employed, SMEs introducing business process innovations, Innovative SMEs collaborating with others and sales of new-to-market and new-to-firm innovations*. On the one hand, working with normalised scores enables one-to-one comparison between the indicators. On the other, it hinders the ability to interpret the indicators directly. Fortunately, for the purposes of understanding the RTDI progress in the EU regions, normalised scores are sufficient.

Assessment of alignment of ERDF RTDI support with national/regional Smart Specialisation Strategies

This and the following sections give a description of the methodology of the assessment of the alignment of ERDF RTDI support with national/regional Smart Specialisation Strategies, the examination of publications linked to ERDF RTDI beneficiaries, the assessment of patenting activities from ERDF-funded publications and the analysis of Stairway to Excellence stimulus through ERDF RTDI support. For all different strands of analysis, the database containing operations and beneficiaries of the ERDF RTDI support of the 2014-2020 funding period plays a key role.[225]

In order to assess the extent to which investments made under the ERDF were in line with the national/regional smart specialisation strategies, the ERDF RTDI projects of the 2014-2020 period have to be linked to the Smart Specialisation Strategies of the respective regions. The methodology and the results of this assessment are described in the following paragraph.

To answer Evaluation Question 11 (“To what extent were the investments made under the ERDF in line with the national/regional Smart Specialisation Strategies?”) a matching approach was applied. This approach matched the ERDF RTDI projects of the 2014-2020 funding period (based on extractions from the WP2 Single Database of operations) with the priority areas of 185 Smart Specialisation Strategies of the different EU Member States and regions. The priority areas were collected in the “Study on prioritisation in Smart Specialisation Strategies in the EU” (Prognos & CSIL, 2021). This priority area database contains key information about the priority areas, including their description, as well as addressing overarching priority areas that were constructed in the Study on prioritisation in Smart Specialisation Strategies in the EU” (Prognos & CSIL, 2021) for the 185 EU Member States and Regions.

These two databases were matched following a word embedding approach (for more information on the word embedding technique see the box below). Thereby, the descriptions of the ERDF RTDI projects of the 2014-2020 funding period were matched with the descriptions of the respective S3 priority areas and their descriptions to see whether they are thematically aligned. The results of the word embedding matching process were then classified in order to ensure the quality of the matches. Thereby, the total similarity of the matching results was utilised for this step. The total similarity is a measure that informs about the degree to which the keywords in the description of an ERDF RTDI project are similar to the whole description of a S3 priority area. The value of this measure can (theoretically) range between 0 and 1 where a value of 1 means that the description of the

[224] See Community innovation survey - Microdata - Eurostat (europa.eu).

[225] See wp2_report_single_database_final.pdf (europa.eu) for the description of the Single Database.

ERDF RTDI project is identical to a S3 priority area. A value of 0 means that the description of the ERDF RTDI project and the description of the respective S3 priority do not show any thematic alignment at all.

Word Embedding

Word embeddings are a class of techniques in the field of natural language processing, where terms get transformed into a vector representation, which encodes the meaning of the word. Terms that are close to each other in vector spaces are expected to have a similar meaning. To calculate the distance between vectors there are different metrics. In the distance calculation for this study, the cosine similarity has been used. Pre-trained neural networks were used to implement the transformation process. These are provided as a package in Python and allow the use of the method without the need to train such a network.

Cosine Similarity

Cosine similarity is a measure used in the field of natural language processing (NLP) and machine learning to quantify the similarity between two vectors. This metric is particularly significant when applied to word embeddings. For example, in the context of word embeddings, the cosine similarity metric can be used to assess the semantic similarity between the words "king" and "queen". Despite these words being different, their embeddings might be positioned closely in the vector space due to their related semantic meanings, resulting in a high cosine similarity score.

Here, total similarity is used as the decisive instrument for determining a match between the ERDF RTDI projects (2014-2020) and the respective S3 priority areas. The examination of the distribution of total similarity indicated a distribution that closely resembled a normal distribution centered around a total similarity of 0.5. Consequently, only matches where an ERDF RTDI project shared a total similarity of 0.6 or above with a priority area were considered as matches. A more detailed analysis of the results further confirmed the validity of this approach. Correspondingly, linkages between ERDF RTDI projects and the priority areas with a lower total similarity led to a significantly decreasing thematical correspondence. For instance, the ERDF RTDI project “System for detection, quantification and diagnosis of high precision welding quality and reliability” in Spain was then matched to the priority area “Social change and innovation” of the national Spanish S3.

Tracing knowledge generated by the ERDF RTDI support from projects to patents

Different forms of R&D-related outputs and outcomes play a key role for the different Policy Instruments of the RTDI support of the ERDF. This activity aims at detecting research outputs that stem from ERDF RTDI support in the 2014-2020 funding period. Here, research outputs are measured in the forms of scientific publications. In order to identify these research outputs, relevant ERDF publications had to be detected. In the **absence of a ready-to-use database that provides this information**, the databases of both OpenAlex[226] and Dimensions.AI[227] were used since these constitute established publication databases.

Using these two databases in a complementing way ensures a high degree in the identification of relevant publications. Moreover, both databases have the advantage that they provide information about the funding sources behind the publications. This information is crucial for assessing publications that are linked to ERDF RTDI beneficiaries. In the

[226] https://openalex.org/ (last access 06.02.2024)

[227] https://www.dimensions.ai/ (last access 06.02.2024)

following, the procedure behind **identifying the ERDF as the funding source** of the publications is described. OpenAlex provides the possibility to specifically filter for publications that acknowledge the ERDF as their funding source. To identify relevant publications in Dimensions.AI, a two-step approach was applied. In a first step, publications that indicated the European Commission as their funding source were identified. Then these publications were assessed whether they mention the ERDF in their acknowledgements. Thereby, attention was also paid to account for the name of the ERDF in all relevant languages (for instance: Europäischer Fonds für regionale Entwicklung (EFRE) for Germany, Fonds européen de développement régional (FEDER) for France, etc.). This was done to ensure that all relevant publications that were funded by the ERDF across all EU Member States were identified.

In the next step, the identified publications that acknowledge the ERDF as a funding source from the OpenAlex and the Dimensions.AI had to be **merged in one database**. This was done to have one unique database with publications that acknowledge the ERDF as a funding source. Using the Digital Object Identifier (DOI) as a unique identifier of a publication, it was ensured that no duplicates (i.e. the same publication in OpenAlex and Dimensions.AI) remained in the database of publications that acknowledge the ERDF as a funding source for the further analysis.

After this step, the organisations behind the publications that are provided by Dimensions.AI and OpenAlex were **linked to the beneficiaries of the ERDF 2014-2020 RTDI support using a matching approach** (see also the info box below on Approximate String Matching). Before the organisations behind the publications could be matched with the ERDF beneficiaries, it was also necessary to translate the names of the ERDF beneficiaries into English[228] to ensure the quality of the matching approach. The reason for that is that the names of the ERDF beneficiaries were mostly provided in the national language (e.g., Universidad Autónoma de Barcelona) while the organisations behind the publications were usually listed in English (e.g., Autonomous University of Barcelona). In the specific example, the term “Universidad Autónoma de Barcelona” would not have triggered a match with “Autonomous University of Barcelona” although it is the same organisation.

By connecting the organisations behind the identified publications with the beneficiaries of the ERDF 2014-2020 RTDI support, the **publications could also be linked to the Policy Instruments of this study**. Since the publications cannot directly be linked to the Policy Instruments, the ERDF beneficiaries were used instead as a connection. By using the ERDF RTDI operations database of this study, the involvement of each beneficiary in the various Policy Instruments could be mapped. Here, beneficiaries can be involved in multiple Policy Instruments if they were also involved in multiple ERDF RTDI operations of the 2014-2020 funding period. Based on these steps and the qualification process, around **78,700 publications** that acknowledge support from the ERDF as their funding source could were linked to EU27 organisations that were beneficiaries of the ERDF RTDI support of the 2014-2020 funding period.

The prior approach set the baseline for further tracing the knowledge generated by the ERDF RTDI support from projects to **patents** since the 78,700 publications were in the next step linked to patents. This was done using citations in the registered patents, called non-patent literature that are provided by PATSTAT. However, these citations to non-patent literature are extremely heterogenous. Hence, a multi-step approach was implemented that accounted for the following scenarios. If structured information was available, the **DOI** (unique identifier) was used to establish a link between the patent and a publication. In the second step **unstructured text data** was matched. In these cases, either **string matching**

[228] Translation was done using DeepL API service. See DeepL API.

(see below) was applied, especially when a **publication title** was available, or a **mixture of a rule-based approach and a machine learning approach** was used.

This constitutes a **novel approach**, that goes beyond existing studies that link patent data to publications.[229]

Stairway to Excellence stimulus through ERDF RTDI support

To assess the stairway to Excellence stimulus through ERDF RTDI support and especially the upstream effects, H2020 data needs to be applied. Here, the relevant data on H2020 funded projects and beneficiaries between 2014 and 2020 is provided by the European Commission via **CORDIS**.[230] This data covers projects and related organisations that were funded by the EU under the Horizon 2020 programme for research and innovation from 2014 to 2020.

To identify the synergies between the **ERDF and Horizon 2020** as well as the Stairway to Excellence stimulus through ERDF RTDI support, the beneficiaries of the ERDF RTDI 2014-2020 database are linked with the organisations funded by H2020 using a matching approach (see Approximate String-Matching box below). Here, the names of the ERDF RTDI beneficiaries and the organisations funded by H2020 are central to the approach since a match is triggered when the name of the ERDF RTDI beneficiary is found in the H2020 organisation list.

Approximate String Matching

Approximate string matching, also known as fuzzy string searching, is an algorithmic approach that enables the identification of strings that are similar but not identical. This process relies on quantifying the "distance" between strings, typically using metrics such as the Levenshtein distance, which calculates the minimum number of single-character edits (insertions, deletions, or substitutions) required to change one string into another. For example, in a database query for "Alexander", an approximate string-matching algorithm might identify "Aleksander" as a close match by recognizing that only a single substitution is needed to reconcile the two strings. This method is indispensable in data cleaning, information retrieval, and natural language processing tasks, where exact matches are improbable due to typographical errors, phonetic variations, or other inconsistencies.

In order to identify the downstream effects, the ERDF RTDI database of beneficiaries and organisations is linked to the **Innovation Radar.**[231] The Innovation Radar identifies up to 10,000 high-potential EU-funded innovations from H2020, LIFE Programme, Framework Programme 7 (FP7), and Competitiveness and Innovation Programme (CIP). Innovations by region are rated based on different criteria including the maturity level of innovation towards commercialisation (Market Ready, Tech Ready, Business Ready, Exploring) based

[229] Guerrero-Bote et al. (2019): The citation from patents to scientific output revisited: a new approach to the matching Patstat / Scopus. Available online: https://revista.profesionaldelainformacion.com/index.php/EPI/article/view/epi.2019.jul.01 (last access 25.06.2024) and Masclans-Armengol et al. (2024): Measuring the commercial potential of science. Available online: https://www.nber.org/system/files/working_papers/w32262/w32262.pdf (last access 25.06.2024)

[230] https://data.europa.eu/data/datasets/cordish2020projects?locale=en (last access 15.02.2024)

[231] https://innovation-radar.ec.europa.eu/ (last access 15.02.2024)

on survey data and a continuously refined methodology.[232] The Innovation Radar data was provided by the European Commission. Similar as before, the ERDF RTDI beneficiaries were matched to the organisations in the Innovation Radar. A match is triggered when the name of the ERDF RTDI beneficiary is found in the Innovation Radar list. Additionally, the ERDF RTDI projects of the matched beneficiaries were compared to the innovations in the Innovation Radar using a word embedding approach (see the box above). This approach allows to calculate the total similarity between the ERDF RTDI projects and the innovations from the Innovation Radar. The total similarity informs about the degree to which a respective project description of the ERDF RTDI database is similar to the description of an innovation from the Innovation Radar. The value of the total similarity can range from 0 to 1 where a value of 0 means that both descriptions do not share any similarity at all. A value of 1 means that both descriptions are identical. This measure was then used to qualify the matching results. Only the similarity scores above 0.5 were flagged as a match. In practice this simply means that reading the descriptions one would be able to tell that they are concerned with the same topic.

Limitations

The following limitations have to be kept in mind while interpreting the results of the different analyses.

To start with the assessment of the alignment of ERDF RTDI support with national/regional Smart Specialisation Strategies, one has to mention that although the word embedding approach is successful in matching ERDF RTDI projects and S3 priorities based on their thematic alignment, some limiting factors need to be outlined. Overall, these limitations of matching ERDF projects to S3 priority areas are also encountered in similar studies (Prognos & CSIL, 2021 and Prognos & CSIL, 2022). Thereby, especially the varying quality of the descriptions of priority areas as well as ERDF RTDI project descriptions plays a key role since the keywords are a key determinant of a successful match. While most fields offer extensively detailed descriptions for their priority areas, certain regions and priority areas offer only five keywords or even fewer. On the other hand, there are also regions with a significantly higher number of keywords. This is crucial because a larger number of keywords enhances the likelihood of a match. Moreover, there is also a variance in the quality of the keywords themselves. While some descriptions include specific keywords that are thematically related to priority descriptions, others priority areas cover a broader range of topics and keywords (e.g., ICT, energy efficiency, and bioeconomy). These varying levels in quality are also found in the descriptions of the ERDF RTDI projects as some descriptions are extremely short and include rather generic keywords. This is also affected by the fact that some projects are missing their descriptions. In other cases, the descriptions are rather general and include examples such as “realization of industrial research and experimental development projects to companies”.

Another limitation comes from the fact that organisation names in all data sets used (be it ERDF, H2020, Innovation Radar, OpenAlex or Dimensions.AI) had misspellings[233], that is the same organisation having conducted two projects would appear twice in a given dataset and the name of this organisation would be misspelled in the second record. For instance, once it would appear as “University of Berlin” and once as “University of Berlin”. In such a case, when trying to match ERDF organisations with, for instance, H2020 organisations the

[232] https://innovation-radar.ec.europa.eu/methodology (last access 16.02.2024) and JRC (2018): Validation of the Innovation Radar assessment framework. Available online: https://publications.jrc.ec.europa.eu/repository/bitstream/JRC110926/jrc110926_ir_validation_report.pdf (last access 16.02.2024)

[233] Or other types of variations in the name, like acronyms, the same name written in multiple languages, etc.

misspelled name would not match since the characters of the two names would not overlap fully. To resolve this limitation, we applied approximate string matching[234] techniques (see Approximate String-Matching box above). This in turn introduced two further challenges: 1) when two organisation names were matched incorrectly because the names were very similar, but they still referred to two different organisations. For instance, organisation name "Felder GMBH" matched "Kelder GMBH". In such a case, we have resolved the incorrect matches by manually removing them; 2) when a match should have been made but the strictness of the matching algorithms did not allow for that. In this case, however, it is not possible to know what the algorithm did not match and thus there is a possibility that in fact there are more ERDF organisations that appear in both H2020 and Innovation Radar than the algorithm matched. Given these challenges this approach needs to be seen as a **conservative approach**, meaning one can be certain that at least the identified number of organisations overlap between the different programmes with some possibility that there are more.

The second limitation pertains to the matching of ERDF and Innovation Radar. Once the match between ERDF and Innovation Radar organisations was established, one needed to identify which of the projects conducted under ERDF contributed to which innovations. For instance, organisation A conducted a single project under ERDF and at the same time had five innovations recorded in the Innovation Radar dataset. The question is to which of the five innovations does the single project conducted under ERDF contributed. To answer this, we applied Natural Language Processing (NLP) technique "Semantic Text Similarity Analysis using Word Embeddings"[235]. For this, project and innovation descriptions were used. The quality of the descriptions is a key determinant of the quality of the matches. Here, a higher number of words in the descriptions increases the chance of a match and some project and innovation descriptions were very limited. This resulted in false positives, a case where the matching algorithm incorrectly identified project and innovation descriptions as being very similar, and false negatives, a case where the algorithm failed to identify a match that should exist. The only way to resolve this is to manually fix the mismatches, that is to read each of the descriptions and compare them to each other, however this is an extremely laborious task that is beyond the scope of the present study[236].

The following three limitations pertain only to the analysis of the publications. First, given the long process of (peer-reviewed) publications, some of the publications considered could be based on funding provided by the ERDF of the 2007-2013 funding period. This can especially concern the identified publications that were published in the years between 2014 and 2016. Unfortunately, it is not possible to directly link the identified publications to the ERDF support of a specific funding period. Second, it is possible that not in all cases the databases (Dimensions.AI and OpenAlex) at hand can indicate that a publication was funded by the ERDF/European Commission. This means that there can be more publications that were funded by the ERDF as the applied approach was able to identify. Third, the classical "linear model" of innovation (or CDM model)[237] that assumes a rather direct causal link from R&D to publications/patents to innovation and productivity is not accurate for all types of regions, especially emerging economies (non-linear relationship between R&D and innovation and production capability). This needs to be considered in the interpretation of the findings. In addition to that and related to the tracing of publications to patents, it is important to highlight the time lag between the dissemination of related publications and patents. In general, one can assume an average time lag of 18 month until

[234] See Approximate string matching - Wikipedia for a general overview of the technique.

[235] See Semantic similarity - Wikipedia for a general overview of the technique.

[236] Another possibility could be to use crowdsourcing platform like Amazon Mechanical Turk; however, the privacy of the EC data does not allow that.

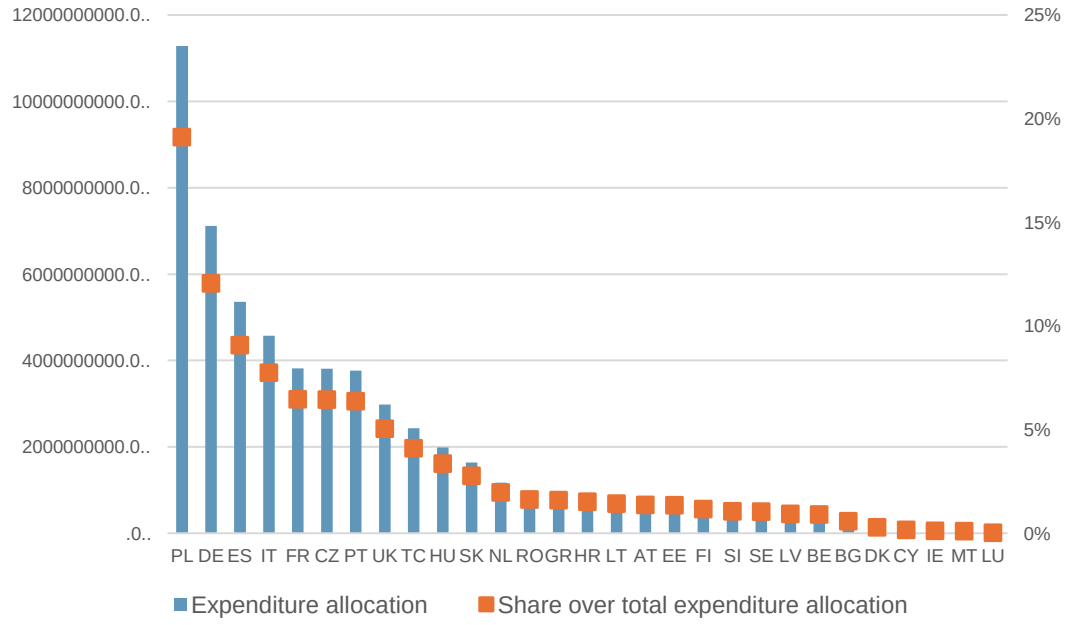
[237] A. Fedyunina & S. Radosevic (2022) The relationship between R&D, innovation and productivity in emerging economies: CDM model and alternatives, Economic Systems, June 2022

a patent is accepted. This can potentially influence the number of identified patents for recent years like 2023 and 2024, as several filed patents might not have been accepted yet at this point in time.

Annex V. Analysis of ERDF expenditure across the policy instruments

This Annex presents some additional key features of the policy instruments deployed to support RTDI. It is mainly based on the analysis of the database of expenditure at the operation and beneficiary level up to the end of 2020 assembled under Work Package 2 – Preparatory Study. However, it also builds on the EC Categorisation Data updated as of the end of 2023 to provide some additional statistics on the forms of finance.

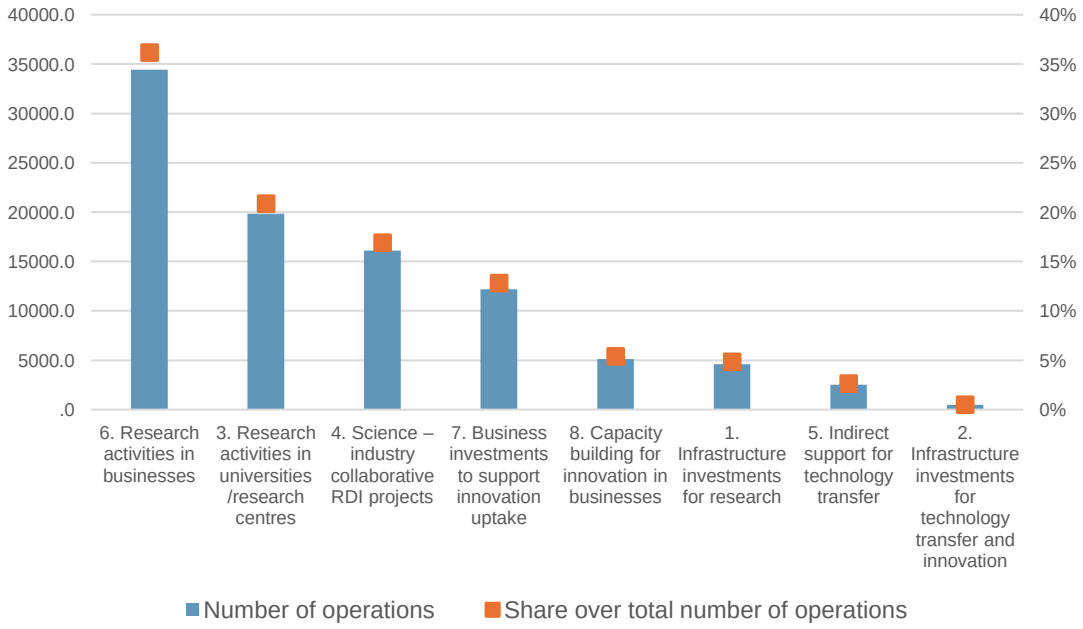
Figure 46. Total expenditure allocation (EUR million) and share of total expenditure allocation (%) by Member States



Note: TC stands for Territorial Cooperation programmes (Interreg) and includes all CPs. The chart considers the total expenditure planned (variable 'Planned Total Amount (Notional)' in 2023).

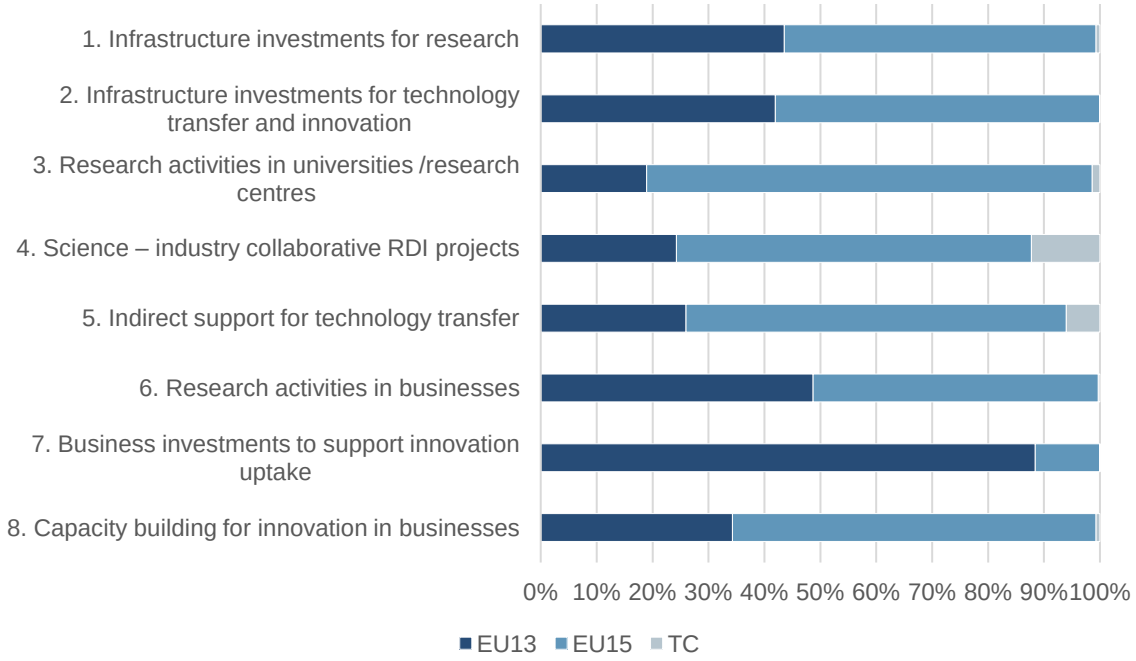
Source: Prognos / CSIL / Visionary Analytics, based on EC categorisation data (last update: end of 2023).

Figure 47. Total number of operations and share of the total (%) by policy instruments



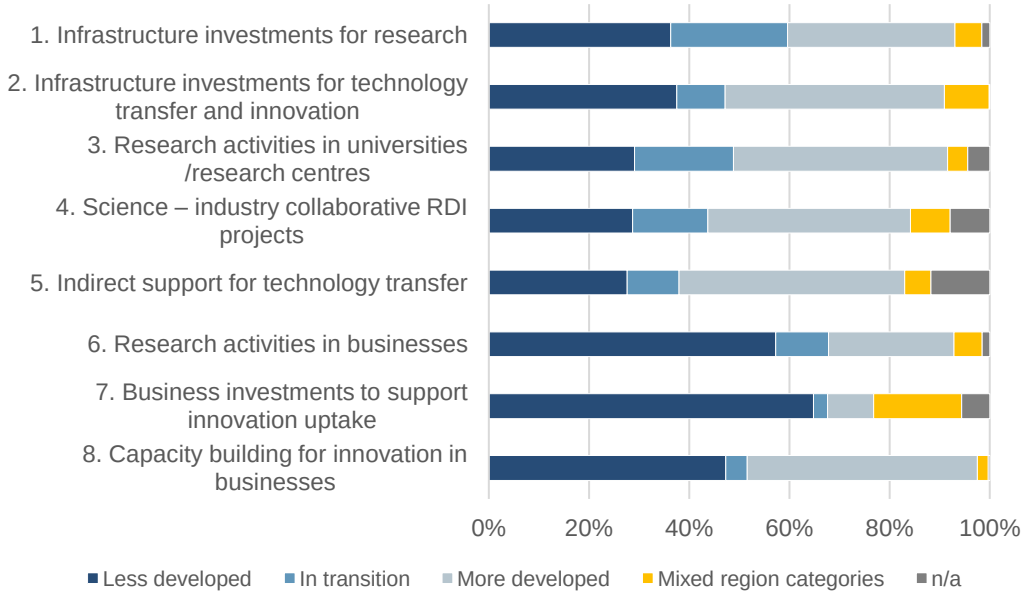
Source: Prognos / CSIL / Visionary Analytics based on WP2 expenditure data (last update: end of 2020).

Figure 48. Distribution of total expenditure by policy instrument and EU13, EU15 and Territorial Cooperation (TC) programmes



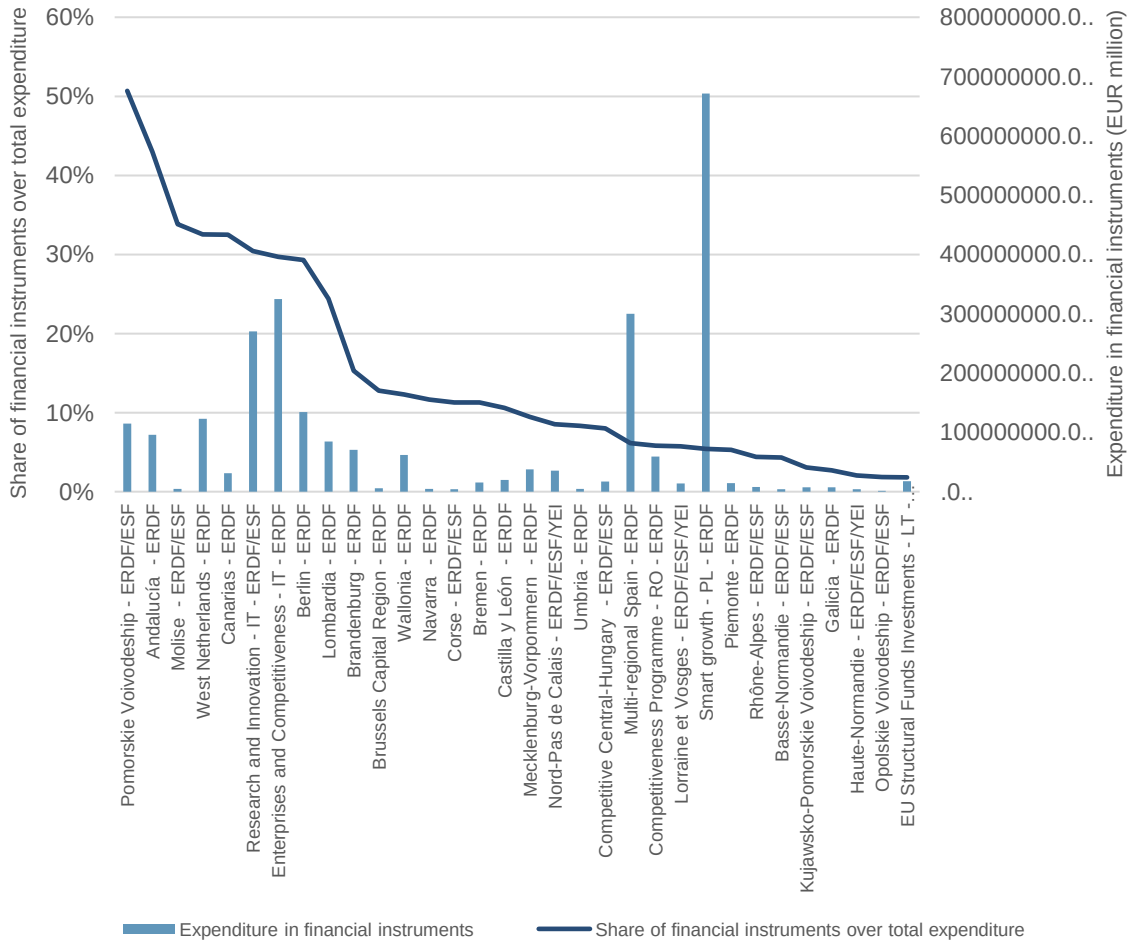
Source: Prognos / CSIL / Visionary Analytics based on WP2 expenditure data (last update: end of 2020).

Figure 49. Distribution of total expenditure by policy instrument and covering different types of regions (less developed, in transition, more developed)



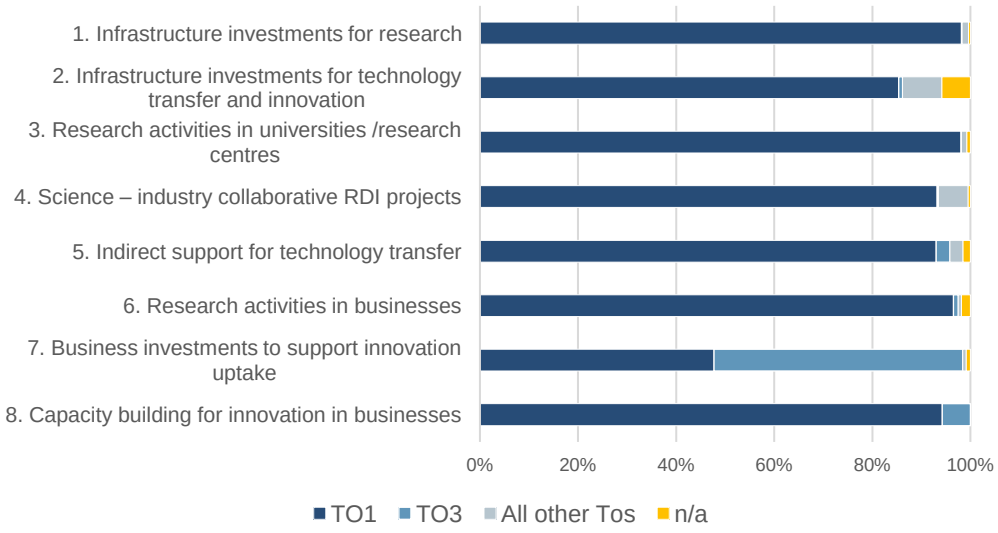
Source: Prognos / CSIL / Visionary Analytics based on WP2 expenditure data (last update: end of 2020).

Figure 50. Share of expenditure through financial instruments by OP



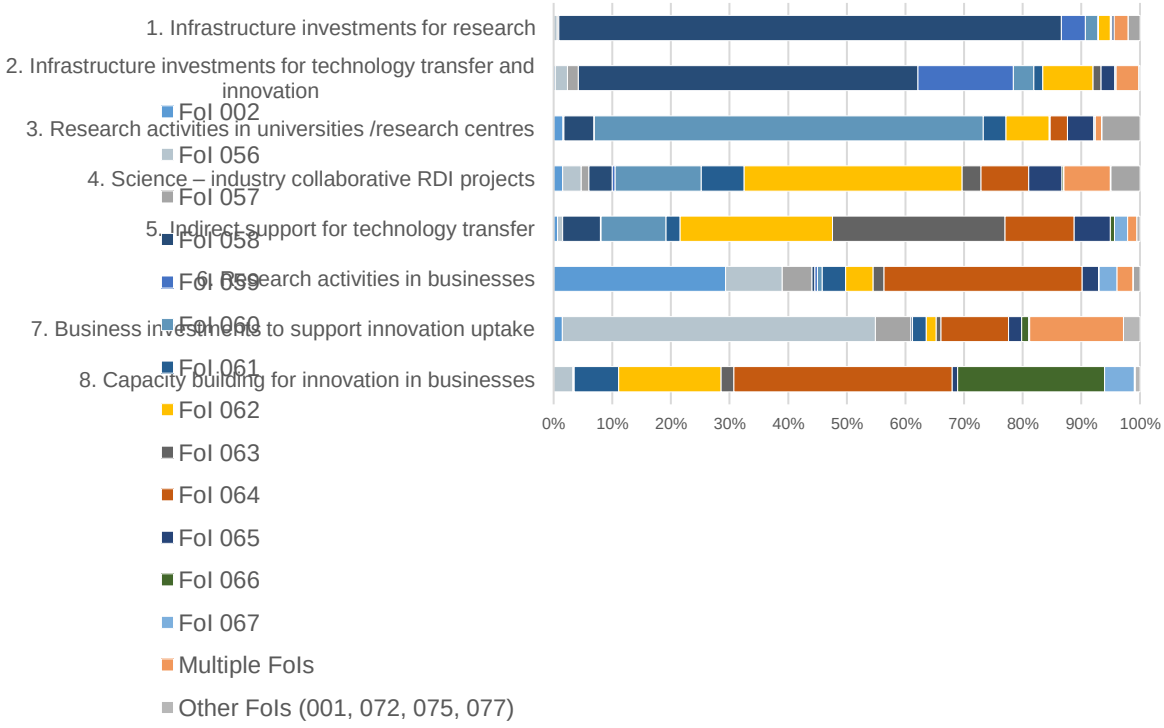
Source: Prognos / CSIL / Visionary Analytics based on WP2 expenditure data (last update: end of 2020).

Figure 51. Distribution of total expenditure by policy instrument and thematic objective



Source: Prognos / CSIL / Visionary Analytics based on WP2 expenditure data (last update: end of 2020).

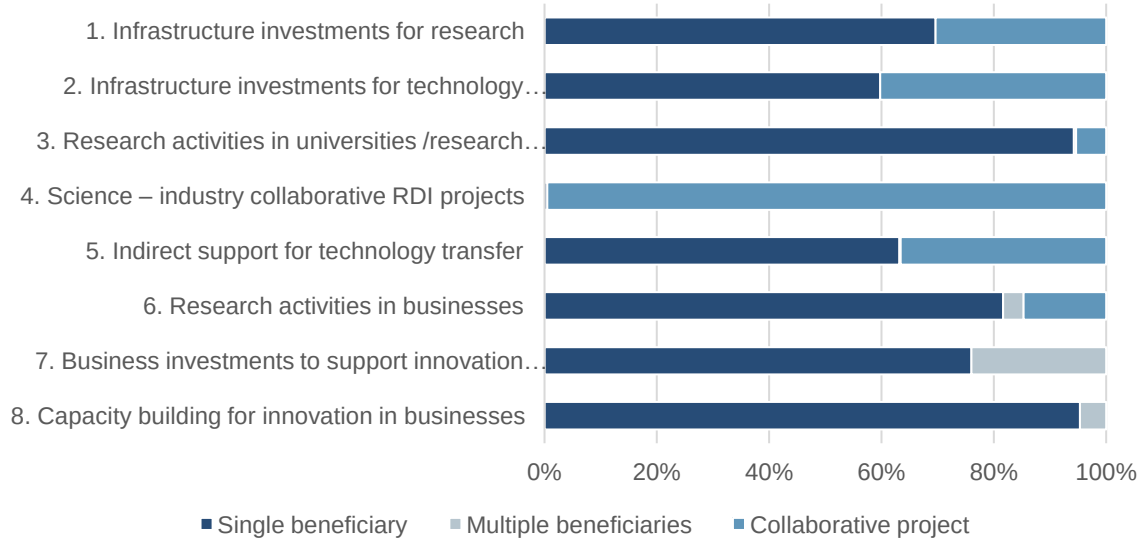
Figure 52. Distribution of total expenditure by policy instrument and FoI



Source: Prognos / CSIL / Visionary Analytics based on WP2 expenditure data (last update: end of 2020).

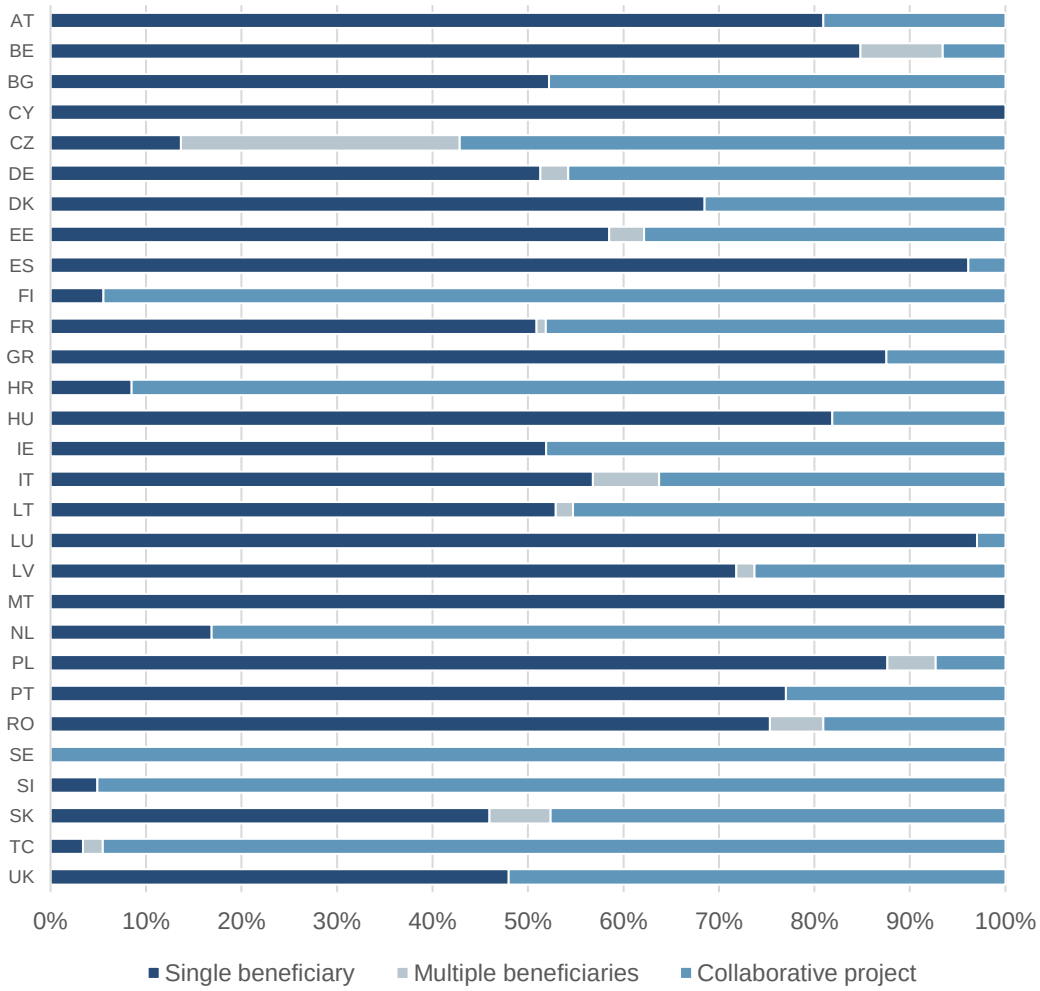
With regards to the **type of projects (single, multiple, collaborative),** the following figure shows their distribution across different types of policy instruments as well as across the different Member States.

Figure 53. Distribution of total expenditure by type of projects (single, multiple, collaborative) and policy instrument



Source: Prognos / CSIL / Visionary Analytics based on WP2 expenditure data (last update: end of 2020).

Figure 54. Distribution of total expenditure by type of projects (single, multiple, collaborative) and Member State



Source: Prognos / CSIL / Visionary Analytics, based on WP2 expenditure data (last update: end of 2020). Note: TC stands for Territorial Cooperation programmes (Interreg) and includes all CPs.

The following table shows the distribution of expenditure and operations, including by type of policy instruments, according to the **typology of beneficiaries** that has been created to cluster the direct beneficiaries targeted by all operations funded to support RTDI.

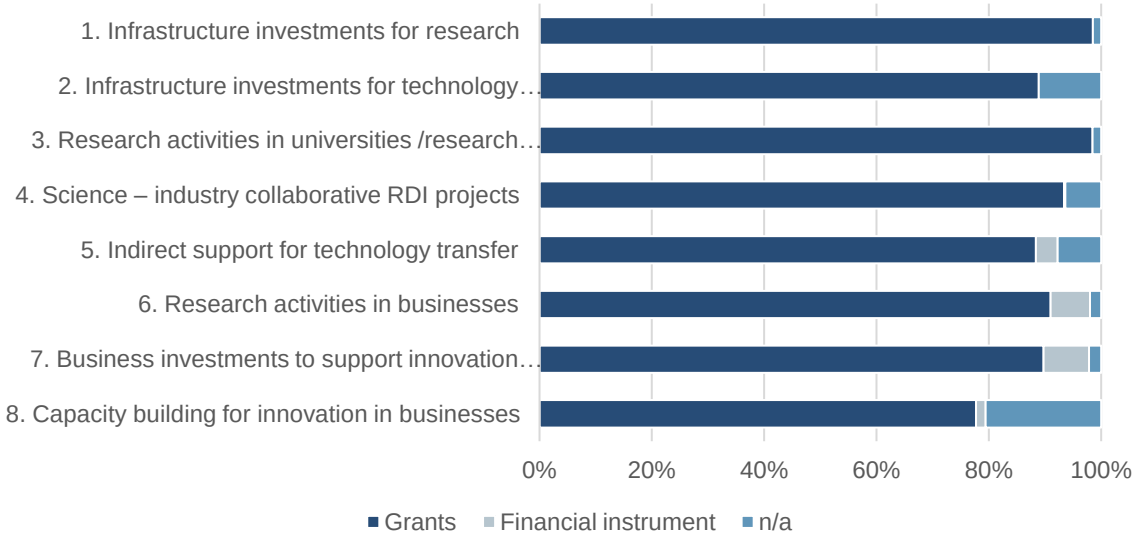
Table 9. Total expenditure allocated by type of direct beneficiaries

Enterprise	29,132	44.03%	47,728	50.11%
Mix of beneficiaries	17,267	26.10%	17,850	18.74%
Higher education institution	6,669	10.08%	13,917	14.61%
Research organisation	5,737	8.67%	9,269	9.73%
Enterprises only	3,755	5.67%	3,974	4.17%
Unclassifiable	1,184	1.79%	180	0.19%
Public administration	902	1.36%	455	0.48%
Research and technology transfer organisation	567	0.86%	620	0.65%
Business support organisation	537	0.81%	789	0.83%
Higher education institution / Research organisations only	333	0.50%	386	0.41%
Financial institution	65	0.10%	4	0.00%
Other	10	0.02%	22	0.02%
N.A.	10	0.01%	43	0.05%

Source: Prognos / CSIL / Visionary Analytics, based on WP2 expenditure data (last update: end of 2020).

The following figure presents the main **forms of finance** used across different types of policy instruments.

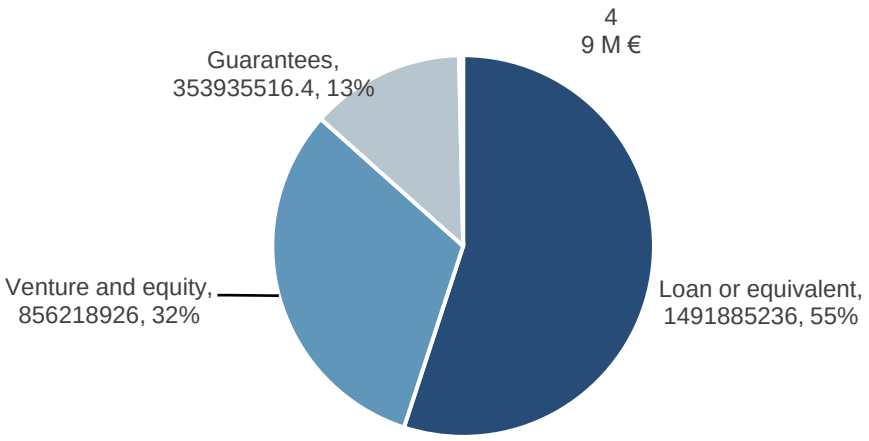
Figure 55. Distribution of total expenditure by form of finance and policy instrument



Source: Prognos / CSIL / Visionary Analytics, based on WP2 expenditure data (last update: end of 2020).

The main types of financial instruments used as of the end of 2023 under the Thematic Objective 1 related to RTDI are instead presented in the figure below.

Figure 56. Distribution of planned expenditure for financial instruments in Thematic Objective 1 "Research and Innovation"

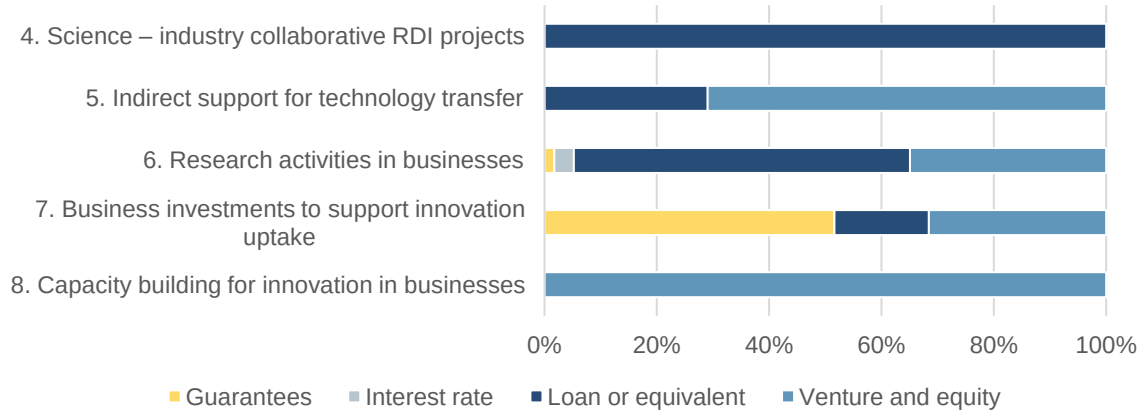


Note: the figure includes information on the forms of finance used and considering the variable "Planned Total Amount (Notional)" for Thematic Objective 1 "Research and Innovation" in year 2023.

Source: Prognos / CSIL / Visionary Analytics, based on EC categorisation data (last update: end of 2023).

Instead, the following figure zooms into the **types of financial instruments** used across the different policy instruments as of the end of 2020.

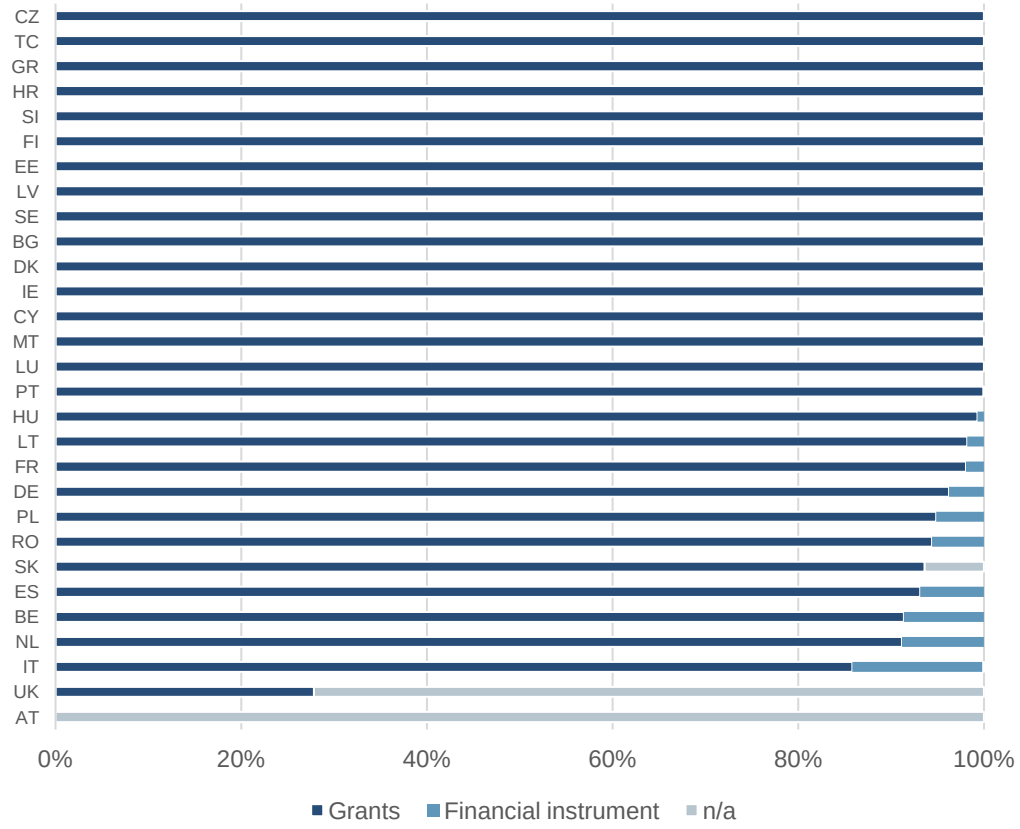
Figure 57. Distribution of total expenditure for financial instruments by policy instrument



Source: Prognos / CSIL / Visionary Analytics, based on WP2 expenditure data (last update: end of 2020).

The figure presented below depicts the use of financial instruments in various Member States.

Figure 58. Distribution of total expenditure by form of finance and Member State



Source: Prognos/CSIL/Visionary Analytics (2024), based on WP2 expenditure data (last update: end of 2020).
Note: TC stands for Territorial Cooperation programmes (Interreg) and includes all CPs.

Annex VI. Synthesis of the assessment by policy instruments

Full text of the policy instrument fiches are presented as self-standing document accompanying this report.

Table 10. Synthetic assessment by evaluation criteria and policy instruments

Infrastructure investments for research	**High** • The alignment of ERDF investments with the territories' smart specialisation strategies is evident, although each territory tailored its approach based on specific regional needs and contexts. • The unforeseen challenges of the COVID-19 pandemic further underscored the importance of flexibility and adaptability in policy design and implementation	**High** • The infrastructure investments succeeded in their goal of enabling innovative activities • Overall effectiveness may have been improved by a closer link between the investment decisions and the needs of local businesses.	**Moderate** • All regions emphasized the crucial role of a well-established strategic framework in guiding ERDF support. • One of the most prominent inefficiencies (EQ6) was the lack of flexibility in project modifications, an issue magnified in the aftermath of the COVID-19 pandemic	**High** • Policy interventions were rooted in strategic plans for specific infrastructure development that enabled long-term planning by beneficiaries • The investments undertaken built on previous investment decisions and on the strengths of the local ecosystem	**High** • the high co-financing rates of projects funded by the ERDF underline its fundamental role in advancing R&D infrastructures across the four territories • The aftermath of the interventions was a marked improvement in beneficiaries' R&D activities. This translated into both an increased (R&D capacity) and an enhanced quality of research endeavours (R&D capability),

Infrastructure investments for technology transfer and innovation	**High** ▪ ERDF support addressed existing needs and contributed to the creation of new jobs and enhancement of skills. ▪ COVID-19 created some challenges (e.g. delays) but solutions were adopted (using of digital tools) ▪ In all three territories investigated, investments supported were in line with smart specialisation strategies.	**High / Moderate** ▪ The support provided by ERDF successfully delivered new/improved physical spaces for enabling knowledge transfer and networking, to conduct test and validation of products and processes as well as to improve innovation skills of firms. ▪ Different degree of achievement were observed in terms of number of firms collaborating with research organisations, enhanced ability of enterprises to develop innovative products and services, increased attractiveness of the territory for talents and investors as well as the development of new patents Main bottlenecks included difficulties faced with public procurement rules (in all territories assessed), compliance with State Aid rules (mostly in Bulgaria), shortage of qualified human capital (brain drain processes) and sufficient number of companies willing and able to push technology frontier (Bulgaria and Czechia)	**High/ Moderate** ▪ The presence of adequate expertise across all actors, the design of the measures in collaboration with local relevant stakeholders, leveraging on existing network/partnerships are the factors positively impacted on the efficient implementation of the measures. ▪ A long-term commitment and integration into national/regional strategies was crucial to ensure the sustainability of infrastructure in the long-term (effective exploitation and achievement of commercial outputs). The support provided in the form of non-repayable grants addressed one of the major barriers faced by target groups in undertaking infrastructure investments (excessive costs associated coupled with uncertainty about their returns).	**High/ Moderate** ▪ All measures assessed were well aligned with the existing regional/national policies and other supporting initiatives, such as national development plans, innovation strategies as well as S3. In two out of three territories analyses, ERDF support built on measures financed by other projects (e.g. Horizon 2020)	**High/ Moderate** ▪ ERDF added value is acknowledged in all the territories assessed. ▪ Achievements were observed although to a different degrees Outcomes at systematic level are expected (too early for being assessed) provided that ERDF measures are coupled with additional complementary interventions.

Research activities in universities and research centres	**Moderate** • ERDF support provided an upfront support for NRIs (Greece), foundational research (Spain), and institutional changes (Estonia and Brittany) useful to deal with limited available financial resources • The pandemic had disruptive effects in all countries, investments made under the ERDF were in line with smart specialisation strategies.	**Moderate/ high** ▪ Generally ERDF support reached targets satisfactorily but not always fully ▪ ERDF increased research capacity. Impacts on job creation could not be ascertained beyond projects ▪ Regional dynamics, local institutional capacity, and the ability to leverage new networks, partnerships, and investments are factors determining the sustainability of the effects.	**Moderate/ high** ▪ ERDF support delivered directly (supporting RTDI projects by universities in ES for example) was more efficient than indirect support to shape a conducive environment (FR and EE) ▪ State Aid issues were not considered to be a major hurdle, but other regulatory issues slowed down the implementation of the policy instrument (e.g., national administrative requirements).	**Moderate/ high** ▪ ERDF support was usefully combined with other EU funding sources for RTDI ▪ S3 had a structuring effect ensuring complementarity between different sources of funding for RTDI.	**Moderate/ high** ▪ There is high quantitative dependence on ERDF in EE and GR ▪ The strategic value of ERDF was acknowledged in FR an ES Limited contribution of ERDF in reducing territorial disparity
Science-industry collaborative RDI projects	**High** ▪ ERDF support addressed network failures and contributed to the enhancement of workforce knowledge/skills ▪ COVID did not represent a significant threat ▪ The link with S3 was highlighted in all the territories investigated	**Moderate/ high** ▪ Overall, ERDF support resulted in achieving the intended outputs, specifically the formation of partnerships between research organisations and business ▪ ERDF support was delivered, to a large extent, in line with the plan. Some extensions due to COVID-19 were reported	**Moderate/ high** ▪ Strategic alignment with national and regional RTDI frameworks has proven beneficial, ensuring that policy measures seamlessly integrate into broader and well-aligned innovation strategies. ▪ The role of facilitators with good project management skills was important in improving efficiency of science-industry collaboration.	**Moderate/ high** ▪ ERDF support was well aligned with the existing regional/ national policies and other supporting initiatives. ▪ In many cases, the ERDF funding fit well into the national policy targeted supporting SMEs (Rhone-Alpes, S&E Ireland, Saxony, Lombardy, Finland). ▪ There is no exact statistical data to provide the number (scale) of research organisations or companies that took advantage of ERDF support	**High** ▪ ERDF resources contributed to the growth of investments, including private financing, in all regions and countries. For example, in LV, the measure attracted significantly more private funding than initially planned for R&I investments. ▪ Effects observed would not have materialised in the absence of ERDF support

		▪ Main bottlenecks were shortage of qualified human capital, lack of follow-up funding, public procurement procedures, IPR.		within other instruments. However, such cases were reported within the case studies.	
Indirect support for technology transfer	**Moderate/ high** ▪ ERDF support did not primarily target job creation. Positive effects were recorded in terms of private RTDI investment in NL and DK ▪ ERDF support has enhanced cooperation and networking in DK and SL ▪ COVID did not represent a significant threat ▪ The link with S3 was strong and explicit in SL and to some extent in DK	**Moderate / high** ▪ ERDF support was implemented according to plans without major deviations and the targets (e.g., n. of companies supported) were generally reached ▪ ERDF contributed to improving innovation performance of targeted companies in NL and DK. In SL, it contributed to developing networking and collaborations ▪ Structural effects impacted the regional ecosystem in NL and SL (access to innovation funding and behavioural changes, respectively)	**Moderate** ▪ Preexisting proclivity to cooperate affected the implementation of ERDF ▪ The role of facilitators with good project management skills was important in improving efficiency ▪ In NL, the choice of resorting to a financial instrument was made to reach short-term results and rapid market introduction. The choice of grant in DK and SL was made to support networking and help SMEs become more innovative and obtain more diffuse and long-term effects.	**Moderate/ high** ▪ ERDF support fitted well in the regional ecosystems ▪ There were no significant synergies with other EU programmes supporting RTDI in NL and DK – to a higher extent in SL	**High** ▪ ERDF contribution was unique and non-substitutable ▪ Effects observed would not have materialised in the absence of ERDF support
Research activities in businesses	**High** The incurred investments were highly relevant for the objective to invest in growth and jobs. As regards private investments, the 50% co-financing virtually ensures the relevance of the support in this respect	**Moderate** ● ERDF support led to reaching the intended outputs in terms of investments in (mostly) tangibles and intangibles, which translated into implementation of	**High** ● The design and allocation of resources to R&D investments were found to be influenced by the policy mix in the region in all cases: all measures either targeted or directly	**High** ● The analysed measures were, at least until the advent of the COVID-19 pandemic and the related support, well aligned with the	**Moderate** ● Evidence suggests that the main additional value of the European support was its capacity to induce more extensive and numerous collaborations compared to existing

	• The COVID19 pandemic hampered implementation of the instrument in the analysed regions to a different extent • The evaluation team leveraged an AI-enabled "word-embedding" technique to match the projects listed in the R&D database with the respective S3 strategies.	innovations in case of each completed project. • The intended outcomes have been met with relative certainty only at the level of beneficiaries.	favoured beneficiaries active in S3 related areas. • The experience of the managing authorities in implementing the support proved to have a significant impact on the implementation process.	existing regional/national policies. The use which authorities make of ERDF funding varies significantly based on the context • Given the breadth of the policy instrument in question, conclusions regarding the extent to which the support was coherent with other EU interventions in the R&D field are difficult to come to.	national support measures. • Across all case study countries, the evidence suggests that the ERDF investments had a significant enabling effect on businesses' research activities and, in a majority of cases, proved decisive in enabling a project that would otherwise not have occurred.
Business investments to support innovation uptake	**Moderate/ high** ▪ ERDF support, co-financing up to 50% of investment costs, significantly boosted private investments, particularly in Polish regions, where company assets doubled within four years. Whereas the impact on employment was moderate with notable growth in SMEs in Cyprus and Poland, where new positions in micro and small enterprises increased by 10-50%. ▪ The impact of COVID-19 varied, with Hungary and Poland experiencing minimal disruption due to the pre-pandemic launch of most projects. Conversely, Cyprus faced significant challenges, extending project	**High** ▪ ERDF support led to a significant number of activities and outputs in line with targets, with 2,601 projects funded across Cyprus, Hungary, and Poland. ERDF support led to reaching the intended outputs in terms of investments in (mostly) tangibles and intangibles, which translated into the implementation of innovations in the case of each completed project. The percentage of the projects which were awarded but withdrawn from execution was insignificant. ▪ The selected programmes in Cyprus, Hungary, and Poland	**Moderate/ high** ▪ ERDF support was influenced by contextual factors, like the national / regional innovation ecosystems, which were more significant in Cyprus than in Hungary and Poland. Programme-specific factors, including the efficiency of procurement processes and the expertise of Managing Authorities, generally facilitated smooth implementation, except for some issues in Cyprus. ▪ The scale of ERDF funding varied across regions, with maximum co-financing ranging from EUR 92,000 in Hungary to EUR 4.6 million in Poland. This variation impacted the scale and innovativeness of	**High with some degree of uncertainty** ▪ ERDF funding was well integrated with national and regional policies, particularly in Hungary and Eastern Poland, where programmes were linked to RIS/S3 strategies such that all 2,520 projects between the two countries were embedded in the S3 priority areas. ▪ The ERDF support in Cyprus, Hungary, and Poland complemented other EU interventions with similar objectives, such as Hungary's "SME START INNOVATION" and	**Moderate** ▪ ERDF intervention significantly increased investments, assets, and production capacity of beneficiary companies, doubling the inputs. ▪ Although collected information and data were insufficient to assess the scale of deadweight effect precisely, experts agreed that without ERDF support, the objectives of the policy would have been pursued at a slower pace and on a smaller scale, with fewer investments, innovations, and technical advancements materialising.

	implementation periods by a year due to extensive closures, while Polish enterprises benefited from the shift to remote work. ▪ Most Polish and Hungarian regions aligned ERDF investments with their S3 strategic frameworks, focusing on national and sectoral priorities. Cyprus did not follow this approach as their S3 strategy was introduced after the grant call was launched.	generally met their objectives, with Poland's sub-measure 1.3.1 exceeding expectations by more than doubling R&D implementation activities, largely due to significant ERDF funding which both spurred innovation and doubled investment scales. ▪ ERDF support helped regions catch up with more innovative counterparts within their countries, particularly in Hungary and Poland. However, the impact on enhancing regional innovation ecosystems and competitiveness compared to other EU regions was moderate and lacked solid data for broader claims.	projects, with Eastern Poland benefiting the most from higher funding levels. ▪ Implementation faced both exogenous obstacles (e.g., COVID-19 pandemic, economic instability due to the war in Ukraine) and endogenous issues (e.g., institutional capacity, red tape). Managing Authorities (MAs) addressed these by extending project timelines and adjusting cost eligibility criteria, although responses to some problems, like exchange rate instability, were limited.	Poland's Smart Growth Operational Programme, enhancing the overall impact. There is no exact statistical data to provide the number (scale) of companies that took advantage of ERDF support within other instruments. However, such cases were reported within the case studies.	
Capacity building for innovation in businesses	**Moderate** ▪ Out of the three countries under the case study, Poland presented positive evidence of jobs created. ▪ COVID-19 had varying effects: Czechia saw little impact due to pre-pandemic project launches, Eastern Poland experienced both a deterrent to project applications and a stimulus for new product development, and Norte faced implementation challenges due to supply chain disruptions.	**Moderate/ high** ▪ ERDF-supported activities in Czechia and Eastern Poland aligned with targets, enhancing SME competitiveness, innovation, and design management. Desired outputs were achieved primarily at the company level, with moderate regional RTDI ecosystem impacts. Positive unintended effects included fostering cooperation beyond projects, while negative effects involved potential national	**Moderate/ high** ▪ ERDF support was influenced by regional innovation ecosystems. Eastern Poland faced low innovation and cooperation levels but had effective support and cooperation processes. Consulting companies' involvement led to variable service quality. In Czechia, financial constraints required multiple applications for large projects. ▪ Implementation faced external obstacles like the	**Moderate/ high** ▪ In Czechia and Eastern Poland, ERDF measures were well aligned with national strategic objectives and complemented other operational programmes. In Czechia, activities integrated with the National S3 Strategy, while in Eastern Poland, successful regional measures were replicated nationally, highlighting the importance	**High with some degree of uncertainty** ▪ ERDF intervention provided significant additional value with high co-financing rates (up to 85% in Eastern Poland, 75% in Norte, and 68% in Czechia), advancing business innovation capacity beyond what national or regional efforts could achieve alone. ▪ Experts agreed that many projects would not have been possible without ERDF support or would have been

▪ A high percentage of RTDI projects were aligned with S3 priorities in Czechia (79%), Norte (69%), and varying degrees in Eastern Poland, but significantly lower alignment was observed in specific funding allocations for capacity building for innovation.	funding reductions and reduced entrepreneurial engagement. ▪ Objectives to increase absorptive capacity and introduce innovations were largely achieved. In Czechia, projects had a lasting impact on innovation capacity; in Eastern Poland, the impact varied by industry and motives. Significant innovation was achieved, with funding also spurring administrative and organisational procedures in Norte and additional private investments. ▪ ERDF support increased export competitiveness in Czechia and R&D expenditure in Poland, benefiting all Polish regions. However, the full impact on regional competitiveness is hard to assess due to recent project completions and small fund allocations.	pandemic and the war in Ukraine, causing economic instability. Internal issues included funding limits for programmes like Innovation Vouchers, requiring multiple applications, and an oversupply of consulting companies leading to low-quality studies. During the pandemic, delays were managed flexibly, but excessive administrative burdens hindered adaptability, highlighting the need for more flexibility for Managing Authorities.	of strategic alignment and coordination. Only 17% of ERDF projects were linked to R&I capacity building, with minimal implementation under specific policy instruments and no reported linkages with Horizon 2020 in Czechia and Eastern Poland. In Norte, support for Horizon 2020 applications was eligible, but specific data was not provided for the analysed measures.	smaller and slower, underscoring the critical role of ERDF funding in strengthening local research and development.

Source: Prognos / CSIL / Visionary Analytics (2024).

Table 11. Key elements of the tested Theory of Change

Immediate outcomes								
Research and education facilities and necessary equipment upgraded	*							
Expansion of R&D services offered; research standards enhanced	*							
Enhanced knowledge transfer capacities and mechanisms (incl. technology transfer infrastructures)		*			*			
Enhanced R&I capacities and skills of researchers			*	*				
Increase in R&D activity			*	*				
Innovation actors improve their skills and capacities (incl. collaboration skills and behaviours)				*	*		*	*
Increased No of employed researchers			*	*		*		
Intermediate outcomes								
Increase in public and private R&D expenditure			*	*	*	*	*	*
Attract / produce better and more students and researchers	*		*					
Interinstitutional/international research networks enhanced	*		*	*	*			
Intensified and more effective collaborations within RDI ecosystem		*		*	*			
Increased ability of research institutions to conduct excellent research	*							
Increased ability of enterprises to develop innovative products					*	*	*	*
Increased No of research outputs (publications, patents, follow-up projects)			*	*		*		
Impacts and wider effects								
Development of RDI ecosystem and synergies within it			*	*	*			
Development of new/critical science and technology areas	*		*	*		*		
New / increased innovation outputs: products, spin-offs, start-ups	*	*	*	*	*	*	*	*
New/increased jobs						*	*	*
Increased productivity, turnover, sales				*		*	*	*
Development of human capital base in the region	*	*						*
Spillover effects to the local/regional economy, e.g. increased attractiveness of the region for talents and/or investors		*		*	*	*	*	*
Key contextual factors								
Stability of policy and macroeconomic environment, attractive tax system	*	*	*	*	*	*	*	*

Existing technological or industrial ecosystem sufficiently mature, connected to priority areas		*		*	*	*	*	
Research infrastructures are (under)developed	*	*	*	*	*			
Absorptive capacities of firms (availability of qualified local SMEs)				*	*	*	*	*
Availability of skilled personnel to utilise the results	*	*	*	*	*	*	*	*
Sufficient administrative capacities	*	*	*	*	*	*	*	*
Appropriate policy design, efficacy of policy implementation, avoiding policy fragmentation	*	*	*	*	*	*	*	*
Broader and long-term commitment to public R&D funding	*	*	*	*				
Synergies between ESF and ERDF, availability of a well-functioning technology transfer system	*	*	*	*	*	*		
Level of consolidation of production and/or knowledge base				*	*	*	*	*
Economic (business) cycles and external market shocks such as COVID-19	*		*			*	*	*

Source: Prognos / CSIL / Visionary Analytics (2024).

Annex VII. Country fiches

Country fiches are presented as self-standing document accompanying this report.

Annex VIII. Case studies

Case studies are presented as a self-standing document accompanying this report.

Annex IX. List of references

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