European Commission

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

Contract N° 2018CE16BAT111

Final Report

Written by CSIL, Prognos AG, Technopolis

December 2021

EUROPEAN COMMISSION

Directorate-General for Regional and Urban Policy
Directorate B — Policy
Unit B.2 — Evaluation and European Semester

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2021

EN

Manuscript completed in December 2021

1st edition

Luxembourg: Publications Office of the European Union, 2021

PDF ISBN 978-92-76-45987-3 doi: 10.2776/112187 KN-01-21-530-EN-N

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List of abbreviations

CA	Contribution Analysis
CCI	Character Code Identifier
CoE(s)	Centre(s) of Excellence
CoC(s)	Centre(s) of Competence
COMP	Competitiveness and Employment objective region
CONV	Convergence objective region
CS	Case studies
DB	Database
DG REGIO	Directorate-General Regional and Urban Policy
EC	European Commission
ERA	European Research Area
ERDF	European Regional Development Fund
ESF	European Social Fund
ESFRI	European Strategy Forum on Research Infrastructures
ESIF	European Structural and Investment Funds
EQ	Evaluation Question
EU	European Union
EUTM	EU trademark
EUR	Euro (currency)
FP	Framework Programme
FP7	Seventh Framework Programme
GDP	Gross Domestic Product
GERD	Gross domestic expenditure on R&D
H2020	Horizon 2020

HEI(s)	Higher Education Institution(s)
ICT	Information and Communication Technology
IPR(s)	Intellectual Property Right(s)
MA(s)	Managing Authority(ies)
MS	Member State(s)
NUTS	Nomenclature des Unités Territoriales Statistiques
OLS	Ordinary least squares
OP(s)	Operational Programme(s)
R&D	Research and Development
RDI	Research Development and Innovation
RIC(s)	Regional Innovation Cluster(s)
RIS	Regional Innovation Strategy
RTD	Research and Technological Development
RTO	Research and Technology Organisation
S3	Smart Specialisation Strategies
S&T	Science and Technology
SFC	System for Fund Management
SG	Steering Group
SME	Small and Medium-Sized Enterprise
STP(s)	Science and Technology Park(s)
TRL(s)	Technology Readiness Level(s)
ToC(s)	Theory of Change(s)
ToR	Terms of References

ABSTRACT

This is the ex-post evaluation of investment in Research and Technological Development (RTD) infrastructures and activities supported by the European Regional Development Fund (ERDF) in the 2007-2013 programming period. It investigates different levels of analysis (at country, Operational Programme, instrument and project level) inspired by theory-based impact evaluation, combining qualitative and quantitative methods.

Findings show that activities originally foreseen in Operational Programmes were successfully executed, with a high level of funds disbursements. The support focused more on strengthening the existing RTD capacities than on transforming regional RTD systems. A positive contribution to R&D capacities was reported especially by infrastructure investments targeting universities, particularly in EU13 regions. The contribution materialised in a higher number of students and tertiary attainments, increase in R&D personnel and researchers and more scientific output.

The main drawback was the lack of observable long-term impacts: improved scientific knowledge did not translate into technological development and innovation. The economic crisis certainly played a role in reducing the capacities, especially of the private sector, to exploit research results. However, synergies and complementarities with existing funding sources were also not always well exploited. Moreover, administrative failures and legal constraints exposed implementations to delays, uncertainties and, for some beneficiaries, financial stress.

RÉSUMÉ

Ce document présente l'évaluation ex post des investissements dans les infrastructures et les activités de recherche et de développement technologique (RDT) soutenus par le Fonds européen de développement régional (FEDER) au cours de la période de programmation 2007-2013. Elle examine différents niveaux d'analyse (au niveau du pays, du programme opérationnel, de l'instrument et du projet) inspirés de l'évaluation d'impact basée sur la théorie, combinant des méthodes qualitatives et quantitatives.

Les résultats montrent que les activités initialement prévues dans les programmes opérationnels ont été exécutées avec succès, avec un niveau élevé de décaissements de fonds. Le soutien s'est davantage concentré sur le renforcement des capacités de RDT existantes que sur la transformation des systèmes régionaux de RDT. Une contribution positive aux capacités de RDT a été signalée en particulier par les investissements en infrastructures ciblant les universités, notamment dans les régions de l'UE13. Cette contribution s'est traduite par un nombre plus élevé d'étudiants et de diplômés de l'enseignement supérieur, une augmentation du personnel de R&D et des chercheurs, ainsi qu'une production scientifique plus importante.

Le principal inconvénient est l'absence d'effets observables à long terme : l'amélioration des connaissances scientifiques ne s'est pas traduite par un développement technologique et une innovation. La crise économique a certainement joué un rôle dans la réduction des capacités, notamment du secteur privé, à exploiter les résultats de la recherche. Cependant, les synergies et les complémentarités avec les sources de financement existantes n'ont pas toujours été bien exploitées. En outre, les défaillances administratives et les contraintes juridiques ont exposé les mises en œuvre à des retards, des incertitudes et, pour certains bénéficiaires, à des tensions financières.

ZUSAMMENFASSUNG

Dies ist die Ex-post-Bewertung von Investitionen in Infrastrukturen und Aktivitäten im Bereich Forschung und technologische Entwicklung (FTE), die vom Europäischen Fonds für regionale Entwicklung (EFRE) in der Förderperiode 2007-2013 unterstützt wurden. Sie untersucht verschiedene Analyseebenen (auf Länder-, Operationeller Programm-, Instrumenten- und Projektebene) in Anlehnung an die theoriegestützte Wirkungsanalyse und kombiniert qualitative und quantitative Methoden.

Die Ergebnisse zeigen, dass die ursprünglich in den Operationellen Programmen vorgesehenen Aktivitäten erfolgreich durchgeführt wurden, wobei ein hohes Maß an Mittelauszahlungen erfolgte. Die Unterstützung konzentrierte sich eher auf die Stärkung der bestehenden FTE-Kapazitäten als auf die Umgestaltung der regionalen FTE-Systeme. Einen positiven Beitrag zu den F&E-Kapazitäten leisteten vor allem die Infrastrukturinvestitionen in die Hochschulen, insbesondere in den EU13-Regionen. Dieser Beitrag schlug sich in einer höheren Zahl von Studenten und Hochschulabschlüssen, einer Zunahme des FuE-Personals und der Forscher sowie in einem höheren wissenschaftlichen Output nieder.

Der größte Nachteil war das weit gehende Fehlen von beobachtbaren langfristigen Auswirkungen: Die verbesserten wissenschaftlichen Kenntnisse schlugen sich nicht in technologischer Entwicklung und Innovation nieder. Die Wirtschaftskrise hat sicherlich dazu beigetragen, dass die Kapazitäten, insbesondere des privaten Sektors, zur Nutzung der Forschungsergebnisse reduziert wurden. Aber auch Synergien und Komplementaritäten mit bestehenden Finanzierungsquellen wurden nicht immer gut genutzt. Darüber hinaus führten Verwaltungsmängel und rechtliche Zwänge zu Verzögerungen, Ungewissheit und für einige Begünstigte zu finanziellem Stress.

Executive summary

The European Commission, Directorate-General Regional and Urban Policy (DG REGIO), has contracted CSIL – Centre for Industrial Studies, in partnership with Prognos and Technopolis Group, to carry out an "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". The evaluation was launched at the end of 2019 and continued until June 2021. This report presents the key findings of the evaluation, triangulating evidence collected from the different tasks performed.

Methodology

This evaluation covered **53 ERDF Operational Programmes (OPs), which invested** EUR 14.64 billion on RTD investments. Within the analysed OPs, the evaluation study focused on **two categories of ERDF expenditure** (01 – RTD activities in research centres, and 02 – RTD infrastructure and centres of competence in a specific technology). The evaluation did not cover public support for investments in firms directly linked to research and innovation, which has been addressed in a previous evaluation of ERDF support for SMEs.

In order to provide a comprehensive assessment, the present evaluation was conducted on the basis of different levels of analysis:

- **OP level:** the evaluation assessed the strategies and policy mixes selected by the OPs. This was done in a more general way for the 53 OPs and in a more specific way for the OPs analyses within seven case studies;
- **Country-level:** this level reviews in detail the use of policy instruments for RTD in different national contexts (including relevant OPs) and the rationale underpinning the policy mix. It was addressed in seven case studies;
- **Instrument level:** this level analyses the "Theories of Change", or TOC (i.e. chains of effects and mechanisms) of selected types of interventions, facilitating the identification of lessons learnt and evidence to support debates and policy considerations.
- **Project and beneficiary level:** this level of analysis explores and describes in detail the diversity of RTD projects funded under the Cohesion Policy in the 53 representative OPs, covering 18 Member States, and classifies them according to defined typologies.

The methodological approach was inspired by theory-based impact evaluation, mapping the causal chain from inputs to outcomes and impact and testing the underlying assumptions. The study went beyond assessing *what* had happened (i.e., the direct effects of the ERDF support for RTD) to explain *why and how* the observed effects had occurred. All methodological activities were theory informed as they intended, first, to reconstruct the rationale of the implemented strategies and instruments and, then, assess the contribution of

ERDF to the observed changes. The study applied the **Contribution Analysis[1] (CA)** approach as a specific form of a theory-based evaluation to assess effectiveness to twenty-one selected individual policy instruments. Moving beyond the standard CA approach, the study analysed the **ToC of individual instruments, examining how they worked as part of a broader "causal package".** The assessment looked not only at outputs, outcomes and impacts but also at a set of supporting factors, pre-conditions and possible risks or threats to the achievement of causal packages.

The study was organised to address a set of evaluation questions concerning the **relevance, coherence, effectiveness, efficiency, added value and sustainability of ERDF support to RTD**. It made use of a combination of different interrelated methods to provide comprehensive answers to the questions. In particular, it included: a mapping of ERDF expenditures by type of project and beneficiary; a cluster analysis describing the RTD performance of EU regions; a literature review to detect the theories of change for the types of instruments; seven case studies at Member-State level addressing nine OPs (including in-depth analyses of three selected policy instruments per case study); a cross-case analysis at the level of four types of interventions; and a seminar with stakeholders and experts to discuss the preliminary results. Finally, it also included an econometric analysis, using multivariate regression and deploying the expenditure data collected from projects and beneficiaries, while testing certain hypotheses regarding the contribution of ERDF instruments to a set of RTD outcomes at the regional level, building on and expanding the qualitative evidence of the case studies.

In addition to statistical indicators and expenditure data, sources of evidence included more than 200 direct interviews with stakeholders and project beneficiaries collected within the framework of the case studies.

Main findings

Rationale of ERDF support to RTD investments

Public support for RTD activities and infrastructures is justified to cope with existing market and system failures and introduce positive externalities into the economic system. In the last decades, a rich literature points **to the need to adopt a systemic approach to RTD public investments**, where **improving and facilitating the interactions and relations of socio-economic actors of territorial RTD systems** should be at the core of the policy. RTD investments meet both the demands of the scientific community in terms of supporting excellent science and the demand for knowledge transfer and innovation for the general benefit of society and the economy.

Support for RTD investments was high on the EU political agenda in the 2007-2013 period, with a target of spending 3% of GDP on R&D across Europe by 2020.

At the beginning of the 2007-2013 programming period, the RTD capacities of the EU regions were concentrated in certain leading regions of Northern and Central Europe. Agglomeration effects existed in most capital and metropolitan regions. Meanwhile, lagging

[1] Mayne (2011)

regions were concentrated in Southern Italy, Greece, Romania and Bulgaria. RTD investment needs were substantial in magnitude but varied in nature.

For all the Central and Eastern European countries that accessed the EU in 2004 and 2007, the 2007-2013 Operational Programmes represented the first systematic set of interventions addressed to the research field. In the selected Western European countries, regional innovation systems were relatively more mature, with a stronger network of universities and research centres and some already extant structures to favour technological diffusion and science-industry collaboration. Nonetheless, there were numerous differences across both countries and regions, both in perceived RTD needs and designed strategic approaches.

The ERDF was expected to play a key role in the 2007-2013 period in supporting RTD capacities across EU regions. It was supposed to contribute and strengthen local or regional networks (or systems) between public and private agents as a place-based approach to support knowledge-based growth.

Over EUR 16 billion of ERDF resources were allocated to support RTD infrastructure, competence centres and activities in the EU Member States and regions.

Funded projects and their rationales

The analysis of expenditure data of 53 OPs illustrates that during the 2007-2013 period, the ERDF invested almost EUR 15 billion to support almost 20,000 RTD projects in the 53 OPs analysed by this evaluation, mainly through non-repayable grants. The largest share of ERDF expenditure (72%) pertained to the **construction of new infrastructure, the modernisation of existing infrastructure, and equipment purchase.** The aim was to promote a technological upgrade of RTD laboratories and build more attractive environments for students and researchers. Almost **60% of the total funds** (almost 80% of the funds for infrastructure development) **were addressed to infrastructure for research**. The main aim of these interventions was to create the necessary conditions to conduct research of the highest international quality. **A minor share** of funds was specifically addressed to provide **ICT infrastructures,** i.e., digitally based services and tools for data and computing-intensive research, seeking to improve the accessibility, interoperability and re-use of scientific data. The remaining expenditure was invested in **upgrading education facilities in universities,** mainly in Poland, but also in Slovakia, Estonia, Germany and the UK; to create an environment and infrastructural base for more modern and interdisciplinary studies in selected fields of specialisation and ultimately to produce a new generation of skilled researchers. This infrastructure-development effort responded to a perceived infrastructure gap, especially among many of the newer Member States of the EU.

The ERDF also funded **R&D activities** through nearly EUR 3 billion. Only **32% of the mapped R&D projects are collaborative, but these account for 56% of the ERDF resources for R&D projects**. Collaborative projects involved, on average, 3.7 beneficiaries - mostly with research providers located in the same region. Data on end beneficiaries reveal that improving science-industry collaborations within local ecosystems was the dominant rationale.

Individual research projects were funded mainly within Higher Education Institutes (HEIs) to strengthen the scientific and technological capacity either in existing fields of research or in emerging areas with great innovation potential.

Mapped projects benefitted about **2,000 institutions, most of them (almost 77%) being public sector organisations**. HEIs and Research and Technology Organisations (RTOs) accounted for almost 88% of the sample of lead beneficiaries and received nearly 83% of the total ERDF contribution. The top ten recipients have concentrated more than 13% of the total ERDF support.

Funded research activities were predominately conducted in **Engineering and Technology, Natural Sciences and Medical and Health Sciences**. The vast majority of projects and expenditure pertains to **applied research**, generally with a possible industrial application.

The rationale underpinning the design and implementation of R&D support instruments was the expectation of triggering three main types of mechanisms: i) seeding early-stage researchers by promoting improved education and training activities for students and early-career researchers; ii) scaling up research activities, performing a higher number of, and more ambitious, research projects with international excellence in specific scientific topics; iii) promoting research projects closer to the research interests and needs of business partners in the regions, while also engaging in increased collaboration with them.

The evaluation revealed **great differences across OPs in how they translated their strategic approaches into policy mixes**. As a result, similar territorial contexts saw the adoption of different combinations of instruments. The Czech Republic, for example, focused almost entirely on RTD infrastructure in universities and public research centres, while Poland and Estonia combined infrastructure investments for research and education with some effort to promote collaborative R&D projects. In Estonia, support focused on Centres of Excellence. In Poland and Romania, science-industry collaboration was promoted through pioneering initiatives of collaborative R&D projects.

Portugal and Italy placed a strong focus on research activities to strengthen research capacities. However, while Portugal focused more on fundamental research, Italy focused on industrial research promoted by the industry in collaboration with research institutes. Countries such as Germany, France, Belgium and Ireland focused more on technology transfer to businesses, the valorisation of research, and support to business R&D in different domains.

Relevance

The evidence collected via the case studies indicates that, in most cases, the **ERDF support for RTD was relevant, meaning that it addressed the most pressing needs of expansion and modernisation of the national RTD systems**. It addressed, in particular, the huge infrastructure gap of Central and Eastern countries. However, the ERDF support also reflected the need to improve science-industry collaboration, mainly in more advanced regions. Overall, the ERDF support to RTD investments concentrated on interventions on the supply side, mainly focused on strengthening the RTD capacities than on improving the performance of the regional RTD systems as a whole.

Project selection was conducted by managing authorities based on a mixed approach. While **infrastructure investments were typically the result of a top-down approach** guided by national road-mapping exercises, research projects followed a more **bottom-up approach, responding to the needs of regional scientific communities** within a well-identified set of scientific and technological priority fields.

Looking at the targeting strategies, it is important to highlight that the dominant approach was more functional than place based. The majority of RTD interventions were geared at supporting **excellence objectives**. ERDF prioritisation strategies targeted territories/institutions/sectors with significant potential or comparative advantages. When the distribution of ERDF support was not geographically driven by eligibility criteria, such as in national OPs in Central and Eastern Europe, **ERDF expenditure was mainly concentrated in urban areas, stronger sectors and more competitive institutions and organisations**. This approach was justified by the need to ensure critical mass, fund absorption and knowledge externalities in more mature territories. Only in a few cases there was a balance between the choice of international or national excellence and territorial cohesion, but overall, the evaluation found a lack of precise context-specific considerations, including territorial imbalances, in the design of the policy. This evaluation however could not provide conclusive evidence about whether the pursue of excellence objectives was made at the expenses of cohesion and may have contributed to increasing the territorial divide.

The observed targeting strategy based on excellence confirms what already noted in the literature as 'innovation paradox', i.e. that regions with a stronger need to invest in RTD seem to be those with a comparatively lower capacity to absorb funding than more mature regions. The **adoption of the Smart Specialisation Strategy in the period 20014-2020** is expected to have offered a workable solution to the innovation paradox and a platform to guide the design of RTD policies in lagging regions. It also possibly offered a more solid theoretical framework to assess the relevance of the adopted policy mix in the different territories, which should be based on a thorough mapping and prioritisation of regional vocation and potential. **Future evaluations should shed light on the extent to which this new approach effectively supported the design and implementation of place based RTD investments,** especially in less developed regions. It should also point to the extent to which this approach has facilitated the understanding of needs, capacities, motivations and interests of the different actors of the system, an aspect that appeared to be weak in the design of 2007-2013 ERDF programmes.

Effectiveness

The main achievement of ERDF support for RTD investment in the period 2007-2013 is a positive and significant contribution to the observed improvement of R&D capacities in the target regions, particularly in EU13 regions. Evidence shows that ERDF investments aimed at modernising education facilities are positively correlated to the **growth rate in the number of tertiary-educated people** and the growth rate of tertiary-educated persons employed in science and technology, in 2007-2017 and within the target regions. The growth rate in the share of tertiary-educated people in the target regions was, on average, 7% in the period under assessment. Investments supported by the ERDF have contributed to this trend by improving the conditions and teaching environments of the target universities, which has attracted more students, not only nationally but also from abroad.

Evidence from the case studies shows that renovated and newly constructed buildings enabled institutions to **accommodate new equipment, which created a better environment** to attract new students and researchers. Evidence further shows that regions with more advanced industrial fabric and higher R&D in the business sector experienced higher growth rates in the number of tertiary educated people employed in science and technology. Problems of absorption capacity of the labour market and labour-market mismatches were specifically reported for Poland but may also apply to other countries.

R&D capacities were further improved in terms of the number of R&D personnel and researchers, with an average growth rate in the target regions of 40% between 2007 and 2017. **ERDF investments in research infrastructures and individual R&D projects in HEIs positively contributed** to the increase in the number of R&D personnel and researchers at the regional level. Infrastructure investments also contributed to the creation or modernisation of public R&D facilities, including ICT-based infrastructures, which increased the potential and capacity of the beneficiary institutions and created more attracting and better performing research and education environments. Individual projects allowed researchers both to enhance existing expertise and to develop new areas of inquiry.

Evidence also points to a **positive and statistically significant relationship between ERDF support and the growth rate in the number of scientific publications**. While a catching-up process in scientific production is particularly visible in the EU13 (145% growth in the volume of publications between 2007 and 2017), it is reasonable to suppose that ERDF investments in HEIs have significantly contributed to this process. Conversely, no relationship is found regarding the *quality* of scientific production (proxied by the growth rate in the number of regional scientific publications in the top25% of most cited publications), which may take longer to catch up.

More limited, however, was the capacity of funded projects to **generate economic benefits from the commercial valorisation of R&D results** and enhance the knowledge transfer capacities and mechanisms from scientific to industry partners. **No statistically significant relationships are found in the econometric analysis between ERDF support and the growth rate of technological outputs**, which confirms the limited uptake of research results observed in the case studies.

The ERDF was not successful in stimulating business R&D, which is the main driver of technological outputs. Evidence from the case studies shows that some **implementation issues were reported for collaborative R&D instruments/projects**, despite reports of generally high interest from beneficiaries. Evidence collected in the field shows that science-industry collaborations did not lead to systematic follow-up projects because of a lack of trust, resources or due to legal problems related to intellectual property rights and technology transfer procedures. Expected results in terms of consolidation of research partnerships showed limited sustainability in the long run. Nonetheless, **some positive results were reported in terms of softer innovation aspects** measured by the growth rate of the EU trademark applications, especially in those regions with higher ERDF expenditures in business support. Positive effects were also reported regarding the managerial capacity of research institutions and the enhancement of their research and innovation capacities.

Overall, there is evidence that the ERDF contributed to building and modernising R&D infrastructure in EU regions, especially those lagging behind. This process of upgrading and improving RTD capacities is especially evident in the EU13, where ERDF contributed to filling the chronic investment gap they had suffered. ERDF investments in 2007-2013 supported the creation of favourable conditions to conduct international-quality research**, helping less developed EU regions to bring their R&I systems closer to EU standards**. Evidence from the cluster analysis of RTD performance in the EU regions shows that half of these regions did not change their relative RTD performance after ten years since the start of the programming period. Although performance improvements were concentrated in stronger regions, some transition regions also saw a catch-up dynamic. Evidence of this evaluation suggests that, **particularly in certain EU13 regions, the ERDF has positively contributed to this catch-up process** of RTD capacities, thus contributing to reducing the disparities among EU regions in performing quality research. Thanks to the combined effects of ERDF investments and favourable framework conditions (including national support to RTD investments), some of the EU13 regions were well equipped to conduct more and better-quality research, contributing to strengthening the EU RTD capacity.

The ERDF was less effective in facilitating the coordination and interactions between all the actors involved in the innovation ecosystem, thus addressing the system failures. In particular, there is **no evidence of an improvement in the science-industry relationship**, which is one of the possible explanations of the observed limited knowledge transfer and innovation uptake. Moreover, while there is a **dominant scale effect of the policy**, where existing systems performed better or maintained a stable performance, **limited if no evidence is available about a transformation of the regional system,** for example in the extent and nature of the science industry links. Indeed, the policy did not move towards a structural transformation in how knowledge is produced, disseminated and exploited. Ultimately, ERDF was less effective in translating the increased research capacity into more competitive territories and regional economies addressing system failures. If this may have come true in a longer time horizon, capitalizing on the investments made with the Smart Specialisation Strategies, it should be verified in future evaluation studies. However, it is important that future evaluations take a more systemic point of view in the assessment. First, by mapping regional systems and their investment needs and, second, by assessing the appropriateness of the observed trajectory of systemic change.

Finally, the present study highlighted the **importance of underlying factors for impact generation** in the implementation of R&D funding - a point widely discussed in the literature. In particular, synergies and complementarities with existing funding sources were not always well exploited. Moreover, administrative failures and legal constraints exposed the implementation to delays, uncertainties, rejections and, indeed, financial stress in a field where timing, long-term commitments and clear rules are crucial incentives for the collaboration of engaged actors.

Coherence

ERDF support for RTD was implemented as **part of a wider policy mix**, including other ERDF policies and other national, regional, and EU initiatives. They all somehow contributed to improving R&D performance in the EU regions. Thus, their respective roles and potential synergies were carefully considered. The role of ERDF differed significantly among regions and countries in terms of financial weight and strategic coherence.

One of the key factors affecting the long-term sustainability of projects was revealed to be the long-lasting strategic and financial commitment to investment priorities, both for private and public organisations. In this regard, the ERDF played a countercyclical role in many regions, representing a ‘safety belt’ for many beneficiaries. One of the evaluation findings is that, in some countries, the ERDF funding in the period 2007-2013 has prevented the erosion of R&D systems in a moment of severe cuts in public funding for education and research, given the induced economic downturn of 2008. Thus, it played a significant substituting role in those countries that were most severely hit by the crisis. Conversely, this may have prevented or delayed the painful restructuring of some national R&D systems, thereby losing the opportunity more selectively to help the most relevant or excellent growth.

Above all, the crisis impacted firms' financial capacity and resources to undertake investments, with a risk of limited fund absorption, especially for those OPs that allocated large resources to collaborative research projects. This underscored the need for **adaptive strategies to cope with changing socio-economic contexts**. Evidence shows that continued public investment in research institutions is key. It allows for follow-up projects to take place that strengthen existing capacities and allow for the development of new ones. Hence, the long-term alignment of ERDF with national and regional RTD strategies becomes a crucial element of success. Resilience in strategy design and implementation is also a crucial element of success in combining different policy instruments and funding schemes.

Coherence with other forms of ERDF support (internal coherence, i.e., coherence with other ERDF measures in the same OP, or ERDF support for RTD by other OPs targeting the same territories) was generally high. There was robust coordination among different OPs and between different priority axes within the same OP, clearly considering possible synergies and complementarity of respective roles.

The ERDF policy mix for RTD was also generally **coherent with regional and national RTD strategies,** especially regarding a strategic alignment of priority sectors and scientific fields. In some countries, when the prevailing rationale was to improve science-industry collaboration, RTD strategies supported by ERDF were often closely linked to objectives of industrial competitiveness. The role of ERDF in shaping national and regional policies was stronger in those countries where it represented a significant share of national or regional R&D expenditure, and therefore mainly in convergence regions.

Despite a high strategic alignment, however, there was often a tacit division of goals between local and ERDF policies and instruments in more operational terms. Coordination was mainly driven by co-financing obligations in these cases, and there was a notable effort to avoid overlapping. In some cases, a lack of political stability and related long-term commitment, and the absence of financial predictability for national RTD strategies, prevented a stronger alignment. In some regions, in the aftermath of the economic crisis in 2008 and subsequent years and shrinking national public expenditures, this also meant the substitution of national funds by ERDF resources.

Good synergies were reported with the ESF, with specific reference to support in the higher-education sector. Here, the combination of ERDF and ESF funding resulted in a limited number of positive examples that showed however significant promise.

ERDF and EU Research and Innovation Framework Programmes were seen as serving related but essentially different purposes. The former mainly provided funds to ensure the enabling conditions to carry out excellent scientific work (through infrastructure investment) and to support applied research benefiting local R&I systems; the latter provided funds for excellent, EU-wide research activities, primarily in fundamental research. Nonetheless, despite ambitions to build on relative strengths and implement projects in continuity between the two funds regarding selected target areas or beneficiaries, no specific arrangements were implemented to facilitate or promote active synergies. No special coordination mechanisms were put in place to implement programmes and specific instruments, mainly because the two funds still followed different implementation mechanisms (e.g., the modality of the selection of the interventions and the object of these interventions). It is not yet clear if this lack of coordination has had some adverse impact on the overall performance of the programs.

Clarity about the 'rules of the game', shared within the common RTD space by science and industry partners and regulating their respective roles and responsibilities while providing the most appropriate incentives for successful partnerships, proved to be decisive. Here, state-aid issues were reported as the most problematic factor in many countries. They are one of the main challenges hampering a more intensive and effective involvement of businesses in the funded projects and follow-up activities. The role and influence of State Aid were more evident in the implementation of policy instruments rather than in their design. **State-aid issues generated uncertainty regarding the eligibility of business enterprises to benefit directly from ERDF and the extent to which the private sector could be involved as users** of the ERDF-funded infrastructures. This had obvious implications on the effectiveness of RTD instruments, especially those which targeted science-industry collaboration. Although State Aid regulation has been later and until recently adjusted and revised to cope with experienced challenges, the question of the coherence between cohesion and competition policy remains open.

Efficiency

Financial concentration is often seen as a desirable outcome of policy action and an indication of efficiency. Evidence collected on funded projects and beneficiaries **highlights a concentration pattern on stronger territories, sectors and leading institutions**. Reflecting existing agglomeration effects of R&D activities and capacities, RTD investments funded by ERDF followed concentration patterns: more than 50% of mapped funds were invested in Poland, Germany and the Czech Republic, while 70% were directed to Convergence regions and 64% to urban areas. ERDF support for RTD was overall sufficiently concentrated to lead to upgrades in both the quality of research infrastructure and research management capacities in most of the countries under investigation. However, its role as "game-changer" or "needle mover" of RTD performance in beneficiary countries and regions was strongly related to the importance of ERDF in the overall national and regional RTD policy mix. As already highlighted, fund concentration on enhancing efficiency may lead to a 'winner-takes-all' dynamic that needs to be addressed with policy action to reduce gaps between winners and losers.

The evaluation also looked at the **efficient use** of financial resources in the management and implementation of interventions, strictly linked to the administrative capacity issue. **The administrative and managerial capacities** of both programme managers and beneficiaries are crucial for effective public spending. Some implementation issues, mainly related to limited administrative capacity or unclear legal framework, were reported especially for collaborative R&D. Uncertainties in the interpretation and application of rules, especially for what concerns State-aid rules, caused delays and generated confusion and adjustments during the implementation process.

It is not novel that administrative capacity can improve the effectiveness of supported instruments but, specifically to RTD, the capacity to ensure selected projects' high scientific quality and their timely selection and funding are identified as key elements. The assurance of a timely and smooth project assessment and selection procedure can improve the quality at entry of funded projects and increase the probability of success. A successful regional

RTD system requires intensive and successful interactions among many different players, alongside multiple stakes and behavioural incentives.

Wider aspects of value for money were out of the scope of this evaluation, given the scale and heterogeneity of the funded interventions which makes it unfeasible to measure and value the produced output in a systematic and comprehensive way.

Sustainability

The long-term financial sustainability of RTD infrastructures was challenging in some cases. The limited use of infrastructure by the private sector and external users made them highly dependent on public funding for the operation and maintenance. This implies that any drop or significant fluctuation in the availability of such resources inevitably posed high financial stress on funded infrastructures, as reported by the case studies. This is particularly important for Major Projects.

The case studies confirm that the collaborative R&D policy instruments were **not fully successful in ensuring the sustainability of the research projects' results**. The weaknesses mainly stem from the less intensive translation of research results into practical innovations. While this was not the primary aim of all the funded projects, it was among the ultimate ambitions of those measures to address network failures of regional innovation systems. On both aspects, the weak point was the unexploited use of supporting infrastructure and poor market orientation of research activities.

Added value

In the broader policy mix, MAs recognise that the main **EU added value was a scale effect produced by accessing a considerable quantity of financial resources**. This holds true especially in the EU13, where ERDF 2007-2013 programmes represented the first systematic set of interventions addressed to the research field after years of underinvestment and limited political priority.

A missed opportunity was the lack of the systematic promotion of interregional or international research collaborations as a potential EU added value. Partnerships of collaborative R&D projects were mainly regional or, albeit only in selected cases, multi-regional within the same country.

EU-wide effects were not among the intended effects of funded instruments. Thus, the contribution of ERDF support to them was more indirect. It occurred through the development of EU-level research communities in specific fields, enabling the construction or upgrading of strategic infrastructures of pan-European relevance (as the later inclusion into the ESFRI roadmap confirms) and also supporting the internationalisation of research communities. It helped **structure and consolidate a European Research Area by promoting the achievement of EU standards in RTD** capacities and production, and this can be claimed to have been the main EU added value of the ERDF support to RTD investments in the period 2007-2013.

Methodological considerations

Beyond the findings related to achievements, the study also allows one to address certain methodological considerations. The consulted experts and stakeholders emphasised that the approach to this ex-post evaluation is quite novel in support for RTD investments, mainly due to its scale, its cross-case analysis, and the strong emphasis on the role of contextual factors. The approach informed by the theory proved especially useful in guiding the evaluation activities and structuring the analysis of individual policy instruments according to a consistent framework. Moreover, it was found that a concept of ToC can be highly useful in the design phase of RTD policy instruments (i.e., in an ex-ante fashion) and in building on the lessons from such evaluations to strengthen our 'foresight' capacities. At the same time, it was noted that further methodological advances are needed. In particular, the experience of this study highlights that a key challenge is how to combine different levels and units of analysis, ensuring at the same time width and depth of the evidence collected. This is particularly important in support for RTD investments, as the unit of analysis typically changes throughout the evaluation exercise, starting from individual operations and ending with innovation ecosystems towards the end of the evaluation.

Policy considerations: an RTD cookbook

The findings of this study suggest that, given the importance of contextual factors, the right combination of ERDF instruments with a broader system of enabling conditions is necessary to achieve the objective of improving regional competitiveness. Based on a comprehensive analysis of achievements and their underlying factors (pre-conditions, supporting factors, risks), the study identifies a list of recommendations that can help avoid common pitfalls in the design and implementation of RTD policy. These represent a sort of 'RTD policy cookbook' for policymakers. Key policy considerations are the following:

- The **preparatory phase** includes the needs assessment for the RTD landscape and the prioritisation process. It should be based on an **in-depth understanding of the existing RTD actors** (i.e., their capacities and expectations, their willingness and incentive to engage in know-how transfer, their territorial distribution), as well as the **national institutional and legal framework** (i.e., administrative capacities, legal constraints, policy framework). Specific points of attention should be the following:
    - The **long-term commitment** of public and private investment benefits from clarity regarding the legal framework. National authorities should guarantee that legislation regarding public procurement, state aid, and other important regulatory areas is sufficiently clear and conducive to a smooth implementation of RTD investments. Clear and effective state-aid rules are important in ensuring that enterprises are eligible for public funding and encouraged to participate in collaborative R&D projects. Administrative burdens related to public procurement should be minimised, and rule changes avoided to reduce delays to projects. Legal constraints and other framework conditions preventing adequate pay for researchers are important factors to consider.
    - Equally importantly, **a clear policy strategy delineating a long-term commitment of public investments** to R&D should be established, communicated and maintained over time, reducing fluctuations in times of crisis. This should include a plan to coordinate the various support

programmes in the field of RTD in the region and country to ensure the effective alignment and complementarity of all funding mechanisms. In this manner, logical continuity for RTD investments in the long research and innovation journey, rather than a clear separation of competencies that may lead to fragmentation, will facilitate follow-up investments.

  - **Programme-management units within MA should be appropriately staffed** and trained. Implementing RTD investment support is a demanding task that requires managerial and entrepreneurial capacity. When these are not already in place, especially in less-developed regions benefiting from large financial envelopes, swift restructuring within responsible administrations should be carried out with dedicated units equipped with necessary staff and competencies.
  - Investment prioritisation and targeting should be informed by an **in-depth understanding of the system failures affecting the regional RTD ecosystem**, looking particularly at the existing relationships between science-industry partners in the region and the drivers that can foster an environment enhancing their collaboration. RTD supply-side investments should be combined with **due consideration of demand-side absorption capacities and constraints.** The absorption capacity of the local labour market or the business sector of trained researchers and advanced technological services offered as a result of the planned investments should be considered. Technology-transfer offices, or permanent collaboration platforms such as competence centres or clusters organisations, can be promoted in those cases where there are possible mismatches between the research supply and actual local demand. Demographic change can have an impact on the territorial absorption potential of RTD capacities. For example, the emigration of students and researchers due to unfavourable framework conditions can dilute the expected local impact of RTD investments and result in the so-called brain-drain phenomenon.
  - In order to improve the sustainability of supported investments, in the design phase, there is the need to further focus R&I support on better use of the supported infrastructure and on market orientation of research activities to support smart economic transformation.
  - Possible trade-offs between excellence and territorial inequality can emerge in the targeting strategy. In a place-based approach, such trade-offs should be addressed by **better considering the local relevance of RTD investments to the territorial context**, avoiding promoting investments motivated by the pursuit of scientific excellence but unrelated to the local business sector and technological capacities.

- During **programme implementation**, it is necessary to ensure transparency and timeliness in both selection procedures and funds disbursement, to prevent delays and ensure that high-quality projects are implemented correctly and produce sustainable results. Positive conditions should be maintained at all times. To do so:
  - Instrumental support from **advisory and support services** may be useful in improving the engagement of stakeholders and ensuring that good-quality projects are prepared. MAs and implementing bodies are encouraged to

guarantee a high level of commitment and willingness to assist during the application process. Capacity building is also essential to develop an awareness of industry needs and the capacity to transfer knowledge. Communication channels can be activated to present and explain R&D results with commercial potential.

- **Administrative procedures for fund disbursement** should be kept as simple as possible to reduce the administrative burden on beneficiaries and any adverse impacts on timely beneficiary payments.
- In selecting infrastructure investments, attention should be paid to ensure **that sufficient and highly qualified R&D and ICT staff** is available that can be employed in the new infrastructure. For long-term financial sustainability, it is crucial that beneficiary infrastructure develop a business model specifying a balanced source of funds. Such models should not rely excessively on one individual source and should maximise the revenue-generating capacity from industrial partners' services.
- The **lasting commitment and interest of private partners vis-à-vis research activities and collaboration with science partners** should be promoted and maintained. Care should be taken to prevent these from being undermined by external shocks or unfavourable contextual conditions.

Résumé exécutif

La Direction générale de la politique régionale et urbaine (DG REGIO) de la Commission européenne a confié au CSIL – Centre d'études industrielles, en partenariat avec Prognos et Technopolis Group, la réalisation d'une « Évaluation des investissements dans les infrastructures et les activités de recherche et de développement technologique (RDT) soutenues par les Fonds européens de développement régional (FEDER) au cours de la période 2007-2013 ». L'évaluation a été lancée fin 2019 et s'est poursuivie jusqu'en juin 2021. Ce rapport présente les principales conclusions de l'évaluation, en triangulant les preuves recueillies à partir des différentes tâches effectuées.

Méthodologie

Cette évaluation a porté sur **53 programmes opérationnels (PO) du FEDER, qui ont consacré** 14,64 milliards d'euros à des investissements de RDT. Dans le cadre des PO analysés, l'étude d'évaluation s'est concentrée sur **deux catégories de dépenses du FEDER** (01 – activités de RDT dans les centres de recherche et 02 – infrastructures de RDT et centres de compétence dans une technologie spécifique). L'évaluation n'a pas couvert le soutien public aux investissements dans des entreprises directement liées à la recherche et à l'innovation, qui a été abordé dans une évaluation précédente du soutien du FEDER aux PME.

Afin de fournir une évaluation complète, la présente évaluation a été réalisée sur la base de différents niveaux d'analyse:

- **Au niveau du PO:** l'évaluation a porté sur les stratégies et les combinaisons de politiques choisies par les PO. Cela a été fait d'une manière plus générale pour les 53 PO et d'une manière plus spécifique pour les analyses des PO au sein de sept études de cas;
- **Au niveau national:** ce niveau examine en détail l'utilisation des instruments politiques pour la RDT dans différents contextes nationaux (y compris les PO pertinents) et la raison d'être qui sous-tend le dosage des politiques. Elle a été abordée dans sept études de cas;
- **Niveau de l'instrument :** ce niveau analyse les "théories du changement", ou TDC (c'est-à-dire les chaînes d'effets et les mécanismes) de types d'interventions sélectionnés, facilitant l'identification des leçons apprises et des preuves pour soutenir les débats et les considérations politiques.
- **Niveau des projets et des bénéficiaires**: ce niveau d'analyse explore et décrit en détail la diversité des projets de RDT financés au titre de la politique de cohésion dans les 53 PO représentatifs, couvrant 18 États membres, et les classe selon des typologies définies.

L'approche méthodologique a été inspirée par l'évaluation d'impact basée sur la théorie, cartographiant la chaîne causale des intrants aux résultats et à l'impact et testant les hypothèses sous-jacentes. L'étude est allée au-delà de l'évaluation de *ce qui* s'était passé (c'est-à-dire les effets directs du soutien du FEDER à la RDT) pour expliquer *pourquoi et comment* les effets observés s'étaient produits. Toutes les activités méthodologiques ont été fondées sur la théorie car elles visaient, d'abord, à reconstruire la logique des stratégies et instruments mis en œuvre et, ensuite, à évaluer la contribution du FEDER aux changements observés. L'étude a appliqué **l'approche de l'analyse des contributions (CBA)** [2] comme une forme spécifique d'évaluation théorique pour évaluer l'efficacité de vingt et un instruments politiques individuels sélectionnés. Allant au-delà de l'approche standard de l'AC, l'étude a analysé la **TdC des instruments individuels, examinant comment ils fonctionnaient dans le cadre d'un « ensemble causal » plus large.** L'évaluation a porté non seulement sur les réalisations, les résultats et les impacts, mais aussi sur un ensemble de facteurs de soutien, de conditions préalables et de risques ou menaces possibles pour la réalisation des paquets de causalité.

L'étude a été organisée pour répondre à un ensemble de questions d'évaluation concernant **la pertinence, la cohérence, l'efficacité, l'efficience, la valeur ajoutée et la durabilité du soutien du FEDER à la RDT.** Elle a utilisé une combinaison de différentes méthodes interdépendantes pour fournir des réponses complètes aux questions. En particulier, elle comprenait: une cartographie des dépenses du FEDER par type de projet et par bénéficiaire; une analyse des clusters décrivant les performances de RDT des régions de l'UE; une revue de la littérature pour détecter les théories du changement pour les types d'instruments; sept études de cas au niveau des États membres portant sur neuf PO (y compris des analyses approfondies de trois instruments politiques sélectionnés par étude de cas); une analyse de cas croisée au niveau de quatre types d'interventions; et un séminaire avec les parties prenantes et les experts pour discuter des résultats préliminaires. Enfin, elle comprenait également une analyse économétrique, utilisant la régression multivariée et déployant les données sur les dépenses collectées auprès des projets et des bénéficiaires, tout en testant certaines hypothèses concernant la contribution des instruments du FEDER à un ensemble de résultats de RDT au niveau régional, en s'appuyant sur et en élargissant les preuves qualitatives des études de cas.

Outre les indicateurs statistiques et les données sur les dépenses, les sources de données comprenaient plus de 200 entretiens directs avec les parties prenantes et les bénéficiaires du projet recueillis dans le cadre des études de cas.

Principales conclusions

Justification du soutien du FEDER aux investissements de RDT

Le soutien public aux activités et aux infrastructures de RDT est justifié pour faire face aux défaillances existantes du marché et du système et pour introduire des externalités positives dans le système économique. Au cours des dernières décennies, une abondante littérature souligne **la nécessité d'adopter une approche systémique des investissements publics de RDT,** où **l'amélioration et la facilitation des interactions et des relations des acteurs socio-économiques des systèmes territoriaux de RDT** devraient être au cœur de la politique. Les investissements de RDT répondent à la fois aux exigences de la communauté scientifique en termes de soutien à l'excellence scientifique et à la demande de transfert de connaissances et d'innovation dans l'intérêt général de la société et de l'économie.

[2] Mayne (2011)

Le soutien aux investissements en RDT figurait en bonne place dans l'agenda politique de l'UE au cours de la période 2007-2013, avec un objectif de consacrer 3 % du PIB à la R&D dans toute l'Europe d'ici 2020.

Au début de la période de programmation 2007-2013, les capacités de RDT des régions de l'UE étaient concentrées dans certaines régions leaders d'Europe du Nord et d'Europe centrale. Des effets d'agglomération existaient dans la plupart des régions capitales et métropolitaines. Dans le même temps, les régions en retard étaient concentrées dans le sud de l'Italie, en Grèce, en Roumanie et en Bulgarie. Les besoins d'investissement en RDT étaient importants par leur ampleur, mais de nature variable.

Pour tous les pays d'Europe centrale et orientale qui ont accédé à l'UE en 2004 et 2007, les programmes opérationnels 2007-2013 ont représenté le premier ensemble systématique d'interventions destiné au domaine de la recherche. Dans certains pays d'Europe occidentale, les systèmes d'innovation régionaux étaient relativement plus matures, avec un réseau renforcé d'universités et de centres de recherche et certaines structures déjà existantes pour favoriser la diffusion technologique et la collaboration science-industrie. Néanmoins, il existait de nombreuses différences entre les deux pays et régions, tant au niveau de la perception des besoins de RDT que des approches stratégiques conçues.

Le FEDER devait jouer un rôle clé au cours de la période 2007-2013 en soutenant les capacités de RDT dans les régions de l'UE. Il était censé contribuer et renforcer les réseaux (ou systèmes) locaux ou régionaux entre les agents publics et privés en tant qu'approche locale pour soutenir la croissance basée sur le savoir.

Plus de 16 milliards d'euros de ressources du FEDER ont été alloués pour soutenir les infrastructures de RDT, les centres de compétences et les activités dans les États membres et les régions de l'UE.

Projets financés et leurs justifications

L'analyse des données de dépenses de 53 PO montre qu'au cours de la période 2007-2013, le FEDER a investi près de 15 milliards d'euros pour soutenir près de 20 000 projets de RDT dans les 53 PO analysés par cette évaluation, principalement par le biais de subventions non remboursables. La part la plus importante des dépenses du FEDER (72 %) concernait la **construction de nouvelles infrastructures, la modernisation des infrastructures existantes et l'achat d'équipements.** L'objectif était de promouvoir une mise à niveau technologique des laboratoires de RDT et de créer des environnements plus attrayants pour les étudiants et les chercheurs. **Près de 60 % du total des fonds** (près de 80 % des fonds pour le développement des infrastructures) **ont été alloués aux infrastructures** pour la **recherche.** L'objectif principal de ces interventions était de créer les conditions nécessaires pour mener des recherches de la plus haute qualité internationale. **Une part mineure** des fonds a été spécifiquement destinée à fournir **des infrastructures TIC,** c'est-à-dire des services et des outils numériques pour la recherche à forte intensité de données et de calcul, afin d'améliorer l'accessibilité, l'interopérabilité et la réutilisation des données scientifiques. Les dépenses restantes ont été investies dans **la modernisation des établissements d'enseignement dans les universités,** principalement en Pologne, mais aussi en Slovaquie, en Estonie, en Allemagne et au Royaume-Uni; pour créer un environnement et une base infrastructurelle pour des études plus modernes et interdisciplinaires dans des domaines de spécialisation sélectionnés et, en fin de compte, pour produire une nouvelle génération de chercheurs qualifiés. Cet effort de développement des infrastructures a répondu à une lacune perçue en matière d'infrastructures, en particulier parmi de nombreux nouveaux États membres de l'UE.

Le FEDER a également financé des **activités de R&D** à hauteur de près de 3 milliards d'euros. Seuls **32% des projets de R&D cartographiés sont collaboratifs, mais ceux-ci représentent 56% des ressources du FEDER pour les projets de R&D.** Les projets collaboratifs ont impliqué, en moyenne, 3,7 bénéficiaires - principalement avec des prestataires de recherche situés dans la même région. Les données sur les bénéficiaires finaux révèlent que l'amélioration des collaborations entre la science et l'industrie au sein des écosystèmes locaux était la raison dominante.

Des projets de recherche individuels ont été financés principalement au sein d'établissements d'enseignement supérieur (EES) afin de renforcer les capacités scientifiques et technologiques, soit dans des domaines de recherche existants, soit dans des domaines émergents à fort potentiel d'innovation.

Les projets cartographiés ont bénéficié à environ **2 000 institutions, la plupart d'entre elles (près de 77%) étant des organisations du secteur public.** Les établissements d'enseignement supérieur et les organisations de recherche et de technologie (ORT) représentaient près de 88 % de l'échantillon de bénéficiaires principaux et recevaient près de 83 % de la contribution totale du FEDER. Les dix premiers bénéficiaires ont concentré plus de 13 % du soutien total du FEDER.

Les activités de recherche financées ont été principalement menées dans les domaines **de l'ingénierie et de la technologie, des sciences naturelles et des sciences médicales et de la santé.** La grande majorité des projets et des dépenses concernent la **recherche appliquée,** généralement avec une application industrielle possible.

La raison d'être de la conception et de la mise en œuvre des instruments de soutien à la R-D était l'espoir de déclencher trois principaux types de mécanismes: i) l'amorçage des chercheurs en début de carrière par la promotion d'activités d'éducation et de formation améliorées pour les étudiants et les chercheurs en début de carrière; ii) intensifier les activités de recherche, réaliser un plus grand nombre de projets de recherche plus ambitieux et d'excellence internationale dans des domaines scientifiques spécifiques; iii) promouvoir des projets de recherche plus proches des intérêts et des besoins de recherche des partenaires commerciaux dans les régions, tout en s'engageant dans une collaboration accrue avec eux.

L'évaluation a révélé **de grandes différences entre les PO dans la façon dont ils ont traduit leurs approches stratégiques en combinaisons de politiques.** Par conséquent, des contextes territoriaux similaires ont vu l'adoption de différentes combinaisons d'instruments. La République tchèque, par exemple, s'est presque entièrement concentrée sur l'infrastructure de RDT dans les universités et les centres de recherche publics, tandis que la Pologne et l'Estonie ont combiné les investissements dans les infrastructures pour la recherche et l'éducation avec un certain effort pour promouvoir des projets de R&D collaboratifs. En Estonie, le soutien s'est concentré sur les centres d'excellence. En Pologne et en Roumanie, la collaboration science-industrie a été encouragée par des initiatives pionnières de projets de R&D collaboratifs.

Le Portugal et l'Italie ont mis l'accent sur les activités de recherche afin de renforcer les capacités de recherche. Cependant, alors que le Portugal se concentrait davantage sur la recherche fondamentale, l'Italie se concentrait sur la recherche industrielle promue par l'industrie en collaboration avec des instituts de recherche. Des pays comme l'Allemagne, la France, la Belgique et l'Irlande se sont davantage concentrés sur le transfert de technologie aux entreprises, la valorisation de la recherche et le soutien à la R&D des entreprises dans différents domaines.

Pertinence

Les preuves recueillies par le biais des études de cas indiquent que, dans la plupart des cas, le soutien du FEDER à la **RDT était pertinent, ce qui signifie qu'il répondait aux besoins les plus urgents d'expansion et de modernisation des systèmes nationaux de RDT.** Il s'est attaqué, en particulier, à l'énorme déficit d'infrastructure des pays du Centre et de l'Est. Toutefois, le soutien du FEDER reflétait également la nécessité d'améliorer la collaboration science-industrie, principalement dans les régions plus avancées. Dans l'ensemble, le soutien du FEDER aux investissements de RDT s'est concentré sur des interventions du côté de l'offre, visant principalement à renforcer les capacités de RDT plutôt qu'à améliorer les performances des systèmes régionaux de RDT dans leur ensemble.

La sélection des projets a été effectuée par les autorités de gestion sur la base d'une approche mixte. Alors que les investissements dans **les infrastructures étaient généralement le résultat d'une approche descendante** guidée par des exercices nationaux de cartographie routière, les projets de recherche suivaient une approche plus **ascendante, répondant aux besoins des communautés scientifiques régionales** dans un ensemble bien identifié de domaines scientifiques et technologiques prioritaires.

En examinant les stratégies de ciblage, il est important de souligner que l'approche dominante était davantage fonctionnelle que l'approche basée sur le lieu. La majorité des interventions de RDT visaient à soutenir des **objectifs d'excellence.** Les stratégies de hiérarchisation des priorités du FEDER ciblaient les territoires/institutions/secteurs présentant des avantages potentiels ou comparatifs significatifs. Lorsque la répartition du soutien du FEDER n'était pas déterminée géographiquement par des critères d'éligibilité, comme dans les PO nationaux d'Europe centrale et orientale, les **dépenses du FEDER étaient principalement concentrées dans les zones urbaines, les secteurs plus forts et les institutions et organisations plus compétitives.** Cette approche était justifiée par la nécessité d'assurer une masse critique, l'absorption des fonds et des externalités des connaissances dans les territoires plus matures. Ce n'est que dans quelques cas qu'il y avait un équilibre entre le choix de l'excellence internationale ou nationale et la cohésion territoriale, mais dans l'ensemble, l'évaluation a révélé un manque de considérations précises spécifiques au contexte, y compris les déséquilibres territoriaux, dans la conception de la politique. Cette évaluation n'a toutefois pas permis de fournir des preuves concluantes quant à savoir si la poursuite des objectifs d'excellence s'est faite au détriment de la cohésion et a pu contribuer à accroître la fracture territoriale.

La stratégie de ciblage observée basée sur l'excellence confirme ce que la littérature a déjà noté comme le « paradoxe de l'innovation », à savoir que les régions ayant un besoin plus fort d'investir dans la RDT semblent être celles qui ont une capacité d'absorption des financements comparativement plus faible que les régions plus matures. **L'adoption de la stratégie de spécialisation intelligente au cours de la période 2014-2020** est censée avoir offert une solution viable au paradoxe de l'innovation et une plate-forme pour guider la conception des politiques de RDT dans les régions en retard. Elle a peut-être aussi offert un cadre théorique plus solide pour évaluer la pertinence du dosage politique adopté dans les différents territoires, qui devrait être basé sur une cartographie et une hiérarchisation approfondie de la vocation et du potentiel régionaux. **Les évaluations futures devraient mettre en lumière la mesure dans laquelle cette nouvelle approche a efficacement soutenu la conception et la mise en œuvre d'investissements de RDT basés sur le lieu,** en particulier dans les régions moins développées. Il convient également de souligner dans quelle mesure cette approche a facilité la compréhension des besoins, des capacités, des motivations et des intérêts des différents acteurs du système, un aspect qui semblait faible dans la conception des programmes du FEDER 2007-2013.

Efficacité

La principale réalisation du soutien du FEDER aux investissements de RDT au cours de la période 2007-2013 est une contribution positive et significative à l'amélioration observée des capacités de R&D dans les régions cibles, en particulier dans les régions de l'UE13. Les données montrent que les investissements du FEDER visant à moderniser les établissements d'enseignement sont positivement corrélés au **taux de croissance du nombre de personnes diplômées de l'enseignement supérieur** et au taux de croissance des personnes diplômées de l'enseignement supérieur employées dans les sciences et la technologie, en 2007-2017 et dans les régions cibles. Le taux de croissance de la part des personnes ayant fait des études supérieures dans les régions cibles était, en moyenne, de 7 % au cours de la période considérée. Les investissements soutenus par le FEDER ont contribué à cette tendance en améliorant les conditions et les environnements d'enseignement des universités cibles, ce qui a attiré davantage d'étudiants, non seulement au niveau national, mais aussi à l'étranger.

Les études de cas montrent que les bâtiments rénovés et nouvellement construits ont permis aux établissements **d'accueillir de nouveaux équipements,** ce qui a créé un meilleur environnement pour attirer de nouveaux étudiants et chercheurs. Les données montrent en outre que les régions dotées d'un tissu industriel plus avancé et d'une R-D plus élevée dans le secteur des entreprises ont connu des taux de croissance plus élevés du nombre de personnes ayant fait des études supérieures employées dans les sciences et la technologie. Des problèmes de capacité d'absorption du marché du travail et des inadéquations du marché du travail ont été spécifiquement signalés pour la Pologne, mais peuvent également s'appliquer à d'autres pays.

Les capacités de R&D ont encore été améliorées en termes de nombre de personnel de R&D et de chercheurs, avec un taux de croissance moyen dans les régions cibles de 40% entre 2007 et 2017. **Les investissements du FEDER dans les infrastructures de recherche et les projets individuels de R&D dans les établissements d'enseignement supérieur** ont contribué positivement à l'augmentation du nombre de personnel de R&D et de chercheurs au niveau régional. Les investissements dans les infrastructures ont également contribué à la création ou à la modernisation d'installations publiques de R&D, y compris des infrastructures fondées sur les TIC, ce qui a accru le potentiel et la capacité des institutions bénéficiaires et créé des environnements de recherche et d'éducation plus attrayants et plus performants. Les projets individuels ont permis aux chercheurs à la fois d'améliorer l'expertise existante et de développer de nouveaux domaines de recherche.

Les données indiquent également une **relation positive et statistiquement significative entre** le soutien du FEDER **et** le taux de croissance du nombre de **publications**

scientifiques. Si un processus de rattrapage de la production scientifique est particulièrement visible dans l'UE13 (croissance de 145 % du volume des publications entre 2007 et 2017), il est raisonnable de supposer que les investissements du FEDER dans les établissements d'enseignement supérieur ont contribué de manière significative à ce processus. Inversement, aucune relation n'est trouvée en ce qui concerne la *qualité* de la production scientifique (représentée par le taux de croissance du nombre de publications scientifiques régionales dans le top 25% des publications les plus citées), qui peut prendre plus de temps à rattraper son retard.

Plus limitée, cependant, était la capacité des projets financés à **générer des avantages économiques à partir de la valorisation commerciale des résultats de la R&D** et à améliorer les capacités et les mécanismes de transfert des connaissances des partenaires scientifiques vers les partenaires industriels. **Aucune relation statistiquement significative n'est trouvée dans l'analyse économétrique entre le soutien du FEDER et le taux de croissance des produits technologiques,** ce qui confirme l'utilisation limitée des résultats de la recherche observés dans les études de cas.

Le FEDER n'a pas réussi à stimuler la R&D des entreprises, qui est le principal moteur des résultats technologiques. Les données issues des études de cas montrent que des problèmes de mise en œuvre de l'environnement ont **été signalés pour des instruments/projets de R&D** collaboratifs, malgré l'intérêt généralement élevé manifesté par les bénéficiaires. Les données recueillies sur le terrain montrent que les collaborations entre la science et l'industrie n'ont pas conduit à des projets de suivi systématiques en raison d'un manque de confiance, de ressources ou de problèmes juridiques liés aux droits de propriété intellectuelle et aux procédures de transfert de technologie. Les résultats attendus en termes de consolidation des partenariats de recherche ont montré une durabilité limitée à long terme. Néanmoins, **certains résultats positifs ont été rapportés en termes d'innovation plus douce,** mesurée par le taux de croissance des demandes de marques de l'UE, en particulier dans les régions où les dépenses du FEDER en soutien aux entreprises sont plus élevées. Des effets positifs ont également été signalés en ce qui concerne la capacité de gestion des établissements de recherche et le renforcement de leurs capacités de recherche et d'innovation.

Dans l'ensemble, il est évident que le FEDER a contribué à la construction et à la modernisation des infrastructures de R&D dans les régions de l'UE, en particulier celles qui sont à la traîne. Ce processus de mise à niveau et d'amélioration des capacités de RDT est particulièrement évident dans l'UE13, où le FEDER a contribué à combler le déficit d'investissement chronique dont il souffrait. Les investissements du FEDER en 2007-2013 ont soutenu la création de conditions favorables à la réalisation de recherches de qualité internationale, **aidant ainsi les régions moins développées de l'UE à rapprocher leurs systèmes de R&I des normes de l'UE.** L'analyse par grappes des performances de RDT dans les régions de l'UE montre que la moitié de ces régions n'ont pas modifié leurs performances relatives en matière de RDT dix ans après le début de la période de programmation. Bien que les améliorations de la performance aient été concentrées dans les régions plus fortes, certaines régions en transition ont également connu une dynamique de rattrapage. Les résultats de cette évaluation suggèrent que, **en particulier dans certaines régions de l'UE13, le FEDER a contribué positivement à ce processus de rattrapage** des capacités de RDT, contribuant ainsi à réduire les disparités entre les régions de l'UE dans la réalisation de recherches de qualité. Grâce aux effets combinés des investissements du FEDER et à des conditions-cadres favorables (y compris le soutien national aux investissements de RDT), certaines régions de l'UE13 étaient bien équipées pour mener des recherches plus approfondies et de meilleure qualité, contribuant ainsi au renforcement de la capacité de RDT de l'UE.

Le FEDER a été moins efficace pour faciliter la coordination et les interactions entre tous les acteurs impliqués dans l'écosystème de l'innovation et ainsi remédier aux défaillances du système. En particulier, il **n'y a aucune preuve d'une amélioration de la relation science-industrie,** ce qui est l'une des explications possibles du transfert limité de connaissances observé et de l'adoption de l'innovation. En outre, bien qu'il y ait un effet d'échelle dominant de la **politique,** où les systèmes existants ont obtenu de meilleurs résultats ou maintenu une performance stable, les preuves **d'une transformation du système régional**, par exemple dans l'étendue et la nature des liens entre la science et l'industrie, **sont limitées**, voire inexistantes. En effet, la politique ne s'est pas orientée vers une transformation structurelle de la manière dont les connaissances sont produites, diffusées et exploitées. En fin de compte, le FEDER a été moins efficace pour traduire l'augmentation de la capacité de recherche en territoires plus compétitifs et en économies régionales pour remédier aux défaillances des systèmes. Si cela a pu se réaliser dans un horizon temporel plus long, en capitalisant sur les investissements réalisés avec les stratégies de spécialisation intelligente, cela devrait être vérifié dans de futures études d'évaluation. Cependant, il est important que les évaluations futures adoptent un point de vue plus systémique dans l'évaluation. Premièrement, en cartographiant les systèmes régionaux et leurs besoins d'investissement et, deuxièmement, en évaluant la pertinence de la trajectoire observée du changement systémique.

Enfin, la présente étude a souligné **l'importance des facteurs sous-jacents pour la génération d'impact** dans la mise en œuvre du financement de la R&D - un point largement discuté dans la littérature. En particulier, les synergies et les complémentarités avec les sources de financement existantes n'ont pas toujours été bien exploitées. En outre, les défaillances administratives et les contraintes juridiques ont exposé la mise en œuvre à des retards, des incertitudes, des rejets et, en fait, des tensions financières dans un domaine où le calendrier, les engagements à long terme et des règles claires sont des incitations cruciales à la collaboration des acteurs engagés.

Cohérence

Le soutien du FEDER à la RDT a été mis en œuvre dans le **cadre d'un *policy mix* plus large,** comprenant d'autres politiques du FEDER et d'autres initiatives nationales, régionales et européennes. Elles ont tous contribué d'une manière ou d'une autre à améliorer les performances de R&D dans les régions de l'UE. Ainsi, leurs rôles respectifs et leurs synergies potentielles ont été soigneusement examinés. Le rôle du FEDER différait considérablement d'une région et d'un pays à l'autre en termes de poids financier et de cohérence stratégique.

L'un des facteurs clés affectant la durabilité à long terme des projets s'est révélé être l'engagement stratégique et financier durable envers les priorités d'investissement, tant pour les organisations privées que publiques. À cet égard, le FEDER a joué un rôle anticyclique dans de nombreuses régions, représentant une « ceinture de sécurité » pour de nombreux bénéficiaires. L'une des conclusions de l'évaluation est que, dans certains pays, le financement du FEDER au cours de la période 2007-2013 a empêché l'érosion des systèmes de R&D à un moment de fortes coupes dans le financement public de l'éducation et de la recherche, compte tenu du ralentissement économique induit en 2008. Ainsi, il a joué un rôle de substitution important dans les pays les plus durement touchés par la crise. Inversement, cela a peut-être empêché ou retardé la restructuration douloureuse de certains systèmes nationaux de R&D, perdant ainsi l'occasion de manière plus sélective de contribuer à la croissance la plus pertinente ou excellente.

Surtout, la crise a eu un impact sur la capacité financière et les ressources des entreprises à entreprendre des investissements, avec un risque d'absorption limitée des fonds, en particulier pour les PO qui ont alloué des ressources importantes à des projets de recherche collaborative. Cela a mis en évidence la nécessité d'adopter des **stratégies d'adaptation pour faire face à l'évolution des contextes socio-économiques.** Les données montrent que l'investissement public continu dans les établissements de recherche est essentiel. Il permet la mise en place de projets de suivi qui renforcent les capacités existantes et permettent le développement de nouvelles capacités. Par conséquent, l'alignement à long terme du FEDER sur les stratégies nationales et régionales de RDT devient un élément crucial du succès. La résilience dans la conception et la mise en œuvre des stratégies est également un élément crucial du succès de la combinaison de différents instruments politiques et régimes de financement.

La cohérence avec d'autres formes de soutien du FEDER (cohérence interne, c'est-à-dire cohérence avec d'autres mesures du FEDER dans le même PO, ou soutien du FEDER à la RDT par d'autres PO ciblant les mêmes territoires) était généralement élevée. Il y avait une coordination solide entre les différents PO et entre les différents axes prioritaires au sein d'un même PO, en tenant clairement compte des synergies possibles et de la complémentarité des rôles respectifs.

Le dosage des politiques du FEDER en matière de RDT était également globalement **cohérent avec les stratégies régionales et nationales de RDT,** en particulier en ce qui concerne un alignement stratégique des secteurs prioritaires et des domaines scientifiques. Dans certains pays, lorsque la logique dominant était d'améliorer la collaboration science-industrie, les stratégies de RDT soutenues par le FEDER étaient souvent étroitement liées aux objectifs de compétitivité industrielle. Le rôle du FEDER dans l'élaboration des politiques nationales et régionales a été renforcé dans les pays où il représentait une part importante des dépenses nationales ou régionales de R&D, et donc principalement dans les régions de convergence.

Toutefois, malgré un alignement stratégique élevé, il y avait souvent une division tacite des objectifs entre les politiques et instruments locaux et du FEDER en termes plus opérationnels. La coordination a été principalement motivée par des obligations de cofinancement dans ces cas, et un effort notable a été fait pour éviter les chevauchements. Dans certains cas, le manque de stabilité politique et d'engagement à long terme qui en a été fait, ainsi que l'absence de prévisibilité financière pour les stratégies nationales de RDT, ont empêché un alignement plus fort. Dans certaines régions, à la suite de la crise économique de 2008 et des années suivantes et de la diminution des dépenses publiques nationales, cela a également signifié la substitution des fonds nationaux par des ressources du FEDER.

De bonnes synergies ont été signalées avec le FSE, avec une référence spécifique au soutien dans le secteur de l'enseignement supérieur. Ici, la combinaison des financements du FEDER et du FSE a donné lieu à un nombre limité d'exemples positifs qui se sont révélés très prometteurs.

Les programmes-cadres de recherche et d'innovation du FEDER et de l'UE ont été considérés comme servant des objectifs connexes mais essentiellement différents. Le premier a principalement fourni des fonds pour garantir les conditions propices à la réalisation d'excellents travaux scientifiques (grâce à des investissements dans les infrastructures) et pour soutenir la recherche appliquée bénéficiant aux systèmes locaux de R&I; le second a fourni des fonds pour d'excellentes activités de recherche à l'échelle de l'UE, principalement dans le domaine de la recherche fondamentale. Néanmoins, malgré les ambitions de s'appuyer sur des forces relatives et de mettre en œuvre des projets dans la continuité entre les deux fonds en ce qui concerne les domaines cibles ou les bénéficiaires sélectionnés, aucun arrangement spécifique n'a été mis en œuvre pour faciliter ou promouvoir des synergies actives. Aucun mécanisme de coordination spécial n'a été mis en place pour mettre en œuvre des programmes et des instruments spécifiques, principalement parce que les deux fonds suivaient encore des mécanismes de mise en œuvre différents (par exemple, la modalité de sélection des interventions et l'objet de ces interventions). Il n'est pas encore clair si ce manque de coordination a eu des répercussions négatives sur le rendement global des programmes.

La clarté des « règles du jeu », partagées au sein de l'espace commun de RDT par les partenaires scientifiques et industriels et réglementant leurs rôles et responsabilités respectifs tout en fournissant les incitations les plus appropriées pour des partenariats fructueux, s'est avérée décisive. Ici, les problèmes d'aides d'État ont été signalés comme le facteur le plus problématique dans de nombreux pays. Ils constituent l'un des principaux défis qui entravent une participation plus intensive et plus efficace des entreprises aux projets financés et aux activités de suivi. Le rôle et l'influence des aides d'État étaient plus évidents dans la mise en œuvre des instruments politiques que dans leur conception. **Les problèmes liés aux aides d'État ont généré une incertitude quant à l'éligibilité des entreprises à bénéficier directement du FEDER et quant à la mesure dans laquelle le secteur privé pourrait être impliqué en tant qu'utilisateurs** des infrastructures financées par le FEDER. Cela a eu des implications évidentes sur l'efficacité des instruments de RDT, en particulier ceux qui ciblaient la collaboration science-industrie. Bien que la réglementation en matière d'aides d'État ait été ultérieurement et jusqu'à récemment adaptée et révisée pour faire face aux défis rencontrés, la question de la cohérence entre la politique de cohésion et la politique de concurrence reste ouverte.

Efficacité

La concentration financière est souvent considérée comme un résultat souhaitable de l'action politique et une indication d'efficacité. Les données recueillies sur les projets financés et les bénéficiaires **mettent en évidence un modèle de concentration sur des territoires, des secteurs et des institutions de premier plan plus forts.** Reflétant les effets d'agglomération existants des activités et des capacités de R&D, les investissements de RDT financés par le FEDER ont suivi des schémas de concentration: plus de 50 % des fonds cartographiés ont été investis en Pologne, en Allemagne et en République tchèque, tandis que 70 % ont été dirigés vers les régions de convergence et 64 % vers les zones urbaines. Le soutien du FEDER à la RDT a été globalement suffisamment concentré pour permettre d'améliorer à la fois la qualité des infrastructures de recherche et les capacités de gestion de la recherche dans la plupart des pays étudiés. Toutefois, son rôle de « changeur de jeu » ou d'« aiguillon » des performances en matière de RDT dans les pays et régions bénéficiaires était fortement lié à l'importance du FEDER dans le dosage global des politiques nationales et régionales de RDT. Comme nous l'avons déjà souligné, la concentration des fonds sur l'amélioration de l'efficacité peut conduire à une dynamique du « gagnant rafle tout » qui doit être abordée par des mesures politiques visant à réduire les écarts entre les gagnants et les perdants.

L'évaluation a également examiné **l'utilisation efficace** des ressources financières dans la gestion et la mise en œuvre des interventions, strictement liée à la question de la capacité administrative. **Les capacités administratives et de gestion** des gestionnaires de programme et des bénéficiaires sont cruciales pour des dépenses publiques efficaces. Certains problèmes de mise en œuvre, principalement liés à une capacité administrative limitée ou à un cadre juridique peu clair, ont été signalés, en particulier pour la R&D collaborative. Les incertitudes dans l'interprétation et l'application des règles, en particulier en ce qui concerne les règles en matière d'aides d'État, ont entraîné des retards et généré de la confusion et des ajustements au cours du processus de mise en œuvre.

Il n'est pas nouveau que la capacité administrative puisse améliorer l'efficacité des instruments soutenus, mais, en particulier pour la RDT, la capacité de garantir la haute qualité scientifique des projets sélectionnés et leur sélection et financement en temps voulu sont identifiées comme des éléments clés. L'assurance d'une procédure d'évaluation et de sélection des projets rapide et harmonieuse peut améliorer la qualité à l'entrée des projets financés et augmenter la probabilité de succès. Un système régional de RDT réussi nécessite des interactions intensives et réussies entre de nombreux acteurs différents, ainsi que de multiples enjeux et incitations comportementales.

Des aspects plus larges de l'optimisation des ressources n'étaient pas du champ d'application de cette évaluation, compte tenu de l'ampleur et de l'hétérogénéité des interventions financées, ce qui rend impossible de mesurer et d'évaluer les résultats produits de manière systématique et globale.

Durabilité

La viabilité financière à long terme des infrastructures de RDT a été difficile dans certains cas. L'utilisation limitée des infrastructures par le secteur privé et les utilisateurs externes les a rendues fortement dépendantes du financement public pour leur fonctionnement et leur maintenance. Cela implique que toute baisse ou fluctuation significative de la disponibilité de ces ressources a inévitablement exercé une forte pression financière sur les infrastructures financées, comme le rapportent les études de cas. Ceci est particulièrement important pour les grands projets.

Les études de cas confirment que les instruments de la politique de R&D collaborative n'ont pas été **pleinement efficaces pour assurer la durabilité des résultats des projets de recherche.** Les faiblesses proviennent principalement de la traduction moins intensive des résultats de la recherche en innovations pratiques. Bien que ce ne soit pas l'objectif principal de tous les projets financés, c'était l'une des ambitions ultimes de ces mesures visant à remédier aux défaillances des réseaux des systèmes d'innovation régionaux. Sur ces deux aspects, le point faible était l'utilisation inexploitée des infrastructures de soutien et la mauvaise orientation des activités de recherche vers le marché.

Valeur ajoutée

Dans le dosage plus large des politiques, les autorités de gestion reconnaissent que la principale **valeur ajoutée de l'UE était un effet d'échelle produit par l'accès à une quantité considérable de ressources financières.** Cela est particulièrement vrai dans l'UE13, où les programmes du FEDER 2007-2013 ont représenté le premier ensemble systématique d'interventions dans le domaine de la recherche après des années de sous-investissement et une priorité politique limitée.

Une occasion manquée a été l'absence de promotion systématique des collaborations de recherche interrégionales ou internationales en tant que valeur ajoutée potentielle de l'UE. Les partenariats de projets de R-D collaboratifs étaient principalement régionaux ou, bien que seulement dans certains cas, multirégionaux au sein d'un même pays.

Les effets à l'échelle de l'UE ne figuraient pas parmi les effets escomptés des instruments financés. Ainsi, la contribution du soutien du FEDER à ces activités a été plus indirecte. Elle s'est produite par le développement de communautés de recherche au niveau de l'UE dans des domaines spécifiques, permettant la construction ou la modernisation d'infrastructures stratégiques d'intérêt paneuropéen (comme le confirme l'inclusion ultérieure dans la feuille de route du Forum stratégique européen sur les infrastructures de recherche (ESFRI) et soutenant également l'internationalisation des communautés de recherche. Il a contribué à structurer et à **consolider un espace européen de la recherche en promouvant la réalisation des normes de l'UE en** matière de capacités et de production de RDT, ce qui peut être considéré comme la principale valeur ajoutée européenne du soutien du FEDER aux investissements de RDT au cours de la période 2007-2013.

Considérations méthodologiques

Au-delà des résultats liés aux réalisations, l'étude permet aussi d'aborder certaines considérations méthodologiques. Les experts et les parties prenantes consultés ont souligné que l'approche de cette évaluation ex post est assez nouvelle en faveur des investissements de RDT, principalement en raison de son ampleur, de son analyse croisée et de l'accent mis sur le rôle des facteurs contextuels. L'approche fondée sur la théorie s'est avérée particulièrement utile pour guider les activités d'évaluation et structurer l'analyse des instruments politiques individuels selon un cadre cohérent. En outre, il a été constaté qu'un concept de TdC peut être très utile dans la phase de conception des instruments de politique de RDT (c'est-à-dire de manière ex ante) et en s'appuyant sur les enseignements tirés de ces évaluations pour renforcer nos capacités de « prospective ». Dans le même temps, il a été noté que de nouvelles avancées méthodologiques sont nécessaires. En particulier, l'expérience de cette étude souligne qu'un défi clé consiste à combiner différents niveaux et unités d'analyse, en assurant en même temps la largeur et la profondeur des preuves recueillies. Ceci est particulièrement important pour soutenir les investissements de RDT, car l'unité d'analyse change généralement tout au long de l'exercice d'évaluation, en commençant par les opérations individuelles et en terminant par les écosystèmes d'innovation vers la fin de l'évaluation.

Considérations politiques : un livre de recettes sur la RDT

Les résultats de cette étude suggèrent que, compte tenu de l'importance des facteurs contextuels, la bonne combinaison des instruments du FEDER avec un système plus large de conditions favorables est nécessaire pour atteindre l'objectif d'amélioration de la compétitivité régionale. Sur la base d'une analyse complète des réalisations et de leurs facteurs sous-jacents (conditions préalables, facteurs de soutien, risques), l'étude identifie une liste de recommandations qui peuvent aider à éviter les pièges courants dans la conception et la mise en œuvre de la politique de RDT. Ceux-ci représentent une sorte de « livre de recettes sur la politique de RDT » pour les décideurs. Les principales considérations stratégiques sont les suivantes :

- La **phase préparatoire** comprend l'évaluation des besoins pour le paysage de la RDT et le processus de hiérarchisation. Elle doit être fondée sur une compréhension approfondie des acteurs de RDT existants (c'est-à-dire leurs capacités et leurs attentes, leur volonté et leur incitation à s'engager dans le transfert de savoir-faire, leur répartition territoriale), ainsi que sur le cadre **institutionnel et juridique national** (c'est-à-dire les capacités administratives, les contraintes juridiques, le cadre politique). Les points d'attention spécifiques devraient être les suivants:
    - **L'engagement à long terme** des investissements publics et privés bénéficie de la clarté du cadre juridique. Les autorités nationales devraient garantir que la législation relative aux marchés publics, aux aides d'État et à d'autres domaines réglementaires importants est suffisamment claire et propice à une mise en œuvre harmonieuse des investissements de RDT. Des règles claires et efficaces en matière d'aides d'État sont importantes pour garantir que les entreprises sont éligibles à un financement public et encouragées à participer à des projets de R&D collaboratifs. Les charges administratives liées aux marchés publics devraient être réduites au minimum et les modifications des règles évitées afin de réduire les retards dans les projets. Les contraintes juridiques et autres conditions-cadres empêchant une rémunération adéquate des chercheurs sont des facteurs importants à prendre en compte.
    - Tout aussi important, **une stratégie politique claire délimitant un engagement à long terme des investissements publics** en faveur de la R-D devrait être établie, communiquée et maintenue au fil du temps, réduisant ainsi les fluctuations en temps de crise. Cela devrait inclure un plan de coordination des différents programmes de soutien dans le domaine de la RDT dans la région et le pays afin d'assurer l'alignement et la complémentarité efficaces de tous les mécanismes de financement. De cette manière, la continuité logique des investissements de RDT dans le long parcours de recherche et d'innovation, plutôt qu'une séparation claire des compétences pouvant conduire à une fragmentation, facilitera les investissements de suivi.
    - **Les unités de gestion de programme au sein de l'autorité de gestion devraient être dotées d'un personnel** et d'une formation appropriés. La mise en œuvre d'un soutien à l'investissement en RDT est une tâche exigeante qui nécessite une capacité managériale et entrepreneuriale. Lorsque celles-ci ne sont pas déjà en place, en particulier dans les régions moins développées bénéficiant d'enveloppes financières importantes, une restructuration rapide au sein des administrations responsables devrait être effectuée avec des unités dédiées dotées du personnel et des compétences nécessaires.

  - La hiérarchisation et le ciblage des investissements devraient s'appuyer sur une **compréhension approfondie des défaillances du système affectant l'écosystème régional de RDT,** en examinant en particulier les relations existantes entre les partenaires scientifiques et industriels de la région et les facteurs qui peuvent favoriser un environnement améliorant leur collaboration. Les investissements de RDT du côté de l'offre devraient être combinés avec **la prise en compte des capacités et des contraintes d'absorption du côté de la demande.** La capacité d'absorption du marché du travail local ou du secteur des entreprises de chercheurs formés et des services technologiques de pointe offerts à la suite des investissements prévus devrait être prise en compte. Les bureaux de transfert de technologie, ou les plates-formes de collaboration permanentes telles que les centres de compétences ou les organisations de clusters, peuvent être encouragés dans les cas où il existe des inadéquations possibles entre l'offre de recherche et la demande locale réelle. L'évolution démographique peut avoir un impact sur le potentiel d'absorption territoriale des capacités de RDT. Par exemple, l'émigration d'étudiants et de chercheurs due à des conditions-cadres défavorables peut diluer l'impact local attendu des investissements de RDT et entraîner ce que l'on appelle le phénomène de fuite des cerveaux.
  - Afin d'améliorer la durabilité des investissements soutenus, au cours de la phase de conception, il est nécessaire d'axer davantage le soutien à la R&I sur une meilleure utilisation de l'infrastructure soutenue et sur l'orientation vers le marché des activités de recherche pour soutenir une transformation économique intelligente.
  - Des compromis possibles entre l'excellence et l'inégalité territoriale peuvent émerger dans la stratégie de ciblage. Dans une approche fondée sur le lieu, ces compromis devraient être abordés **en tenant mieux compte de la pertinence locale des investissements de RDT** dans le contexte territorial, en évitant de promouvoir des investissements motivés par la poursuite de l'excellence scientifique mais sans rapport avec le secteur des entreprises locales et les capacités technologiques.

- Au cours de la **mise en œuvre** du programme, il est nécessaire d'assurer la transparence et la rapidité des procédures de sélection et des décaissements des fonds, afin d'éviter les retards et de veiller à ce que les projets de haute qualité soient correctement mis en œuvre et produisent des résultats durables. Les conditions positives doivent être maintenues en tout temps. Pour ce faire :
  - Le soutien instrumental des **services consultatifs et d'appui** peut être utile pour améliorer l'engagement des parties prenantes et veiller à ce que des projets de bonne qualité soient préparés. Les autorités de gestion et les organismes de mise en œuvre sont encouragés à garantir un niveau élevé d'engagement et de volonté d'aider pendant le processus de demande. Le renforcement des capacités est également essentiel pour développer une prise de conscience des besoins de l'industrie et la capacité de transférer des connaissances. Les canaux de communication peuvent être activés pour présenter et expliquer les résultats de la R&D à potentiel commercial.
  - **Les procédures administratives de décaissement des fonds** devraient être aussi simples que possible afin de réduire la charge administrative pesant

sur les bénéficiaires et toute incidence négative sur les paiements en temps utile des bénéficiaires.

- Lors de la sélection des investissements dans les infrastructures, il convient de veiller à ce que l'on dispose **d'un personnel suffisant et hautement qualifié en matière de R&D et de TIC** pouvant être employé dans la nouvelle infrastructure. Pour la viabilité financière à long terme, il est essentiel que l'infrastructure bénéficiaire développe un modèle d'entreprise spécifiant une source équilibrée de fonds. Ces modèles ne devraient pas reposer excessivement sur une seule source individuelle et maximiser la capacité génératrice de revenus provenant des services des partenaires industriels.
- **L'engagement et l'intérêt durables des partenaires privés vis-à-vis des activités de recherche et de la collaboration avec les partenaires scientifiques** devraient être encouragés et maintenus. Il convient de veiller à ce que ceux-ci ne soient pas compromis par des chocs externes ou des conditions contextuelles défavorables.

Zusammenfassung

Die Europäische Kommission, Generaldirektion Regional- und Stadtpolitik (GD REGIO), hat CSIL - Centre for Industrial Studies in Zusammenarbeit mit Prognos und der Technopolis Group mit der Durchführung einer "Evaluation der Investitionen in Infrastrukturen und Aktivitäten im Bereich Forschung und technologische Entwicklung (FTE), die im Zeitraum 2007-2013 aus dem Europäischen Fonds für regionale Entwicklung (EFRE) gefördert wurden" beauftragt. Die Evaluation wurde Ende 2019 eingeleitet und lief bis Juni 2021. In diesem Bericht werden die wichtigsten Ergebnisse der Evaluierung vorgestellt, wobei die im Rahmen der verschiedenen Aufgaben gesammelten Daten trianguliert werden.

Methode

Die Evaluierung umfasste **53 Operationelle Programme (OP) des EFRE**, in denen 14,64 Milliarden Euro für FTE-Investitionen ausgegeben wurden. Innerhalb der analysierten OPs konzentrierte sich die Evaluierungsstudie auf **zwei Kategorien von EFRE-Ausgaben** (01 - FTE-Tätigkeiten in Forschungszentren und 02 - FTE-Infrastruktur und Kompetenzzentren für eine bestimmte Technologie). Die öffentliche Unterstützung für Investitionen in Unternehmen, die in direktem Zusammenhang mit Forschung und Innovation stehen, war nicht Gegenstand der Evaluierung, die aber in einer früheren Evaluierung der EFRE-Unterstützung für KMU behandelt wurde.

Um eine umfassende Bewertung vorzunehmen, wurde die vorliegende Bewertung auf der Grundlage verschiedener Analyseebenen durchgeführt:

- **OP-Ebene**: Bei der Bewertung wurden die von den OPs gewählten Strategien und Policy-Mixes beurteilt. Dies geschah auf allgemeinere Weise für die 53 OPs und auf spezifischere Weise für die OP-Analysen innerhalb von sieben Fallstudien;
- **Länderebene**: Auf dieser Ebene werden der Einsatz politischer Instrumente für die FTE in verschiedenen nationalen Kontexten (einschließlich relevanter OPs) und die dem Policy-Mix zugrunde liegenden Überlegungen im Detail untersucht. Sie wurde in sieben Fallstudien behandelt;
- **Instrumentenebene**: Auf dieser Ebene werden die "Theories of Change" oder TOC (d. h. Wirkungsketten und Mechanismen) ausgewählter Arten von Interventionen analysiert, was die Ermittlung von Erkenntnissen und Beweisen zur Unterstützung von Debatten und politischen Überlegungen erleichtert.
- **Projekt- und Begünstigtenebene**: Auf dieser Analyseebene wird die Vielfalt der im Rahmen der Kohäsionspolitik finanzierten FTE-Projekte in den 53 repräsentativen OPs, die 18 Mitgliedstaaten abdecken, im Detail untersucht und beschrieben und nach definierten Typologien klassifiziert.

Der methodische Ansatz orientierte sich an der theoriegestützten Wirkungsevaluierung, die die Kausalkette von den Inputs zu den Ergebnissen und Auswirkungen abbildet und die zugrunde liegenden Annahmen überprüft. Die Studie ging über die Bewertung dessen, was geschehen war (d. h. die direkten Auswirkungen der EFRE-Unterstützung für FTE) hinaus, um zu erklären, warum und wie die beobachteten Auswirkungen eingetreten waren. Alle methodischen Aktivitäten waren theoriegeleitet, da sie darauf abzielten, zunächst die Gründe für die umgesetzten Strategien und Instrumente zu rekonstruieren und dann den Beitrag des

EFRE zu den beobachteten Veränderungen zu bewerten. In der Studie wurde der Ansatz der **Beitragsanalyse**[3] (**Contribution Analysis, CA**) als spezifische Form einer theoriebasierten Bewertung angewandt, um die Wirksamkeit von einundzwanzig ausgewählten einzelnen Politikinstrumenten zu beurteilen. Die Studie ging über den Standard-CA-Ansatz hinaus und **analysierte die Wirkungskette der einzelnen Instrumente, indem sie untersuchte, wie sie als Teil eines umfassenderen "Kausalpakets" funktionierten**. Bei der Bewertung wurden nicht nur Outputs, Ergebnisse und Auswirkungen untersucht, sondern auch eine Reihe von unterstützenden Faktoren, Vorbedingungen und mögliche Risiken oder Gefahren für das Erreichen der Kausalitätspakete.

Die Studie wurde durchgeführt, um eine Reihe von Bewertungsfragen zur **Relevanz, Kohärenz, Wirksamkeit, Effizienz, zum Mehrwert und zur Nachhaltigkeit der EFRE-Unterstützung für FTE** zu beantworten. Sie nutzte eine Kombination verschiedener, miteinander verbundener Methoden, um umfassende Antworten auf diese Fragen zu geben. Sie umfasste insbesondere: eine Kartierung der EFRE-Ausgaben nach Projekttyp und Begünstigtem; eine Cluster-Analyse, die die FTE-Leistung der EU-Regionen beschreibt; eine Literaturrecherche, um die Theorien des Wandels für die Arten von Instrumenten zu ermitteln; sieben Fallstudien auf Ebene der Mitgliedstaaten, die sich mit neun OPs befassen (einschließlich eingehender Analysen von drei ausgewählten politischen Instrumenten pro Fallstudie); eine fallübergreifende Analyse auf der Ebene von vier Arten von Interventionen; und ein Seminar mit Interessenvertretern und Experten, um die vorläufigen Ergebnisse zu diskutieren. Schließlich umfasste sie auch eine ökonometrische Analyse unter Verwendung multivariater Regression und unter Verwendung der bei den Projekten und Begünstigten erhobenen Ausgabendaten, wobei bestimmte Hypothesen hinsichtlich des Beitrags der EFRE-Instrumente zu einer Reihe von FTE-Ergebnissen auf regionaler Ebene getestet wurden, die auf den qualitativen Erkenntnissen der Fallstudien aufbauen und diese erweitern.

Zusätzlich zu den statistischen Indikatoren und Ausgabendaten wurden im Rahmen der Fallstudien mehr als 200 direkte Interviews mit Akteuren und Projektbegünstigten geführt.

Zentrale Erkentnisse

Begründung für die EFRE-Unterstützung von FTE-Investitionen

Die öffentliche Förderung von FTE-Tätigkeiten und -Infrastrukturen ist gerechtfertigt, um bestehende Markt- und Systemmängel auszugleichen und positive externe Effekte in das Wirtschaftssystem einzubringen. In den letzten Jahrzehnten wurde in der Literatur umfangreich auf **die Notwendigkeit hingewiesen, bei öffentlichen FTE-Investitionen einen systemischen Ansatz zu verfolgen**, bei dem **die Verbesserung und Erleichterung der Interaktionen und Beziehungen zwischen den sozioökonomischen Akteuren der territorialen FTE-Systeme** im Mittelpunkt der Politik stehen sollte. FTE-Investitionen erfüllen sowohl die Anforderungen der wissenschaftlichen Gemeinschaft an die Förderung exzellenter Wissenschaft als auch die Nachfrage nach Wissenstransfer und Innovation zum allgemeinen Nutzen der Gesellschaft und der Wirtschaft.

[3] Mayne (2011)

Die Unterstützung von FTE-Investitionen stand im Zeitraum 2007-2013 ganz oben auf der politischen Agenda der EU, mit dem Ziel, bis 2020 europaweit 3% des BIP für FuE auszugeben.

Zu Beginn der Förderperiode 2007-2013 konzentrierten sich die FTE-Kapazitäten der EU-Regionen auf bestimmte führende Regionen in Nord- und Mitteleuropa. Agglomerationseffekte gab es in den meisten Hauptstadt- und Metropolregionen. Die weniger entwickelten Regionen befanden sich dagegen in Süditalien, Griechenland, Rumänien und Bulgarien. Der FTE-Investitionsbedarf war erheblich, aber von unterschiedlicher Art.

Für alle mittel- und osteuropäischen Länder, die der EU zwischen 2004 und 2007 beigetreten sind, stellten die operationellen Programme 2007-2013 die erste systematische Reihe von Interventionen im Forschungsbereich dar. In den ausgewählten westeuropäischen Ländern waren die regionalen Innovationssysteme relativ ausgereift, mit einem stärkeren Netzwerk von Universitäten und Forschungszentren und einigen bereits bestehenden Strukturen zur Förderung der technologischen Verbreitung und der Zusammenarbeit zwischen Wissenschaft und Industrie. Dennoch gab es sowohl in den Ländern als auch in den Regionen zahlreiche Unterschiede, sowohl was den wahrgenommenen FTE-Bedarf als auch was die strategischen Ansätze betrifft.

Der EFRE sollte im Zeitraum 2007-2013 eine Schlüsselrolle bei der Unterstützung der FTE-Kapazitäten in allen EU-Regionen spielen. Er sollte dazu beitragen, lokale oder regionale Netzwerke (oder Systeme) zwischen öffentlichen und privaten Akteuren als ortsbezogenen Ansatz zur Förderung des wissensbasierten Wachstums zu stärken.

Über 16 Mrd. EUR an EFRE-Mitteln wurden für die Unterstützung von FTE-Infrastrukturen, Kompetenzzentren und Aktivitäten in den EU-Mitgliedstaaten und Regionen bereitgestellt.

Geförderte Projekte und ihre Begründungen

Die Analyse der Ausgabendaten von 53 OPs zeigt, dass der EFRE im Zeitraum 2007-2013 fast 15 Mrd. EUR zur Unterstützung von fast 20.000 FTE-Projekten in den 53 von dieser Evaluierung analysierten OPs investierte, hauptsächlich in Form von nicht rückzahlbaren Zuschüssen. Der größte Teil der EFRE-Ausgaben (72%) entfiel auf den **Bau neuer Infrastrukturen, die Modernisierung bestehender Infrastrukturen und die Anschaffung von Ausrüstung**. Ziel war es, die technologische Modernisierung der FTE-Labors zu fördern und ein attraktiveres Umfeld für Studenten und Forscher zu schaffen. Fast **60% der Gesamtmittel** (fast 80% der Mittel für die Entwicklung der Infrastruktur) **waren für die Forschungsinfrastruktur bestimmt**. Das Hauptziel dieser Maßnahmen bestand darin, die notwendigen Voraussetzungen für die Durchführung von Forschung auf höchstem internationalen Niveau zu schaffen. **Ein kleinerer Teil der Mittel** war speziell für die Bereitstellung von **IKT-Infrastrukturen** bestimmt, d. h. von digital gestützten Diensten und Instrumenten für die daten- und rechnerintensive Forschung, um die Zugänglichkeit, Interoperabilität und Wiederverwendung wissenschaftlicher Daten zu verbessern. Die verbleibenden Ausgaben wurden in die **Modernisierung von Bildungseinrichtungen an Universitäten**, hauptsächlich in Polen, aber auch in der Slowakei, Estland, Deutschland und dem Vereinigten Königreich, investiert, um ein Umfeld und eine infrastrukturelle Basis für modernere und interdisziplinäre Studien in ausgewählten Fachgebieten zu schaffen und letztlich eine neue Generation qualifizierter Forscher hervorzubringen. Diese Bemühungen um die Entwicklung der Infrastruktur waren eine Reaktion auf eine wahrgenommene Infrastrukturlücke, insbesondere in vielen der neueren Mitgliedstaaten der EU.

Der EFRE finanzierte auch **FuE-Aktivitäten** mit fast 3 Mrd. EUR. Nur **32% der erfassten FuE-Projekte sind Verbundprojekte, auf die jedoch 56% der EFRE-Mittel für FuE-Projekte entfallen**. An den Verbundprojekten waren im Durchschnitt 3,7 Begünstigte beteiligt - meist mit Forschungseinrichtungen in derselben Region. Aus den Daten über die Endbegünstigten geht hervor, dass die Verbesserung der Zusammenarbeit zwischen Wissenschaft und Industrie innerhalb lokaler Ökosysteme das Hauptmotiv war.

Einzelne Forschungsprojekte wurden hauptsächlich innerhalb von Hochschulen finanziert, um die wissenschaftlichen und technologischen Kapazitäten entweder in bestehenden Forschungsbereichen oder in neu entstehenden Bereichen mit großem Innovationspotenzial zu stärken.

Die kartierten Projekte kamen etwa **2.000 Einrichtungen** zugute, **von denen die meisten (fast 77%) Organisationen des öffentlichen Sektors waren**. Hochschuleinrichtungen und Forschungs- und Technologieorganisationen (RTOs) machten fast 88% der Stichprobe der Hauptbegünstigten aus und erhielten fast 83% der gesamten EFRE-Beteiligung. Die zehn Hauptempfänger haben mehr als 13% der gesamten EFRE-Unterstützung erhalten.

Die geförderten Forschungsaktivitäten wurden überwiegend in den Bereichen **Ingenieurwesen und Technologie, Naturwissenschaften sowie Medizin und Gesundheit** durchgeführt. Die überwiegende Mehrheit der Projekte und Ausgaben bezieht sich auf die **angewandte Forschung**, im Allgemeinen mit einer möglichen industriellen Anwendung.

Die Konzeption und Umsetzung der F&E-Förderinstrumente beruhte auf der Erwartung, drei Haupttypen von Mechanismen in Gang zu setzen: i) Förderung von Nachwuchsforschern durch verbesserte Aus- und Weiterbildungsmaßnahmen für Studenten und Nachwuchsforscher; ii) Ausweitung der Forschungstätigkeiten, Durchführung einer größeren Anzahl von Forschungsprojekten mit internationalem Spitzenniveau zu bestimmten wissenschaftlichen Themen; iii) Förderung von Forschungsprojekten, die näher an den Forschungsinteressen und -bedürfnissen der Wirtschaftspartner in den Regionen liegen, bei gleichzeitiger verstärkter Zusammenarbeit mit ihnen.

Die Evaluierung deckte **große Unterschiede zwischen den OPs auf in der Art und Weise, wie sie ihre strategischen Ansätze in einen Policy-Mix umgesetzt haben**. Infolgedessen wurden in ähnlichen territorialen Kontexten unterschiedliche Kombinationen von Instrumenten eingesetzt. Die Tschechische Republik beispielsweise konzentrierte sich fast ausschließlich auf die FTE-Infrastruktur in Universitäten und öffentlichen Forschungszentren, während Polen und Estland Infrastrukturinvestitionen für Forschung und Bildung mit einigen Anstrengungen zur Förderung von FuE-Kooperationsprojekten kombinierten. In Estland konzentrierte sich die Unterstützung auf Exzellenzzentren. In Polen und Rumänien wurde die Zusammenarbeit zwischen Wissenschaft und Industrie durch bahnbrechende Initiativen für kooperative FuE-Projekte gefördert.

Portugal und Italien legten einen starken Schwerpunkt auf Forschungsaktivitäten zur Stärkung der Forschungskapazitäten. Während sich Portugal jedoch mehr auf die Grundlagenforschung konzentrierte, legte Italien den Schwerpunkt auf die industrielle Forschung, die von der Industrie in Zusammenarbeit mit Forschungsinstituten gefördert wurde. Länder wie Deutschland, Frankreich, Belgien und Irland konzentrierten sich mehr auf den Technologietransfer an Unternehmen, die Valorisierung der Forschung und die Unterstützung der FuE von Unternehmen in verschiedenen Bereichen.

Relevanz

Aus den Fallstudien geht hervor, dass **die EFRE-Unterstützung für FTE in den meisten Fällen relevant war, d. h., dass sie den dringendsten Bedarf an Erweiterung und Modernisierung der nationalen FTE-Systeme deckte**. Insbesondere wurde damit das große Infrastrukturdefizit in den mittel- und osteuropäischen Ländern angegangen. Die EFRE-Unterstützung spiegelte jedoch auch die Notwendigkeit wider, die Zusammenarbeit zwischen Wissenschaft und Industrie zu verbessern, vor allem in den fortgeschritteneren Regionen. Insgesamt konzentrierte sich die EFRE-Unterstützung für FTE-Investitionen auf Interventionen auf der Angebotsseite, die hauptsächlich auf die Stärkung der FTE-Kapazitäten und weniger auf die Verbesserung der Leistung der regionalen FTE-Systeme insgesamt ausgerichtet waren.

Die Projektauswahl wurde von den Verwaltungsbehörden auf der Grundlage eines gemischten Ansatzes vorgenommen. Während **Infrastrukturinvestitionen in der Regel das Ergebnis eines Top-Down-Ansatzes waren**, der sich an nationalen Roadmapping-Verfahren orientierte, folgten Forschungsprojekte eher einem **Bottom-Up-Ansatz, der auf die Bedürfnisse regionaler wissenschaftlicher Gemeinschaften** innerhalb einer genau festgelegten Reihe wissenschaftlicher und technologischer Prioritätsbereiche abstellte.

Bei der Betrachtung der Zielgruppenstrategien ist es wichtig hervorzuheben, dass der vorherrschende Ansatz eher funktional als ortsbezogen war. Die meisten FTE-Interventionen waren auf die Unterstützung von **Exzellenzzielen** ausgerichtet. Die EFRE-Priorisierungsstrategien zielten auf Gebiete/Einrichtungen/Sektoren mit erheblichem Potenzial oder komparativen Vorteilen ab. In den Fällen, in denen die Verteilung der EFRE-Mittel nicht durch geografische Förderkriterien bestimmt wurde, wie z. B. bei den nationalen OPs in Mittel- und Osteuropa, **konzentrierten sich die EFRE-Ausgaben hauptsächlich auf städtische Gebiete, stärkere Sektoren und wettbewerbsfähigere Einrichtungen und Organisationen**. Dieser Ansatz war durch die Notwendigkeit gerechtfertigt, in reiferen Gebieten eine kritische Masse, die Absorption der Mittel und externe Effekte des Wissens zu gewährleisten. Nur in einigen wenigen Fällen gab es ein Gleichgewicht zwischen der Entscheidung für internationale oder nationale Spitzenleistungen und dem territorialen Zusammenhalt, aber insgesamt stellte die Bewertung fest, dass es bei der Gestaltung der Politik an präzisen kontextspezifischen Überlegungen, einschließlich territorialer Ungleichgewichte, mangelte. Die Bewertung konnte jedoch keine schlüssigen Beweise dafür liefern, ob die Verfolgung von Exzellenzzielen auf Kosten der Kohäsion erfolgte und möglicherweise zur Verstärkung der territorialen Kluft beigetragen hat.

Die beobachtete, auf Exzellenz ausgerichtete Strategie bestätigt, was in der Literatur bereits als "Innovationsparadox" bezeichnet wurde, nämlich dass Regionen mit einem größeren Bedarf an FTE-Investitionen anscheinend eine vergleichsweise geringere Kapazität zur Aufnahme von Finanzmitteln haben als reifere Regionen. Die **Verabschiedung der Strategie der intelligenten Spezialisierung im Zeitraum 2014-2020** dürfte eine praktikable Lösung für das Innovationsparadox und eine Plattform für die Gestaltung der FTE-Politik in weniger entwickelten Regionen geboten haben. Möglicherweise bot sie auch einen solideren theoretischen Rahmen für die Bewertung der Relevanz des angenommenen Policy-Mix in den verschiedenen Gebieten, der auf einer gründlichen Kartierung und Priorisierung der regionalen Berufung und des Potenzials beruhen sollte. **Künftige Evaluationen sollten Aufschluss darüber geben, inwieweit dieser neue Ansatz die Konzeption und Durchführung ortsbezogener FTE-Investitionen**, insbesondere in weniger entwickelten Regionen, **wirksam unterstützt hat**. Es sollte auch aufgezeigt werden, inwieweit dieser Ansatz das Verständnis der Bedürfnisse, Kapazitäten, Motivationen und Interessen der verschiedenen Akteure des Systems erleichtert hat - ein Aspekt, der bei der Konzeption der EFRE-Programme 2007-2013 offenbar zu kurz kam.

Effektivität

Die wichtigste Errungenschaft der EFRE-Unterstützung für FTE-Investitionen im Zeitraum 2007-2013 ist ein positiver und signifikanter Beitrag zur beobachteten Verbesserung der FuE-Kapazitäten in den Zielregionen, insbesondere in den Regionen der EU13. Es ist erwiesen, dass die EFRE-Investitionen zur Modernisierung von Bildungseinrichtungen positiv mit der **Wachstumsrate der Zahl der Personen mit Hochschulbildung** und der Wachstumsrate der in Wissenschaft und Technologie beschäftigten Personen mit Hochschulbildung im Zeitraum 2007-2017 und in den Zielregionen korreliert sind. Die Wachstumsrate des Anteils der Personen mit tertiärem Bildungsabschluss in den Zielregionen lag im Bewertungszeitraum bei durchschnittlich 7%. Die vom EFRE unterstützten Investitionen haben zu diesem Trend beigetragen, indem sie die Bedingungen und das Lehrumfeld der Zieluniversitäten verbessert haben, was nicht nur im Inland, sondern auch im Ausland mehr Studierende angezogen hat.

Aus den Fallstudien geht hervor, dass renovierte und neu errichtete Gebäude es den Einrichtungen ermöglichten, **neue Geräte unterzubringen, wodurch ein besseres Umfeld geschaffen wurde**, um neue Studenten und Forscher anzuziehen. Außerdem zeigt sich, dass Regionen mit einer fortschrittlicheren Industriestruktur und einem höheren FuE-Anteil im Unternehmenssektor höhere Wachstumsraten bei der Zahl der im tertiären Bereich ausgebildeten Beschäftigten in Wissenschaft und Technik aufweisen. Probleme mit der Absorptionskapazität des Arbeitsmarktes und der Diskrepanz zwischen Angebot und Nachfrage auf dem Arbeitsmarkt wurden speziell für Polen berichtet, können aber auch für andere Länder gelten.

Die F&E-Kapazitäten wurden in Bezug auf die Anzahl des F&E-Personals und der Forscher weiter verbessert, mit einer durchschnittlichen Wachstumsrate in den Zielregionen von 40% zwischen 2007 und 2017. **EFRE-Investitionen in Forschungsinfrastrukturen und einzelne FuE-Projekte in Hochschulen** trugen positiv zum Anstieg der Zahl der FuE-Mitarbeiter und Forscher auf regionaler Ebene bei. Infrastrukturinvestitionen trugen auch zur Schaffung oder Modernisierung öffentlicher FuE-Einrichtungen, einschließlich IKT-gestützter Infrastrukturen, bei, wodurch das Potenzial und die Kapazität der begünstigten Einrichtungen erhöht und ein attraktiveres und leistungsfähigeres Forschungs- und Bildungsumfeld geschaffen wurde. Einzelne Projekte ermöglichten es den Forschern, sowohl bestehendes Fachwissen zu erweitern als auch neue Forschungsbereiche zu erschließen.

Es gibt auch Hinweise auf einen **positiven und statistisch signifikanten Zusammenhang zwischen der EFRE-Förderung und der Wachstumsrate bei der Zahl der wissenschaftlichen Veröffentlichungen**. Während in der EU13 ein Aufholprozess in der wissenschaftlichen Produktion besonders deutlich zu erkennen ist (145% Wachstum des Publikationsvolumens zwischen 2007 und 2017), liegt die Vermutung nahe, dass die EFRE-Investitionen in die Hochschulen wesentlich zu diesem Prozess beigetragen haben.

Umgekehrt lässt sich kein Zusammenhang mit der Qualität der wissenschaftlichen Produktion (gemessen an der Wachstumsrate der Anzahl regionaler wissenschaftlicher Veröffentlichungen in den oberen 25% der meistzitierten Publikationen) feststellen, die möglicherweise länger braucht, um aufzuholen.

Die Fähigkeit der geförderten Projekte, **wirtschaftlichen Nutzen aus der kommerziellen Verwertung von FuE-Ergebnissen zu ziehen** und die Kapazitäten und Mechanismen für den Wissenstransfer von Wissenschaftlern zu Industriepartnern zu verbessern, **war dagegen geringer**. **Die ökonometrische Analyse ergab keine statistisch signifikanten Zusammenhänge zwischen der EFRE-Förderung und der Wachstumsrate des technologischen Outputs**, was die in den Fallstudien beobachtete begrenzte Übernahme der Forschungsergebnisse bestätigt.

Der EFRE war nicht erfolgreich bei der Stimulierung der FuE in den Unternehmen, die die Hauptantriebskraft für den technologischen Output ist. Aus den Fallstudien geht hervor, dass bei **kooperativen FuE-Instrumenten/Projekten** trotz des allgemein großen Interesses der Begünstigten **einige Probleme bei der Durchführung** gemeldet wurden. Die vor Ort gesammelten Belege zeigen, dass die Zusammenarbeit zwischen Wissenschaft und Industrie nicht zu systematischen Folgeprojekten führte, weil es an Vertrauen, Ressourcen oder rechtlichen Problemen im Zusammenhang mit Rechten an geistigem Eigentum und Technologietransferverfahren mangelte. Die erwarteten Ergebnisse im Hinblick auf die Konsolidierung von Forschungspartnerschaften erwiesen sich auf lange Sicht als wenig nachhaltig. Nichtsdestotrotz wurden **einige positive Ergebnisse in Bezug auf „weichere" Innovationsaspekte**, gemessen an der Wachstumsrate der EU-Markenanmeldungen, gemeldet, insbesondere in den Regionen mit höheren EFRE-Ausgaben für die Unternehmensförderung. Positive Auswirkungen wurden auch in Bezug auf die Managementkapazitäten von Forschungseinrichtungen und die Verbesserung ihrer Forschungs- und Innovationskapazitäten gemeldet.

Insgesamt gibt es Belege dafür, dass der EFRE zum Aufbau und zur Modernisierung der FuE-Infrastruktur in den EU-Regionen beigetragen hat, insbesondere in den Regionen mit Entwicklungsrückstand. Dieser Prozess der Modernisierung und Verbesserung der FTE-Kapazitäten ist besonders in den EU-13-Regionen zu beobachten, wo der EFRE dazu beigetragen hat, die chronische Investitionslücke zu schließen, unter der sie gelitten hatten. Die EFRE-Investitionen im Zeitraum 2007-2013 unterstützten die Schaffung günstiger Bedingungen für die Durchführung von Forschung auf internationalem Niveau und **halfen den weniger entwickelten EU-Regionen, ihre F&I-Systeme näher an die EU-Standards heranzuführen**. Aus der Clusteranalyse der FTE-Leistung in den EU-Regionen geht hervor, dass die Hälfte dieser Regionen ihre relative FTE-Leistung zehn Jahre nach Beginn der Förderperiode nicht verändert hat. Obwohl sich die Leistungsverbesserungen auf die stärkeren Regionen konzentrierten, gab es auch in einigen Übergangsregionen eine Aufholdynamik. Die Ergebnisse dieser Evaluation deuten darauf hin, dass **der EFRE insbesondere in bestimmten EU13-Regionen einen positiven Beitrag zu diesem Aufholprozess** bei den FTE-Kapazitäten geleistet und damit zur Verringerung der Unterschiede zwischen den EU-Regionen bei der Durchführung hochwertiger Forschung beigetragen hat. Dank der kombinierten Wirkung von EFRE-Investitionen und günstigen Rahmenbedingungen (einschließlich nationaler Unterstützung für FTE-Investitionen) waren einige der EU13-Regionen gut gerüstet, um mehr und qualitativ bessere Forschung zu betreiben, was zur Stärkung der FTE-Kapazitäten der EU beitrug.

Der EFRE war weniger wirksam bei der Erleichterung der Koordinierung und der Interaktionen zwischen allen am Innovationsökosystem beteiligten Akteuren und somit bei der Behebung von Systemmängeln. Insbesondere gibt es **keine Anzeichen für eine Verbesserung der Beziehungen zwischen Wissenschaft und Industrie**, was eine der möglichen Erklärungen für den beobachteten begrenzten Wissenstransfer und die Innovationsaufnahme ist. Darüber hinaus gibt es zwar einen **vorherrschenden Skaleneffekt der Politik**, bei dem die bestehenden Systeme besser abschneiden oder eine stabile Leistung beibehalten, aber es gibt **nur wenige oder gar keine Belege für eine Umgestaltung des regionalen Systems**, z. B. in Bezug auf Umfang und Art der Verbindungen zwischen Wissenschaft und Industrie. In der Tat hat die Politik nicht zu einer strukturellen Veränderung der Art und Weise beigetragen, wie Wissen produziert, verbreitet und genutzt wird. Letztendlich war der EFRE weniger wirksam bei der Umsetzung der erhöhten Forschungskapazitäten in wettbewerbsfähigere Gebiete und regionale Wirtschaften, die sich mit Systemmängeln befassen. Ob dies bei einem längeren Zeithorizont und unter Ausnutzung der mit den Strategien für intelligente Spezialisierung getätigten Investitionen der Fall gewesen wäre, sollte in künftigen Studien überprüft werden. Es ist jedoch wichtig, dass künftige Evaluierungen einen systemischen Blickwinkel bei der Bewertung einnehmen. Erstens durch eine Kartierung der regionalen Systeme und ihres Investitionsbedarfs und zweitens durch eine Bewertung der Angemessenheit des beobachteten Verlaufs des systemischen Wandels.

Schließlich hat die vorliegende Studie die **Bedeutung der grundlegenden Faktoren für die Erzeugung von Auswirkungen** bei der Umsetzung der FuE-Finanzierung hervorgehoben - ein Punkt, der in der Literatur breit diskutiert wird. Insbesondere wurden Synergien und Komplementaritäten mit bestehenden Finanzierungsquellen nicht immer gut genutzt. Darüber hinaus waren administrative Versäumnisse und rechtliche Zwänge bei der Umsetzung von Verzögerungen, Unsicherheiten, Ablehnungen und sogar finanziellem Stress in einem Bereich ausgesetzt, in dem Zeitplanung, langfristige Verpflichtungen und klare Regeln entscheidende Anreize für die Zusammenarbeit engagierter Akteure darstellen.

Kohärenz

Die EFRE-Unterstützung für FTE wurde als **Teil eines umfassenderen Policy-Mix** umgesetzt, der auch andere EFRE-Maßnahmen und andere nationale, regionale und EU-Initiativen umfasst. Sie alle trugen irgendwie zur Verbesserung der F&E-Leistung in den EU-Regionen bei. Daher wurden ihre jeweiligen Aufgaben und potenziellen Synergien sorgfältig geprüft. Die Rolle des EFRE unterschied sich in Bezug auf das finanzielle Gewicht und die strategische Kohärenz erheblich zwischen den Regionen und Ländern.

Als einer der Schlüsselfaktoren für die langfristige Nachhaltigkeit von Projekten erwies sich das langfristige strategische und finanzielle Engagement für Investitionsprioritäten, sowohl für private als auch für öffentliche Einrichtungen. In dieser Hinsicht spielte der EFRE in vielen Regionen eine antizyklische Rolle und stellte für viele Begünstigte einen "Sicherheitsgürtel" dar. Eines der Ergebnisse der Evaluierung ist, dass die EFRE-Finanzierung im Zeitraum 2007-2013 in einigen Ländern die Erosion der F&E-Systeme verhindert hat, als die öffentlichen Mittel für Bildung und Forschung angesichts des wirtschaftlichen Abschwungs von 2008 stark gekürzt wurden. Somit spielte sie in den Ländern, die am stärksten von der Krise betroffen waren, eine wichtige Ersatzrolle. Umgekehrt könnte dies die schmerzhafte Umstrukturierung einiger nationaler F&E-Systeme verhindert oder verzögert haben, wodurch die Chance vertan wurde, selektiver die relevantesten oder hervorragendsten Wachstumsbereiche zu unterstützen.

Vor allem wirkte sich die Krise auf die finanzielle Kapazität und die Ressourcen der Unternehmen zur Durchführung von Investitionen aus, was das Risiko einer begrenzten Mittelabsorption mit sich brachte, insbesondere für diejenigen OPs, die umfangreiche Mittel für Verbundforschungsprojekte bereitstellten. Dies unterstreicht die Notwendigkeit **anpassungsfähiger Strategien zur Bewältigung der sich verändernden sozioökonomischen Rahmenbedingungen**. Es hat sich gezeigt, dass kontinuierliche öffentliche Investitionen in Forschungseinrichtungen von entscheidender Bedeutung sind. Sie ermöglichen Folgeprojekte, die bestehende Kapazitäten stärken und den Aufbau neuer Kapazitäten ermöglichen. Daher wird die langfristige Ausrichtung des EFRE auf nationale und regionale FTE-Strategien zu einem entscheidenden Element des Erfolgs. Auch bei der Kombination verschiedener politischer Instrumente und Finanzierungsformen ist die Belastbarkeit bei der Strategiegestaltung und -umsetzung ein entscheidendes Element für den Erfolg.

Die **Kohärenz mit anderen Formen der EFRE-Unterstützung** (interne Kohärenz, d. h. Kohärenz mit anderen EFRE-Maßnahmen im selben OP oder EFRE-Unterstützung für FTE durch andere OP, die auf dieselben Gebiete abzielen) war im Allgemeinen hoch. Es gab eine solide Koordinierung zwischen verschiedenen OPs und zwischen verschiedenen Prioritätsachsen innerhalb desselben OP, wobei mögliche Synergien und die Komplementarität der jeweiligen Aufgaben klar berücksichtigt wurden.

Der EFRE-Policy-Mix für FTE war im Allgemeinen auch mit **den regionalen und nationalen FTE-Strategien kohärent**, insbesondere im Hinblick auf eine strategische Ausrichtung der prioritären Sektoren und Wissenschaftsbereiche. In einigen Ländern, in denen die Verbesserung der Zusammenarbeit zwischen Wissenschaft und Industrie im Vordergrund stand, waren die vom EFRE unterstützten FTE-Strategien oft eng mit den Zielen der industriellen Wettbewerbsfähigkeit verknüpft. Die Rolle des EFRE bei der Gestaltung nationaler und regionaler Politiken war in den Ländern stärker, in denen er einen bedeutenden Anteil der nationalen oder regionalen F&E-Ausgaben ausmachte, und somit vor allem in den Konvergenzregionen.

Trotz einer hohen strategischen Übereinstimmung gab es jedoch häufig eine stillschweigende Aufteilung der Ziele zwischen den lokalen und den EFRE-Politiken und -Instrumenten in eher operativer Hinsicht. Die Koordinierung wurde in diesen Fällen hauptsächlich durch Kofinanzierungsverpflichtungen vorangetrieben, und es gab bemerkenswerte Bemühungen, Überschneidungen zu vermeiden. In einigen Fällen verhinderten ein Mangel an politischer Stabilität und ein damit verbundenes langfristiges Engagement sowie das Fehlen finanzieller Vorhersehbarkeit für nationale FTE-Strategien eine stärkere Abstimmung. In einigen Regionen bedeutete dies nach der Wirtschaftskrise im Jahr 2008 und in den Folgejahren sowie aufgrund der schrumpfenden nationalen öffentlichen Ausgaben auch die Substitution nationaler Mittel durch EFRE-Mittel.

Gute Synergien wurden mit dem ESF festgestellt, insbesondere bei der Unterstützung des Hochschulsektors. Hier führte die Kombination von EFRE- und ESF-Mitteln zu einer begrenzten Anzahl von positiven Beispielen, die jedoch vielversprechend waren.

Der **EFRE und die EU-Rahmenprogramme für Forschung und Innovation dienten zwar verwandten, aber grundsätzlich unterschiedlichen Zwecken**. Erstere stellten hauptsächlich Mittel zur Verfügung, um die Voraussetzungen für die Durchführung exzellenter wissenschaftlicher Arbeit (durch Infrastrukturinvestitionen) zu schaffen und die angewandte Forschung zu unterstützen, die den lokalen F&I-Systemen zugute kommt; letztere stellten Mittel für exzellente, EU-weite Forschungsaktivitäten bereit, vor allem in der Grundlagenforschung. Trotz der Bestrebungen, auf den relativen Stärken aufzubauen und Projekte in Kontinuität zwischen den beiden Fonds hinsichtlich ausgewählter Zielbereiche oder Begünstigter durchzuführen, wurden keine spezifischen Vereinbarungen getroffen, um aktive Synergien zu erleichtern oder zu fördern. Es wurden keine besonderen Koordinierungsmechanismen für die Durchführung von Programmen und spezifischen Instrumenten eingerichtet, vor allem weil die beiden Fonds immer noch unterschiedliche Durchführungsmechanismen anwenden (z. B. die Modalitäten für die Auswahl der Interventionen und den Gegenstand dieser Interventionen). Es ist noch nicht klar, ob sich dieser Mangel an Koordinierung nachteilig auf die Gesamtleistung der Programme ausgewirkt hat.

Als entscheidend erwies sich die **Klarheit über die "Spielregeln"**, die innerhalb des gemeinsamen FTE-Raums von den Partnern aus Wissenschaft und Industrie geteilt werden und die ihre jeweiligen Rollen und Zuständigkeiten regeln und gleichzeitig die geeignetsten Anreize für erfolgreiche Partnerschaften bieten. In diesem Zusammenhang wurden in vielen Ländern Fragen der staatlichen Beihilfen als der problematischste Faktor genannt. Sie sind eines der Haupthindernisse für eine intensivere und effektivere Beteiligung der Unternehmen an den geförderten Projekten und Folgeaktivitäten. Die Rolle und der Einfluss staatlicher Beihilfen zeigten sich eher bei der Umsetzung der politischen Instrumente als bei deren Gestaltung. **Fragen der staatlichen Beihilfen führten zu Unsicherheiten in Bezug auf die Berechtigung von Unternehmen, direkt vom EFRE zu profitieren, und das Ausmaß, in dem der private Sektor als Nutzer** der EFRE-finanzierten Infrastrukturen einbezogen werden konnte. Dies hatte offensichtliche Auswirkungen auf die Wirksamkeit der FTE-Instrumente, insbesondere derjenigen, die auf die Zusammenarbeit zwischen Wissenschaft und Industrie abzielen. Obwohl die Verordnung über staatliche Beihilfen später und bis vor kurzem angepasst und überarbeitet wurde, um den erfahrenen Herausforderungen gerecht zu werden, bleibt die Frage der Kohärenz zwischen Kohäsions- und Wettbewerbspolitik offen.

Effizienz

Finanzielle Konzentration wird oft als ein wünschenswertes Ergebnis politischer Maßnahmen und als ein Zeichen von Effizienz angesehen. Die über finanzierten Projekte und Begünstigte gesammelten Daten **zeigen ein Konzentrationsmuster auf stärkere Gebiete, Sektoren und führende Einrichtungen**. Entsprechend den bestehenden Agglomerationseffekten von FuE-Aktivitäten und -Kapazitäten folgten die aus dem EFRE finanzierten FTE-Investitionen Konzentrationsmustern: Mehr als 50% der erfassten Mittel wurden in Polen, Deutschland und der Tschechischen Republik investiert, während 70% in Konvergenzregionen und 64% in städtische Gebiete flossen. Die EFRE-Förderung für FTE war insgesamt so konzentriert, dass sie in den meisten untersuchten Ländern zu einer Verbesserung sowohl der Qualität der Forschungsinfrastruktur als auch der Kapazitäten des Forschungsmanagements führte. Die Rolle des EFRE als "game-changer" oder "needle-mover" für die FTE-Leistung in den Empfängerländern und -regionen hing jedoch stark von der Bedeutung des EFRE im gesamten nationalen und regionalen FTE-Politikmix ab. Wie bereits hervorgehoben wurde, kann die Konzentration der Fonds auf die Steigerung der

Effizienz zu einer "winner-takes-all"-Dynamik führen, der mit politischen Maßnahmen begegnet werden muss, um die Kluft zwischen Gewinnern und Verlierern zu verringern.

Die Evaluierung untersuchte auch den **effizienten Einsatz** der Finanzmittel bei der Verwaltung und Durchführung der Maßnahmen, was eng mit der Frage der Verwaltungskapazität zusammenhängt. Die **Verwaltungs- und Managementkapazitäten** sowohl der Programmverwalter als auch der Begünstigten sind von entscheidender Bedeutung für die Wirksamkeit der öffentlichen Ausgaben. Einige Umsetzungsprobleme, die vor allem mit begrenzten Verwaltungskapazitäten oder unklaren rechtlichen Rahmenbedingungen zusammenhängen, wurden insbesondere für die kooperative FuE gemeldet. Unsicherheiten bei der Auslegung und Anwendung von Vorschriften, insbesondere bei den Vorschriften für staatliche Beihilfen, führten zu Verzögerungen, Verwirrung und Anpassungen während des Durchführungsprozesses.

Es ist nicht neu, dass Verwaltungskapazitäten die Wirksamkeit der geförderten Instrumente verbessern können, aber speziell für die FTE wird die Fähigkeit, die hohe wissenschaftliche Qualität ausgewählter Projekte sowie deren rechtzeitige Auswahl und Finanzierung zu gewährleisten, als Schlüsselelement genannt. Die Gewährleistung eines rechtzeitigen und reibungslosen Projektbewertungs- und -auswahlverfahrens kann die Qualität der geförderten Projekte bei ihrem Eintritt verbessern und die Erfolgswahrscheinlichkeit erhöhen. Ein erfolgreiches regionales FTE-System erfordert eine intensive und erfolgreiche Interaktion zwischen vielen verschiedenen Akteuren sowie eine Vielzahl von Anteilen und Verhaltensanreizen.

Weitergehende Aspekte des Kosten-Nutzen-Verhältnisses waren nicht Gegenstand dieser Evaluierung, da der Umfang und die Heterogenität der geförderten Maßnahmen eine systematische und umfassende Messung und Bewertung der erzielten Ergebnisse unmöglich machen.

Nachhaltigkeit

Die **langfristige finanzielle Tragfähigkeit von FTE-Infrastrukturen war in einigen Fällen eine Herausforderung**. Die begrenzte Nutzung der Infrastruktur durch den Privatsektor und externe Nutzer machte sie in hohem Maße von öffentlichen Mitteln für Betrieb und Instandhaltung abhängig. Dies bedeutet, dass jeder Rückgang oder jede erhebliche Schwankung in der Verfügbarkeit solcher Mittel unweigerlich eine große finanzielle Belastung für die finanzierten Infrastrukturen darstellt, wie in den Fallstudien berichtet wird. Dies ist besonders wichtig für Großprojekte.

Die Fallstudien bestätigen, dass die Instrumente der kollaborativen F&E-Politik **nicht in vollem Umfang erfolgreich waren, um die Nachhaltigkeit der Ergebnisse der Forschungsprojekte zu gewährleisten**. Die Schwächen sind vor allem auf die weniger intensive Umsetzung der Forschungsergebnisse in praktische Innovationen zurückzuführen. Dies war zwar nicht das primäre Ziel aller geförderten Projekte, gehörte aber zu den obersten Zielen der Maßnahmen zur Behebung von Netzwerkfehlern in regionalen Innovationssystemen. Bei beiden Aspekten lag der Schwachpunkt in der ungenutzten Verwendung der unterstützenden Infrastruktur und der geringen Marktorientierung der Forschungsaktivitäten.

Mehrwerte

Im Rahmen des breiteren Policy-Mix erkennen die Verwaltungsbehörden an, dass **der wichtigste EU-Mehrwert ein Skaleneffekt war, der durch den Zugang zu einer beträchtlichen Menge an Finanzmitteln erzielt wurde**. Dies gilt vor allem für die EU13, wo die EFRE-Programme 2007-2013 die erste systematische Reihe von Maßnahmen darstellten, die sich an den Forschungsbereich richteten, nachdem jahrelang zu wenig investiert wurde und die politische Priorität begrenzt war.

Eine verpasste Gelegenheit stellte das Fehlen einer systematischen Förderung von interregionalen oder internationalen Forschungskooperationen als potenzieller EU-Mehrwert dar. Partnerschaften für gemeinsame FuE-Projekte waren hauptsächlich regional oder, wenn auch nur in ausgewählten Fällen, multiregional innerhalb desselben Landes.

EU-weite Effekte gehörten nicht zu den angestrebten Wirkungen der geförderten Instrumente. Daher war der Beitrag der EFRE-Unterstützung zu diesen Projekten eher indirekt. Sie erfolgte durch die Entwicklung von Forschungsgemeinschaften auf EU-Ebene in bestimmten Bereichen, die den Aufbau oder die Modernisierung strategischer Infrastrukturen von gesamteuropäischer Bedeutung ermöglichten (wie die spätere Aufnahme in die ESFRI-Roadmap bestätigt) und auch die Internationalisierung von Forschungsgemeinschaften unterstützten. Es trug zur **Strukturierung und Konsolidierung des Europäischen Forschungsraums bei, indem es die Erreichung von EU-Standards bei den FTE-Kapazitäten und der FTE-Produktion förderte**, und dies kann als der wichtigste EU-Mehrwert der EFRE-Unterstützung für FTE-Investitionen im Zeitraum 2007-2013 bezeichnet werden.

Methodische Erwägungen

Abgesehen von den Ergebnissen in Bezug auf das Erreichte bietet die Studie auch die Möglichkeit, bestimmte methodische Überlegungen anzustellen. Die befragten Sachverständigen und Interessengruppen betonten, dass der Ansatz dieser Ex-post-Bewertung bei der Unterstützung von FTE-Investitionen recht neu ist, vor allem wegen seines Umfangs, seiner fallübergreifenden Analyse und der starken Betonung der Rolle von Kontextfaktoren. Der theoretisch fundierte Ansatz erwies sich als besonders nützlich, um die Bewertungsaktivitäten zu lenken und die Analyse der einzelnen politischen Instrumente nach einem einheitlichen Rahmen zu strukturieren. Darüber hinaus hat sich gezeigt, dass ein Konzept von ToC in der Konzeptionsphase von FTE-Politikinstrumenten (d. h. ex-ante) und bei der Nutzung der Lehren aus solchen Evaluierungen zur Stärkung unserer "Vorausschau"-Kapazitäten sehr nützlich sein kann. Gleichzeitig wurde festgestellt, dass weitere methodische Fortschritte erforderlich sind. Insbesondere die Erfahrungen dieser Studie machen deutlich, dass eine zentrale Herausforderung darin besteht, verschiedene Analyseebenen und -einheiten zu kombinieren und gleichzeitig die Breite und Tiefe der gesammelten Erkenntnisse zu gewährleisten. Dies ist besonders wichtig bei der Unterstützung von FTE-Investitionen, da sich die Analyseeinheit in der Regel im Laufe der Evaluierung ändert, angefangen bei einzelnen Operationen bis hin zu Innovationsökosystemen am Ende der Evaluierung.

Politische Überlegungen: ein FTE-Kochbuch

Die Ergebnisse dieser Studie deuten darauf hin, dass in Anbetracht der Bedeutung kontextbezogener Faktoren die richtige Kombination von EFRE-Instrumenten mit einem breiteren System von förderlichen Bedingungen erforderlich ist, um das Ziel der Verbesserung der regionalen Wettbewerbsfähigkeit zu erreichen. Auf der Grundlage einer umfassenden Analyse des Erreichten und der ihm zugrunde liegenden Faktoren (Voraussetzungen, unterstützende Faktoren, Risiken) enthält die Studie eine Liste von Empfehlungen, die dazu beitragen können, häufige Fallstricke bei der Gestaltung und Umsetzung der FTE-Politik zu vermeiden. Diese stellen eine Art "FTE-Politik-Kochbuch" für politische Entscheidungsträger dar. Die wichtigsten politischen Überlegungen sind die folgenden:

- Die **Vorbereitungsphase** umfasst die Bedarfsermittlung für die FTE-Landschaft und den Prozess der Prioritätensetzung. Sie sollte auf einem **eingehenden Verständnis der vorhandenen FTE-Akteure** (d. h. ihrer Kapazitäten und Erwartungen, ihrer Bereitschaft und ihres Anreizes, sich am Know-how-Transfer zu beteiligen, ihrer territorialen Verteilung) sowie des **nationalen institutionellen und rechtlichen Rahmens** (d. h. Verwaltungskapazitäten, rechtliche Zwänge, politischer Rahmen) beruhen. Besondere Aufmerksamkeit sollte den folgenden Punkten gelten:
    - Das **langfristige Engagement** öffentlicher und privater Investitionen profitiert von klaren rechtlichen Rahmenbedingungen. Die nationalen Behörden sollten sicherstellen, dass die Rechtsvorschriften für das öffentliche Auftragswesen, staatliche Beihilfen und andere wichtige Regelungsbereiche hinreichend klar sind und eine reibungslose Durchführung von FTE-Investitionen begünstigen. Klare und wirksame Regeln für staatliche Beihilfen sind wichtig, um zu gewährleisten, dass Unternehmen für öffentliche Mittel in Frage kommen und zur Teilnahme an kooperativen FuE-Projekten ermutigt werden. Der Verwaltungsaufwand im Zusammenhang mit der öffentlichen Auftragsvergabe sollte so gering wie möglich gehalten werden, und Regeländerungen sollten vermieden werden, um Verzögerungen bei Projekten zu vermeiden. Rechtliche Beschränkungen und andere Rahmenbedingungen, die eine angemessene Bezahlung von Forschern verhindern, sind wichtige Faktoren, die berücksichtigt werden müssen.
    - Ebenso wichtig ist **eine klare politische Strategie, die ein langfristiges Engagement der öffentlichen Hand** für F&E festlegt, kommuniziert und im Laufe der Zeit aufrechterhalten wird, um Schwankungen in Krisenzeiten zu verringern. Dazu sollte ein Plan zur Koordinierung der verschiedenen Förderprogramme im Bereich der FTE in der Region und im Land gehören, um die wirksame Abstimmung und Komplementarität aller Finanzierungsmechanismen zu gewährleisten. Auf diese Weise wird die logische Kontinuität der FTE-Investitionen auf dem langen Weg der Forschung und Innovation – und nicht eine klare Trennung der Zuständigkeiten, die zu einer Fragmentierung führen könnte – Folgeinvestitionen erleichtern.
    - Die **Programmverwaltungseinheiten innerhalb der Verwaltungsbehörden sollten personell angemessen ausgestattet** und geschult sein. Die Umsetzung der FTE-Investitionsförderung ist eine anspruchsvolle Aufgabe, die Management- und unternehmerische Kapazitäten erfordert. Wenn diese

nicht bereits vorhanden sind, insbesondere in weniger entwickelten Regionen, die von umfangreichen Finanzmitteln profitieren, sollte eine rasche Umstrukturierung innerhalb der zuständigen Verwaltungen vorgenommen werden, indem spezielle Einheiten mit dem erforderlichen Personal und den erforderlichen Kompetenzen ausgestattet werden.

- Die Festlegung von Investitionsprioritäten und -zielen sollte auf einem **gründlichen Verständnis der Systemmängel beruhen, die das regionale FTE-Ökosystem beeinträchtigen**, wobei insbesondere die bestehenden Beziehungen zwischen den Partnern aus Wissenschaft und Industrie in der Region und die Faktoren zu berücksichtigen sind, die ein Umfeld schaffen können, das ihre Zusammenarbeit fördert. FTE-Investitionen auf der Angebotsseite sollten mit einer **angemessenen Berücksichtigung der Absorptionskapazitäten und -beschränkungen auf der Nachfrageseite kombiniert werden**. Die Absorptionskapazität des lokalen Arbeitsmarktes oder des Unternehmenssektors für ausgebildete Forscher und fortgeschrittene technologische Dienstleistungen, die als Ergebnis der geplanten Investitionen angeboten werden, sollte berücksichtigt werden. Technologietransferbüros oder permanente Kooperationsplattformen wie Kompetenzzentren oder Clusterorganisationen können in den Fällen gefördert werden, in denen möglicherweise ein Missverhältnis zwischen dem Forschungsangebot und der tatsächlichen lokalen Nachfrage besteht. Der demografische Wandel kann sich auf das territoriale Absorptionspotenzial der FTE-Kapazitäten auswirken. So kann beispielsweise die Abwanderung von Studenten und Forschern aufgrund ungünstiger Rahmenbedingungen die erwarteten lokalen Auswirkungen von FTE-Investitionen verwässern und zu dem so genannten Brain-Drain-Phänomen führen.

- Um die Nachhaltigkeit der geförderten Investitionen zu verbessern, muss die F&I-Förderung in der Konzeptionsphase stärker auf eine bessere Nutzung der geförderten Infrastruktur und auf die Marktorientierung der Forschungstätigkeiten ausgerichtet werden, um einen intelligenten wirtschaftlichen Wandel zu unterstützen.

- Mögliche Zielkonflikte zwischen Exzellenz und territorialer Ungleichheit können sich in der Strategie für die Ausrichtung ergeben. In einem ortsbezogenen Ansatz sollten solche Zielkonflikte dadurch angegangen werden, dass **die lokale Relevanz von FTE-Investitionen für den territorialen Kontext besser berücksichtigt wird** und vermieden wird, dass Investitionen gefördert werden, die durch das Streben nach wissenschaftlicher Exzellenz motiviert sind, aber keinen Bezug zum lokalen Unternehmenssektor und den technologischen Kapazitäten haben.

- Während der **Programmdurchführung** ist es notwendig, sowohl bei den Auswahlverfahren als auch bei der Auszahlung der Mittel für Transparenz und Pünktlichkeit zu sorgen, um Verzögerungen zu vermeiden und sicherzustellen, dass qualitativ hochwertige Projekte korrekt durchgeführt werden und nachhaltige Ergebnisse erzielen. Es sollten stets positive Bedingungen aufrechterhalten werden. Um dies zu erreichen:
    - Instrumentelle Unterstützung durch **Beratungs- und Unterstützungsdienste** kann nützlich sein, um das Engagement der Beteiligten zu verbessern und

sicherzustellen, dass Projekte von guter Qualität vorbereitet werden. Zulassungsbehörden und Durchführungsstellen werden ermutigt, ein hohes Maß an Engagement und Bereitschaft zur Unterstützung während des Antragsprozesses zu gewährleisten. Der Aufbau von Kapazitäten ist auch wichtig, um ein Bewusstsein für die Bedürfnisse der Industrie und die Fähigkeit zum Wissenstransfer zu entwickeln. Kommunikationskanäle können aktiviert werden, um F&E-Ergebnisse mit kommerziellem Potenzial zu präsentieren und zu erklären.

- Die **Verwaltungsverfahren für die Auszahlung der Mittel** sollten so einfach wie möglich gehalten werden, um den Verwaltungsaufwand für die Begünstigten und etwaige negative Auswirkungen auf die pünktlichen Zahlungen der Begünstigten zu verringern.
- Bei der Auswahl von Infrastrukturinvestitionen sollte darauf geachtet werden, dass **genügend hochqualifiziertes FuE- und IKT-Personal** zur Verfügung steht, das in der neuen Infrastruktur eingesetzt werden kann. Für die langfristige finanzielle Nachhaltigkeit ist es von entscheidender Bedeutung, dass die begünstigten Infrastrukturen ein Geschäftsmodell entwickeln, das eine ausgewogene Finanzierungsquelle vorsieht. Solche Modelle sollten sich nicht zu sehr auf eine einzelne Quelle stützen und die Fähigkeit zur Erzielung von Einnahmen aus den Dienstleistungen der Industriepartner maximieren.
- Das **dauerhafte Engagement und Interesse privater Partner an Forschungsaktivitäten und der Zusammenarbeit mit wissenschaftlichen Partnern** sollte gefördert und aufrechterhalten werden. Es sollte darauf geachtet werden, dass diese nicht durch externe Schocks oder ungünstige Kontextbedingungen untergraben werden.

1. Introduction

1.1. Objective and scope of the study

The general **objective** of the present study is to perform an **ex-post evaluation of investment in Research and Technological Development (RTD) infrastructures and activities,** as supported by the European Regional Development Fund (ERDF) in the 2007-2013 programming period. Furthermore, there is interest in **understanding the factors** that contribute to the success or failure of these investments. The evaluation study was expected to account for the factors and mechanisms of change underlying given achievements within different socio-economic conditions.

This evaluation focuses on **53 Operational Programmes (OPs)** selected by the European Commission out of the total of 215 OPs funded by the ERDF (see ANNEX I) and covering 18 Member States out of 28 as well as a substantial amount of RTD investments (with EUR 14.64 billion of contribution, i.e., **about 85% of the EU total funding for the relevant themes**) under diverse contexts. Within the selected OPs, the evaluation study focuses on **two categories of ERDF expenditures** (01 – RTD activities in research centres, and 02 – RTD infrastructure and centres of competence in a specific technology)[4]. Public support for investments in firms directly linked to research and innovation is not subject to evaluation[5].

Different levels of analysis were considered:

- **OP level:** this level analyses the strategies and policy mixes put forward by the OPs, their linkage with specific contexts and their linkages with other policies. This was done in a more general way for the 53 OPs and in a more specific way for the OPs analyses within seven case studies
- **Country-level:** this level reviews, in detail, the use of policy instruments for RTD in different national contexts (including relevant OPs), as well as the rationale underpinning the policy mix. It was addressed in seven case studies;
- **Instrumental level:** this level analyses the theories of change (chains of effect and mechanisms) of selected types of intervention, allowing the identification of 'lessons learnt' and providing evidence to support debates and future policy considerations;
- **Project and beneficiary level:** this level of analysis explores and describes in detail the diversity of RTD projects funded under Cohesion Policy in the 53 representative OPs, covering 18 Member States. It also classifies them according to well-defined typologies.

Looking at different levels of analysis yielded complementary benefits, providing different perspectives of analysis, but also challenges when it came to integrating the different pieces of evidence in a unique and uncontradictory evaluative message.

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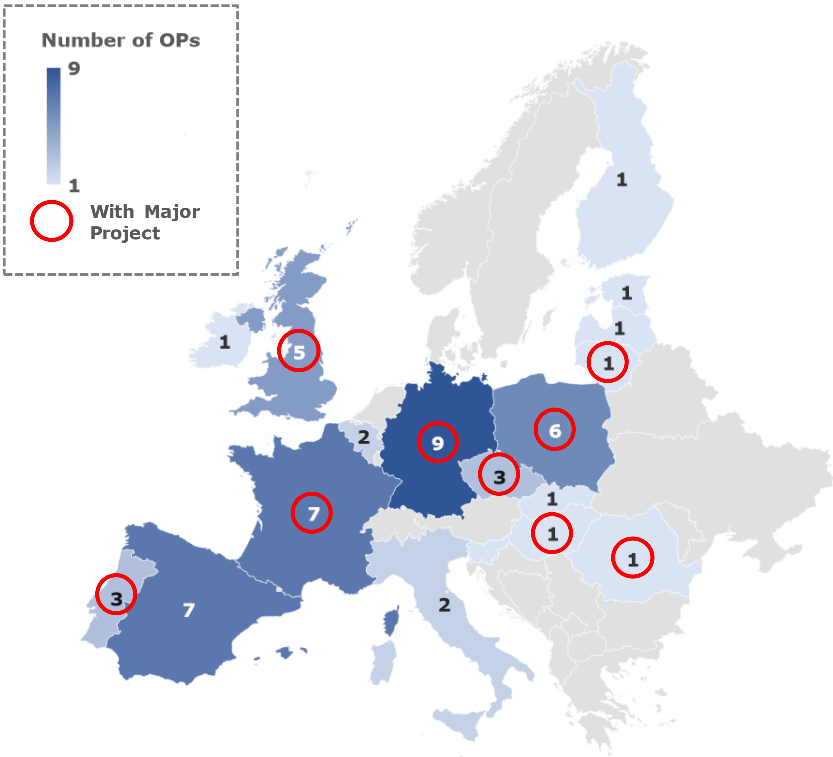
[4] More specifically, they include: support for RTD activities in research centres (e.g., scientific R&D activities; collaborative research activities; support for the internationalisation of research activities; development of researchers and other personnel involved in R&D activities; support for technology-transfer activities; and the valorisation of research results), support for RTD infrastructures, and support for competence centres in a specific technology.

[5] Nonetheless, evidence from Task 1 revealed that, in a limited number of cases, support for RTD activities in SMEs was mistakenly encoded under codes 01 or 02.

Figure 1. Representative sample of 53 Operational Programmes and Member States



Source: Authors

1.2. Methodology

1.2.1. A theory-informed approach to evaluation

The proposed methodological approach stems from the ambition to build a theory-based impact evaluation in the specific context of RTD infrastructures and activities. In particular, the role of the "theory" behind the supported interventions (i.e. the overall rationale and expected supporting factors, pre-conditions 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 econometric analysis. In this way, the study went beyond assessing *what* had happened (i.e., the direct effects of the ERDF support for RTD), and it also tried to provide answers about *why and how* the observed effects had occurred.

For the assessment of the degree of effectiveness of selected policy instruments, the study followed the approach of **Contribution Analysis (CA)** (Mayne, 2011), a specific form of theory-based evaluation that focuses on 'causal relationships and explanatory conclusions between observed changes and specific interventions' (European Commission, 2013). **'Theories of Change' (ToC)** are central to this approach. The aim is to provide evidence to reduce uncertainty rather than to define links between interventions and effects. This approach relies on assumptions that should be made visible as both requirements for and limits to our evaluation.

The principles of CA were used to guide the collection and processing of evidence to provide a judgment on the effectiveness of selected policy instruments in the seven case studies. However, the adopted approach went beyond the standard CA approach in several ways, adapting to the specificity of the evaluation and the need to be operationalised in a manageable yet rigorous way that could be implemented consistently by all country experts performing the field analysis. One specific element expanding beyond the standard CA was considering that **an intervention works as part of a broader 'causal package',** comprising the intervention outputs, a set of support factors, preconditions and possible risks or threats. The assessment of the effectiveness of individual policy instruments was therefore designed along with three main steps:

- Assessing what has changed in the performance of the beneficiaries of ERDF;
- Assessing the extent to which the ERDF has contributed to the observed changes;
- Assessing how and via which mechanisms or contextual factors, outcomes and results materialise.

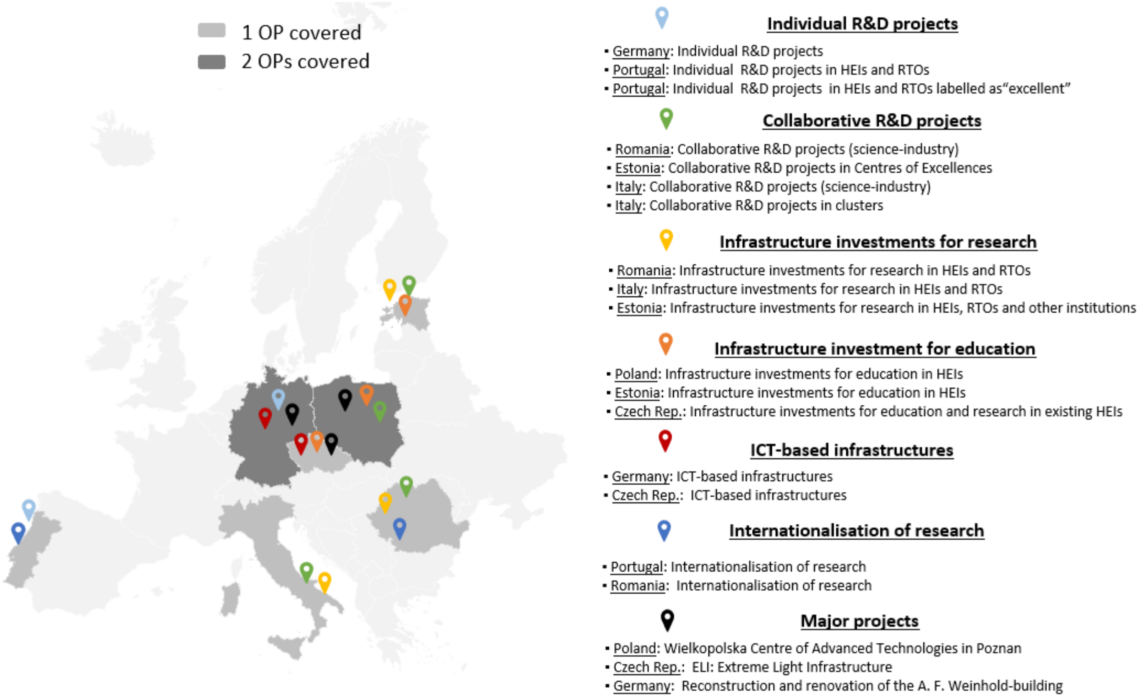
1.2.2. Combined methods for evaluation

This evaluation was guided by a set of **Evaluation Questions** corresponding to several evaluation criteria (see ANNEX II). The evaluation approach relied on a combination of different methods to provide comprehensive answers to the questions (see ANNEX III for a synthetic presentation of the number of observations and stakeholders engaged for each task and method). In particular:

- **A mapping of ERDF expenditures by types of projects and beneficiaries funded by 53 OPs** provided a fine-grained description of what was funded on the ground and the logic underpinning the mix.
- **An analysis of strategies and objectives pursued by the 53 OPs to understand** the funded instruments' motivations and rationales.
- **A cluster analysis** described the RTD performance of EU regions in the period under assessment.
- **A literature review** identified prior theories of change regarding ERDF support for RTD investments and their expected results.
- **Seven case studies** at Member State (MS) level assessed, in detail, a selected number of OPs and their most representative policy instruments (a total of **21 policy instruments were assessed with a contribution analysis**). This was done to build more precise theories about the implemented instruments and collect evidence on observed outcomes and results and the conditions for their materialisation. Primary evidence collected via the case studies came from 200 interviews with managing authorities, stakeholders, final beneficiaries and independent experts.
- **A cross-case analysis,** at the levels of four types of intervention, aggregated and generalised the theories, and results duly crystallised in terms of *what* works, *where,* and according to *which* mechanisms.
- **A seminar** with stakeholders and experts allowed the discussion of preliminary results;
- An **econometric analysis**, employing a multivariate regression and using the data collected from funded projects and beneficiaries, allowed the testing of a set of hypotheses about the contribution of the various types of instruments to a set of regional outcomes (see ANNEX IV). The multivariate analysis permits one to isolate the contribution of specific ERDF types of instrument to specific regional outcomes from other potential factors (these 'other' factors might include, e.g., regional socio-

economic start conditions, other R&D policies beyond the ERDF interventions, etc.). The analysis was not meant to provide an estimation of the size of the observed effects, which was not conceivable given the available data[6], but to offer a complement to the qualitative analysis of the case studies. In combination with the understanding of the causal mechanisms explored in the case studies, the estimated statistical significance expanded and corroborated their findings on the contribution of ERDF interventions to some observed changes.

Figure 2. Map of selected case studies and policy instruments

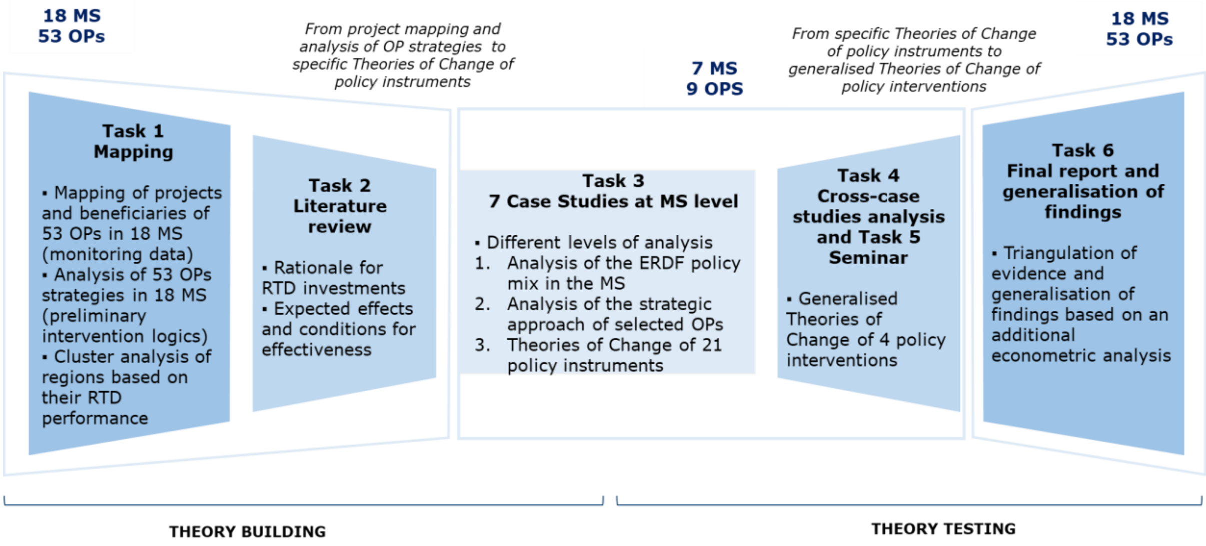


Source: Authors

The combination of different methods was instrumental in collecting a comprehensive set of evidence. Their interconnection 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-cases analysis, econometric 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.

[6] In particular, lacking a control group of non-treated regions, a pure counterfactual method, such as propensity score matching, regression discontinuity design or difference in difference, could not be carried out.

Figure 3. Methodological framework: a combination of methods



Source: Authors

1.3. Limitations and mitigation measures

Despite the huge amount of data and evidence collected via the evaluation activities, some limitations remain. Among these, the most significant are as follows:

- **The scope of the evaluation** is limited to investments supported under expenditure codes 01 and 02. Nevertheless, within the target OPs, other codes of expenditure (see Section 5.1.3) also synergistically contributed to the overarching objective of strengthening the regional RTD systems. This was true, in particular, as far as the contribution of ERDF concerns the objective of bridging the gap between the provision and the use of research results. The distinction between ERDF expenditure codes in this area is rather artificial, also prone to possible miscoding on the part of the MA. Focusing merely on codes 01 and 02 may have limited the capacity of the present evaluation to explore the contribution of ERDF to this strategic objective. Nonetheless, this evaluation could partially address this gap by building on the results of a previous evaluation focused on ERDF support for SME research and innovation (European Commission, 2016b).
- **Evidence on outcome and impact** at the level of individual policy instruments is mostly qualitative and perception-based. Respondents' possible optimism biases were mitigated by triangulating among different stakeholders and by complementing primary evidence with secondary data sources.
- A theory-based impact evaluation was performed on 21 individual instruments, as implemented in seven MS. This was, therefore, **a limited sample of all implemented instruments**. By construction, the contribution analysis aimed to provide evidence to reduce uncertainty regarding the mechanisms underpinning the observed changes, rather than to define links between interventions and observed changes. This approach relies on certain assumptions as both requirements for and limits to our evaluation. A standardised approach to producing the contribution analyses and assessments and to reporting on preconditions, supporting factors and risks, was designed and promoted among the case-study authors. Nevertheless, some degree of discretion may remain in the way judgements are derived, both in terms of the evidential base (particularly, the balance between evidence generated by the case

studies and the existing literature) and the interpretation of such evidence and causal mechanisms.

- The **poor quality of some beneficiary data** (lack of partner beneficiaries for collaborative projects, duplication or missing data) prevented a more in-depth analysis, and it also obstructed systematic matching with external databases (for instance, matching with the CORDIS database could be carried out only for the selected OPs of the case studies).

Despite these limitations, the triangulation of data sources and extensive discussions with country experts, senior advisors, 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.

1.4. Structure of the report

The report is organised as follows:

- Section 2 sets the evaluation scene by discussing the rationales of public support to RTD investments and the expected role of ERDF when the programmes were designed.
- Section 3 describes the mapped projects and beneficiaries, the rationales of different instruments, and the policy mix of ERDF support in different countries.
- Section 4 illustrates the main achievements and missed opportunities.
- Section 5 discusses the role of the ERDF in the broader ‘causal package’, including regional, national and other EU policies relevant for RTD investments; it also discusses the key underlying factors for impact generation.
- Section 6 assesses the sustainability of achieved impacts.
- Section 7 discusses the EU added value.
- Section 8 includes the study's conclusions and policy recommendations, pointing to those aspects that were already addressed in the following programming periods.
- Section 9 presents some open issues for future studies and evaluation, including some lessons learned on methodology.

The report is complemented by a set of Annexes. In particular:

- Annex I lists the sample of 53 Operational Programmes within the scope of this study
- Annex II includes the evaluation matrix with answers to the specific evaluation questions and sources of evidence;
- Annex III lists the number of observations and stakeholders engaged in each task and method;
- Annex IV describes the methodology and results of the econometric analysis;
- Annex V includes the list of core and common indicators related to RTD investments;
- Annex VI contains the list of references used for this report.

2. Setting the scene

This chapter describes the EU RTD and policy context at the beginning of the programming period to set the scene of the entire study. It first discusses the key rationales underpinning public support to RTD investments, both in more general terms and with specific reference to ERDF, and then provides a brief overview of the RTD performance of EU regions and the main identified investment needs.

2.1. Rationale of public support for RTD investments

The important role of public R&D funding in stimulating economic growth is substantiated in the literature. A vast amount of empirical evidence suggests that about two-thirds of economic growth in Europe between 1995 and 2007 originated from research and innovation activities[7]. Moreover, R&I investments were determined to account for 15% of all investment-related productivity gains in Europe, and this figure went up to 40% and 50% in countries like the United Kingdom and Finland, respectively (European Commission, 2017a).

Public intervention is widely accepted in the research-policy field due to the existence of **market failures**. The general logic behind public intervention is based on the observation that, due to uncertainty, indivisibility, spillovers and externalities, as well as the non-appropriability of research and innovation processes, pure reliance on market forces would not secure the necessary long-term investments (most notably in basic research) and thus would massively restrict the productive potential of economies (Arrow, 1962; Griliches 1979; Romer, 1990). RTD infrastructures, competence centres and activities respond to specific objectives, and initiatives are aimed at generating a wide variety of benefits for the recipients of public funding, but also for ultimate beneficiaries and other actors, by means of **externalities and spillover effects**. Indeed, there is a common view that research infrastructures are financed because they promise not only scientific achievements but also because technological innovations, possibly with applications in different domains, may arise as by-products of their activity (Dahlin & Behrens, 2005; Hallonsten, 2014). Public funds are used to purchase equipment and utility services, to remunerate staff, and for many other purposes, including R&D for high-technology equipment. These funds are then diffused throughout the economy into such enterprise areas as manufacturing, construction, transportation, wholesale and retail trade, insurance and real estate, and (thus) ultimately the tax base itself.

There has been a **growing recognition in the literature that the concept of market failure provides an insufficient explanation** of the rationale of public interventions in RTD activities and especially barriers they seek to address. In the last decades, studies have identified the need of going beyond the definition of market failures and a rich literature about **system failures has emerged** (Smith, 2000; Arnold, 2004). This change seems driven by recognising a more holistic approach in governance to solve increasingly complex problems and the greater demand for evidence-based policies. From this perspective, the rationale

[7] See the study by NESTA and the Lisbon Council, available at https://lisboncouncil.net/publication/publication/99.html

behind public intervention in the RTD field is identified via a range of systemic failures, mainly comprising capability failures (such as managerial deficits, lack of technological understanding, poor learning ability, inadequate absorption capacity); failure in institutions; network failures (interaction among actors in the innovation system, issues in industry structure such as high competition or monopolies); infrastructural failure; framework failures (shortcomings of regulatory frameworks, intellectual property rights and other background conditions, such as consumer demand, culture and social values); and policy failures (deficiencies in the political governance system).

According to this approach, innovation is understood as a **complex process involving multiple socio-economic actors whose interactions are given by relations among and interventions of non-market agents**. Market-dependent rules contribute – but do not determine – the behaviour of these actors. Accordingly, and as noted by Bleda and Del Río (2013), policymakers should find solutions, not to market failures per se, but on how to facilitate coordination and interactions between all the actors involved in the innovation ecosystem. Innovation has started to be viewed as a non-linear process that involves interactions between different actors, including enterprises, organisations and institutions. The various authors (e.g., Freeman 1987, 1988, Lundvall 1992, Nelson 1993 and Edquist, 1997) point out that the success of innovation depends on a complex process that is characterised by reciprocity and feedback mechanisms.

2.2. ERDF priorities in the RTD field during the 2007-2013 period

The Europe 2020 Strategy adopted in 2010 put research, development and innovation at the top of the EU agenda for smart, sustainable and inclusive growth. In that period, R&D expenditure was increasing across the EU but was still considerably below the 3% target of investment in R&D as a share of Gross Domestic Product (in 2007, this share ranged from a maximum of 3.35% for Finland to less than 1% in most Central and Eastern European countries, the only exceptions being the Czech Republic with 1.31% and Estonia with 1.07[8]).

Since then, despite a yearly increase of 1% since 2000, R&D expenditure in Europe has remained below the set target. Its share of world expenditure on R&D has declined compared to the EU's global competitors. Only Germany, Denmark and Cyprus reached their targets, with the greatest progress reported by Poland, Greece, Estonia, Hungary and the Czech Republic (European Commission, 2020).

In order to contribute to the overarching goal of making the EU a leading knowledge-based economy, **the Community Strategic Guidelines for Cohesion Policy in 2007-2013 emphasised the need to stimulate and enhance Research and Innovation capacities.** Priority was allocated to the support of existing poles of excellence, making better use of existing potential and avoiding the excessive spatial dispersion of resources. Increasing private and public investment in RTD and innovation also encouraged partnerships across the different regions of the Union. Meanwhile, creating and exploiting a larger pool of high-quality research talent in Europe was identified as a key strategy. In line with the systemic

[8] Source: Eurostat

approach to innovation, RTD infrastructures, competence centres, and activities were considered necessary to help structure the scientific community and contribute to the construction of an efficient research and innovation ecosystem. The role of research infrastructures as key to enhancing national and regional RTD capacities was also emphasised. The development of pan-European research infrastructures and their impact on the regional ecosystems were seen as a key driver of economic growth.

R&D investments were strongly linked to the objective of fostering regional innovation. The report on "Creating an Innovative Europe"[9] stressed the key role of the regional level to foster an Innovative Europe and underlie the choice to concentrate a large share of Cohesion Policy resources for 2007-2013 on the Innovation priority. **About EUR 86.4 billion or nearly 25% of the total allocation went towards innovation in the broader sense**, including research centres and infrastructure, technology transfer and innovation in firms, the development and diffusion of information and communication technologies, and human capital development. These investments represented more than a tripling of absolute financial resources dedicated to innovation and R&D compared to the previous period (2000-2006). The amount also largely exceeded the budget of the 7th Framework Programme for Research (EUR 50.5 billion) and the Framework Programme for Competitiveness and Innovation (EUR 3.6 billion).

Although still significant, looking at only the RTD component of such finding envelope, the figure is much lower. In the period 2007-2013, **over EUR 16 billion of ERDF resources (almost 5% of the total ERDF allocation) were invested** through 212 Operational Programmes in projects supporting RTD infrastructure, competence centres and activities in the EU Member States and regions (codes 01 and 02). More than EUR 11 billion (65.5% of the total) was allocated to research infrastructure support (code 02) and around EUR 5.8 billion (34.5% of the total) to research activities support (code 01).

2.3. The ERDF approach to RTD investments

The academic debate stresses a **potential tension between EU R&I policy and EU cohesion policy since some scholars claim the two policies evince distinct goals** that cannot coexist harmoniously. The traditional objective of scientific excellence is related to a cosmopolitan sense of belonging to international scientific communities, while place-based R&I ecosystems are strictly linked to considerations of regional relevance and territorial vocation. Supporting RTD in less-developed regions may risk creating 'pockets of excellence' not connected to local contexts (Foray, Morgan & Radosevic, 2018).

The approach of Cohesion Policy support to RTD is expected to differ from the one of the European Research Area. The Cohesion Policy has an important role to play to stimulate the promotion of regional innovation systems (i.e. cluster formation, networking, knowledge transfer, fostering specialisation on locally-based strengths and opportunities) that is seen as a kind of self-help and learning tool for triggering local, self-sustained growth dynamics, primarily targeted at peripheral regions, which would, in turn, help these less-favoured regions to catch up with core regions (Landabaso *et al*. 2002, De Bruijn and Lagendijk 2005).

[9] http://ec.europa.eu/invest-in-research/pdf/download_en/aho_report.pdf

In the period 2007-2013, the expected role of ERDF was to contribute and strengthen local or regional networks (or systems) between public and private agents. Such networks, which rely on the interaction - in a specific territory - of stakeholders that adapt, generate and extend knowledge and innovation, have been defined in the literature as Regional Innovation Systems (RISs) (Cooke *et al.,* 1997). The notion of 'regional innovation system' was proposed by Cooke (1992, 2001) to indicate the **regional place-based nature of the system of factors which can ensure knowledge-based growth**. A system of innovation is constituted by a number of elements and by the relationship between these elements, which interact in the production, diffusion and use of new and economically useful knowledge (Jacoby 2010, Georghiou, 1993).

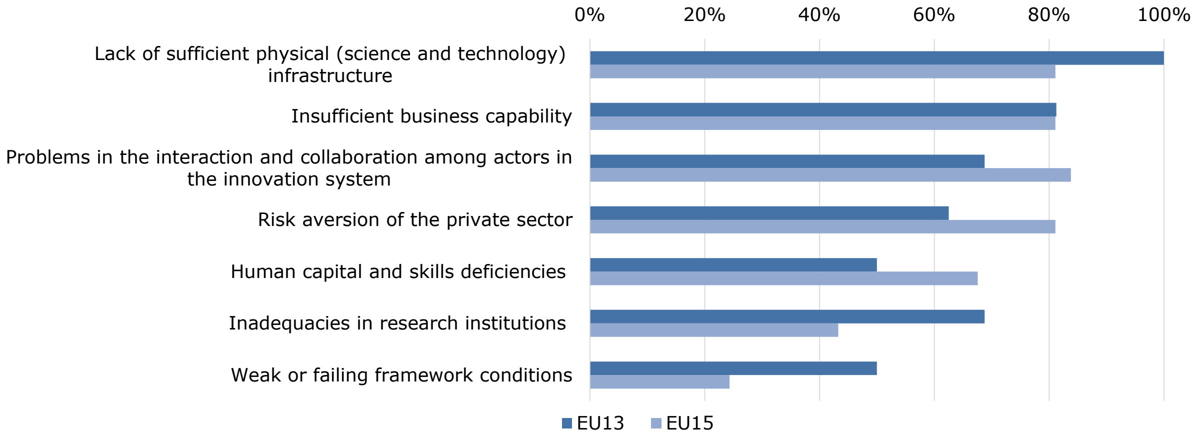
However, from a policy design point of view, **supporting RTD investments when funds are concentrated in less developed regions is challenging**. Regions with a stronger need to invest in RTD seem to have a comparatively lower capacity to absorb funding than more developed regions (the well-known innovation paradox, Landabaso *et al*. 2002). Evidence from the literature shows that research and innovation policies which result effectively in developed areas may not be transferable to lagging-behind regions which have to address specific criticalities (Hospers and Beugelskijk, 2002; Ebbekink and Lagendijk, 2013). Thus, it is not sufficient for lagging regions to adhere to the policy mix of more advanced regions, and it might even be counterproductive. These considerations led the European Commission to increasingly adopt a 'smart specialisation strategy (Foray and Van Ark, 2007; Foray *et al*., 2009) as a possible solution to the innovation paradox. According to this approach, public investments in RTD should be focused on regional knowledge strengths, leveraging specific local assets with a view to transforming productive structures towards higher value-added activities (Boschma and Gianelle, 2013; Foray, 2014). Although the S3 was officially introduced as an ex-ante conditionality for investment in research, development and innovation only for the 2014-2020 programmes, the approach was promoted after 2010 and may have influenced the way RTD infrastructure- and activities interventions were reprogrammed and delivered, at least in the second half of the past programming period.

2.4. Investments needs and regional differences

The analysis of the 53 OPs (documentary review complemented by direct interviews with the Managing Authorities) shows that the 53 OPs reviewed generally did not refer to specific, individual rationales of RTD investments, **but they recognised multiple investment needs** (see Figure 4).

Although different formulations were used in programming documents, two consisted of the key barriers identified by the policymakers. On one side, there was **the lack of a critical mass of infrastructure endowments and research capacities to enable the production of top-class research**. On the other, there was the need to increase the industrial relevance of the regional science base by **linking existing or emerging poles of scientific excellence to areas of industrial strength**. While the lack of density of research capacities seemed more relevant for the EU13 countries, the asserted needs of the EU15 MSs related more commonly to better science-industry linkages.

Figure 4. Rationale for RTD investment by type of country – share of EU13 and EU15 OPs mentioning 'need'



Note: Each OP can be associated with more than one need. The percentage was calculated as the number of EU13 (or EU15) OPs mentioning need(s) over the total number of EU13 (or EU15) OPs. The total number of EU13 OPs was 16, while the total number of EU15 OPs was 37.

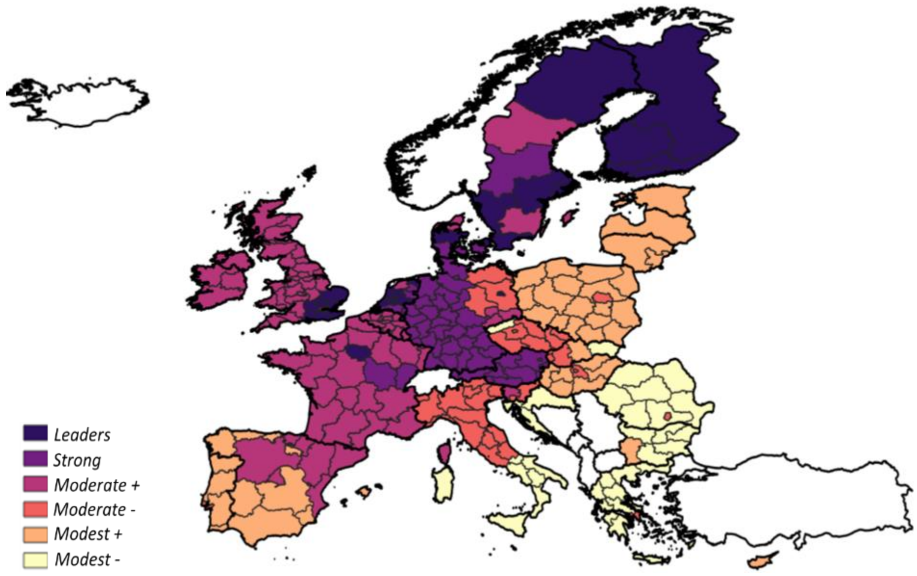
Source: Authors' review of the OP programming documents

The diagnosis reflected in the programming documents is not surprising. It mirrors fairly accurately the situation at the beginning of the programming period, as highlighted by the cluster analysis and the literature and policy documents (European Commission, 2009; Radosevic and Lepori, 2009). For all the **Central and Eastern European countries** that accessed the EU in 2004 and 2007, the 2007-2013 Operational Programmes represented **the first systematic set of interventions addressed to the research field**. They were facing **the most considerable challenges**: the public-research system was fragmented, with the research and higher-education systems being split between academies of science and universities; research technologies were obsolete; collaboration with industry was minimal, due to a lack of strategic awareness of the importance of innovation among companies, and due to insufficient orientation of research towards industry needs. The main problem was linked to education and research infrastructures, which were in poor condition and outdated. They, therefore, failed to contribute to top-level research and educational activities, thereby limiting their attractiveness for companies and international research networks.

Compared to the EU13 Member States, in the selected **Western European countries, regional innovation systems were, overall, relatively more mature,** with a stronger network of universities and research centres and some already extant structures to favour technological diffusion and science-industry collaboration, such as clusters, poles of excellence, and science-and-technology parks. Nonetheless, there were numerous differences across both countries and regions, both in terms of perceived RTD needs and designed strategic approaches. On the one hand, Germany was one of the ten most research-intensive economies worldwide, with only limited development needs in certain areas of R&D in convergence regions. Here, traditionally strong SMEs played a notable role in innovation, and there was intensive historical cooperation between the science and enterprise sectors. On the other hand, Portugal and Italy were still follower countries. Italy, in particular, suffered from strong regional disparities beyond a generalised weak research system at the national level. This problem also stemmed from a long tradition of scarce mobilisation of financial resources for research.

Existing RTD capacities were highly concentrated in certain key, leading EU regions. As evinced by the cluster analysis carried out for this study,[10] regions (labelled *Leaders*) characterised by a **strong knowledge-based economy** that was, in turn, supported by both the public and the private sectors, were concentrated in Northern Europe and the capital regions of Denmark, France, UK, Germany and the Netherlands. The regions of central Europe, including most Western Germany, Austria and some French regions, were characterised by a higher share of expenditure on R&D in the business sector and a higher number of patent applications, indicating **strong technological performance** (labelled *Strong*). Conversely, lagging regions were concentrated in Southern and Eastern Europe, with these showing a rather **limited knowledge basis, research paradigm and technological profile,** alongside poor local conditions for feeding science and research (labelled *Modest-*). Nonetheless, Poland, the Baltic countries, Hungary and Southern Spain demonstrated the key advantage of a supply of general advanced skills and the related importance of the availability of fresh human capital as shown by their high share of tertiary-educated people (*Modest+*). Among the Central and Eastern countries, the best performing regions were in the Czech Republic, Slovenia, Slovakia and the capital regions of Hungary, Poland and Romania. They manifested a performance similar to that of Eastern Germany and Northern Italy, where the cluster results suggested that science and technology activity in the economies of these regions built more on tacit knowledge and the uptake of technologies developed elsewhere.

Figure 5. RTD regional contexts: results of a cluster analysis - 2007



Source: Authors

These agglomeration effects were not surprising. Indeed, widespread empirical evidence shows that research and innovation activities tend physically and spatially to agglomerate in defined geographical areas. Some studies (e.g., Falk, Hölzl and Leo, 2007) highlight how the

[10] A cluster analysis of European regions was conducted, with the aim of identifying a typology of RTD contexts that could support the critical interpretation of findings arising from the evaluation study. We constructed an ad hoc data set of RTD-related variables, combining some variables already used in the Regional Innovation Scoreboard with other variables describing aspects suggested (by the literature) as being particularly relevant for RTD activities and infrastructure investments (R&D expenditure; human capital; science and technological outputs; general context variables).

nationally fragmented nature of the public research system can contribute to innovation gaps among regions, as this fragmentation does not allow the exploitation of scale effects and/or efficiency in RTD investments (particularly for large infrastructures) that would otherwise derive from the concentration of resources on selected priorities.

3. Funded projects and their rationale

This section aims to understand which considerations informed the design of the observed regional and national policy mixes and, in particular, to what extent the needs to be tackled were reflected in the selected projects. It describes the types of projects and beneficiaries supported by the ERDF in the RTD field in the 2007-2013 programming period. It also further explains the rationale for instrument types funded by the target OPs drawing from the rationales described in the literature and the empirical evidence from the mapped projects. It finally describes the observed ERDF strategies for RTD support adopted by the Member States and embedded in the different OPs, together with their underlying rationales.

3.1. Overview of funded projects

The analysis of expenditure mapped more than 20,000 projects,[11] half of which occurred in Spain alone.[12] Altogether, they absorbed almost EUR 14.9 billion, which is 2% higher than the allocated amount retrieved from the Final Implementation Report. The ERDF contribution was typically provided in the form of non-repayable grants. Private co-funding was provided only for 15.7% of the almost 8,000 projects for which this information is available. The average duration of projects was three years.

Projects funded infrastructure investments, R&D activities and other types of activity.[13] A residual share was either not classifiable or should not have been classified under codes 01 and 02. To further distinguish the logic of interventions among the different projects, these main types were further split into ten different types of intervention. The largest share of ERDF expenditure was **concentrated on support for infrastructure investment (72% of total expenditure),** with infrastructure investment for research absorbing more than half of ERDF expenditure (57%).

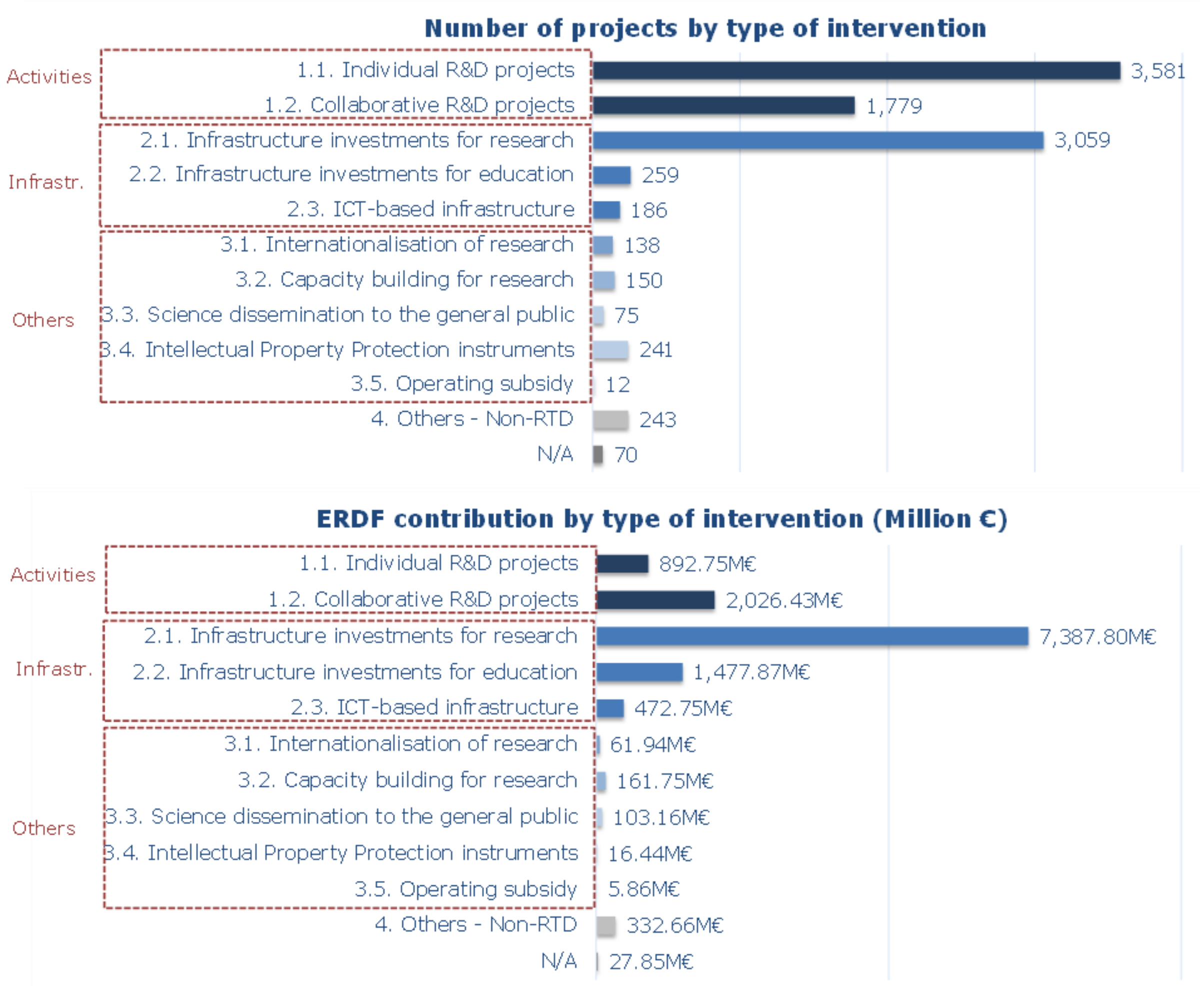
In terms of numbers, the most common types of intervention were R&D projects (55% of the total). A smaller share of projects (6%) and expenditure (3%) was allocated to implementing other RTD activity. A residual portion (3% of the projects and ERDF expenditure) fell into a residual fourth category, namely activities that were not strictly related to RTD and should instead have been classified under different codes.

[11] In the context of this evaluation, a 'project' should be understood as any activity, carried out individually or collaboratively, conducted over a definite time period, and planned to achieve a particular aim, which has benefited from investments through EU regional policy programmes.

[12] Spain had a peculiar monitoring system which lacks any project-level identification code. This prevented the aggregation of all expenditure data at project level. In the report, approximate data and information on the Spanish programmes are provided, but they are not considered when producing aggregate project-level statistics, in order to preserve the accuracy and reliability of the rest of the data.

[13] The comparison between the types of intervention attributed to individual projects, and the official category of expenditure under which the same project was coded by the Managing Authorities, reveals that a certain share of projects had been miscoded, and that it was indeed necessary to reclassify the projects according to a new taxonomy to have a more precise distinction between investments for RTD activities and RTD infrastructures. More specifically, around 9% of projects and 19% of ERDF contributions coded as 01 referred, in fact, to infrastructure investments. When one considers the projects coded as 02, it is found that 83% of these projects and 94% of the respective ERDF contribution had been properly coded, with the remaining share being research projects, other RTD activities (e.g., capacity-building activities delivered to research centres) or other non-RTD related investments (e.g., infrastructure investment in incubator centres to support entrepreneurship and innovation, but not RTD activities).

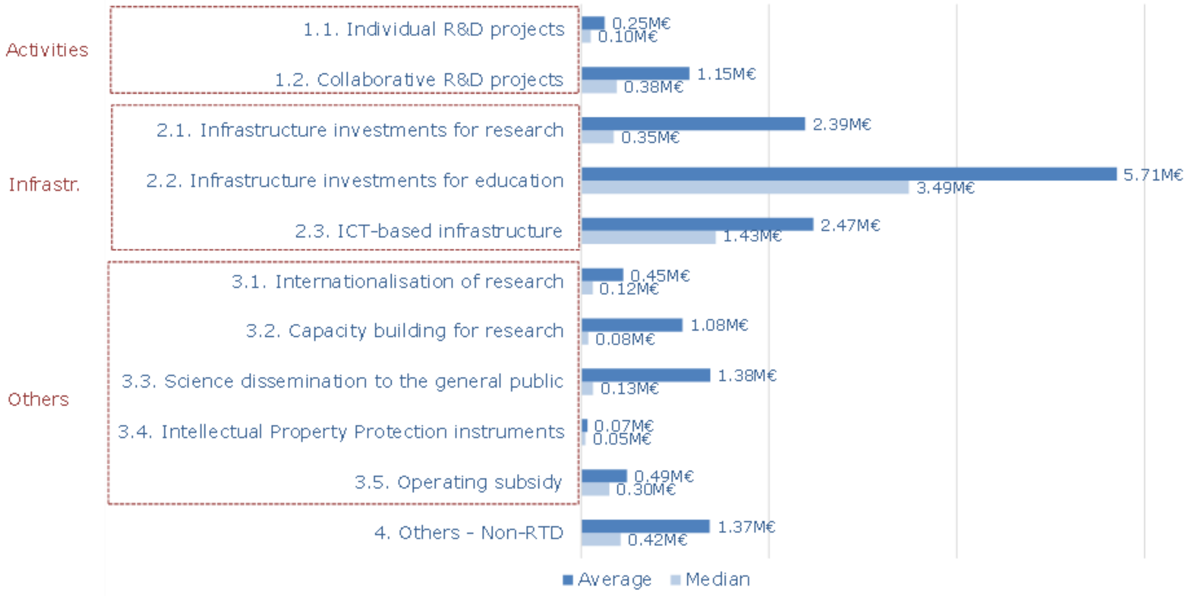
Figure 6. Types of funded projects, number and million EUR



Source: Authors based on monitoring data from the 46 OPs, excluding the seven Spanish OPs

Funded projects are, on average, of a significant financial scale: they received an average ERDF contribution of EUR 1.3 Million, while 24 Major Projects absorbed 10% of total ERDF expenditure in the considered OPs (i.e., EUR 1.49 Billion). Infrastructure investments for education activities cost, on average, much more than other types of investment.

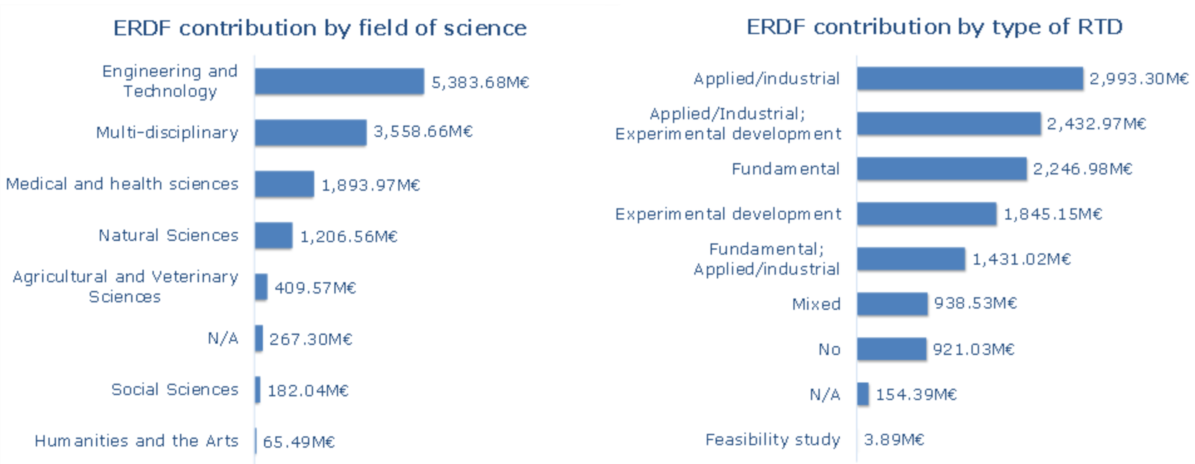
Figure 7. Project financial scale, average and median ERDF contribution (million EUR) by type of instrument



Source: Authors based on monitoring data from the 46 OPs, excluding the seven Spanish OPs

The funded research was predominantly conducted in the field of Engineering and Technology, Natural Sciences and Medical and Health sciences. The vast majority of projects and expenditure pertained to applied research, generally with a possible industrial application.

Figure 8. Type of research, total ERDF contribution (million EUR)



Source: Authors based on monitoring data from the 46 OPs, excluding the seven Spanish OPs

3.2. Overview of beneficiaries

The majority of beneficiaries (almost 77%) are publicly owned organisations. Higher Education Institutes (HEIs) and Research and Technological Organisations (RTOs) account for nearly 88% of the sample of lead beneficiaries and received nearly 83% of the total ERDF contribution. Enterprises comprised 4.5% of the total direct beneficiaries, 70% of these being SMEs. They played the role of partners in collaborating R&D projects, typically with HEIs and

RTOs. There were recurrent beneficiaries: on average, each body/institution was funded by 4-5 projects.

A taxonomy of beneficiaries

The study defined a stylised taxonomy of direct beneficiaries of investment projects in RTD infrastructures and activities based on the literature review. Mapped beneficiaries were classified according to this taxonomy. It includes:

1. Higher-education institutions (HEIs), including universities and institutes of technology

HEIs are drivers of regional competitiveness, mainly through their primary missions in education (human capital and skills development) and as academic research organisations. The (inter-)national scale of universities as research organisations, the wide breadth of disciplines covered, their core education and training function, and their often large property portfolios give HEIs the option to involve themselves in a wider set of regional RTD-support activities. Typically, they engage with activities that relate to basic science principles and the development of technology concepts. Industry-university collaborations also exist, but these activities are peripheral to the main missions in education and academic research. As industry partners, HEIs are more likely to develop new-to-market and world-class innovations than incremental ones, thanks to their traditional role of performing state-of-the-art academic research.

2. Research and technology organisations (RTOs)

RTOs are national/regional actors whose core mission is to bridge the gap between basic science and market solutions. Compared to HEIs, they are closer to businesses' and governments' RTD needs, and they provide them with a range of research, development and technology services. Their role is more prominent in analytical studies around proof of concept rather than basic science principles or the development of technological concepts. They also usually share research results with their industrial partners. Although the formal definition of RTOs varies, reflecting RTOs institutional statutes, governance, business models, funding models and resources, they are united by the idea of knowledge transfer and support for industry, and usually also by a degree of technological or sectoral specialisation.

3. Competence centres (CoCs) or Centres of excellence (CoEs)

Competence centres or Excellence centres are forms of university-industry research alliance that conduct both fairly fundamental but also more applied and problem-oriented research. They deploy a combination of academic excellence alongside industrial needs and problems to focus joint academic-industry R&D on areas of high innovative potential. As a result, they typically engage in activities that relate to basic science principles and the development of technology concepts and analytical studies around the proof of concept.

4. Science and technology parks (STPs)

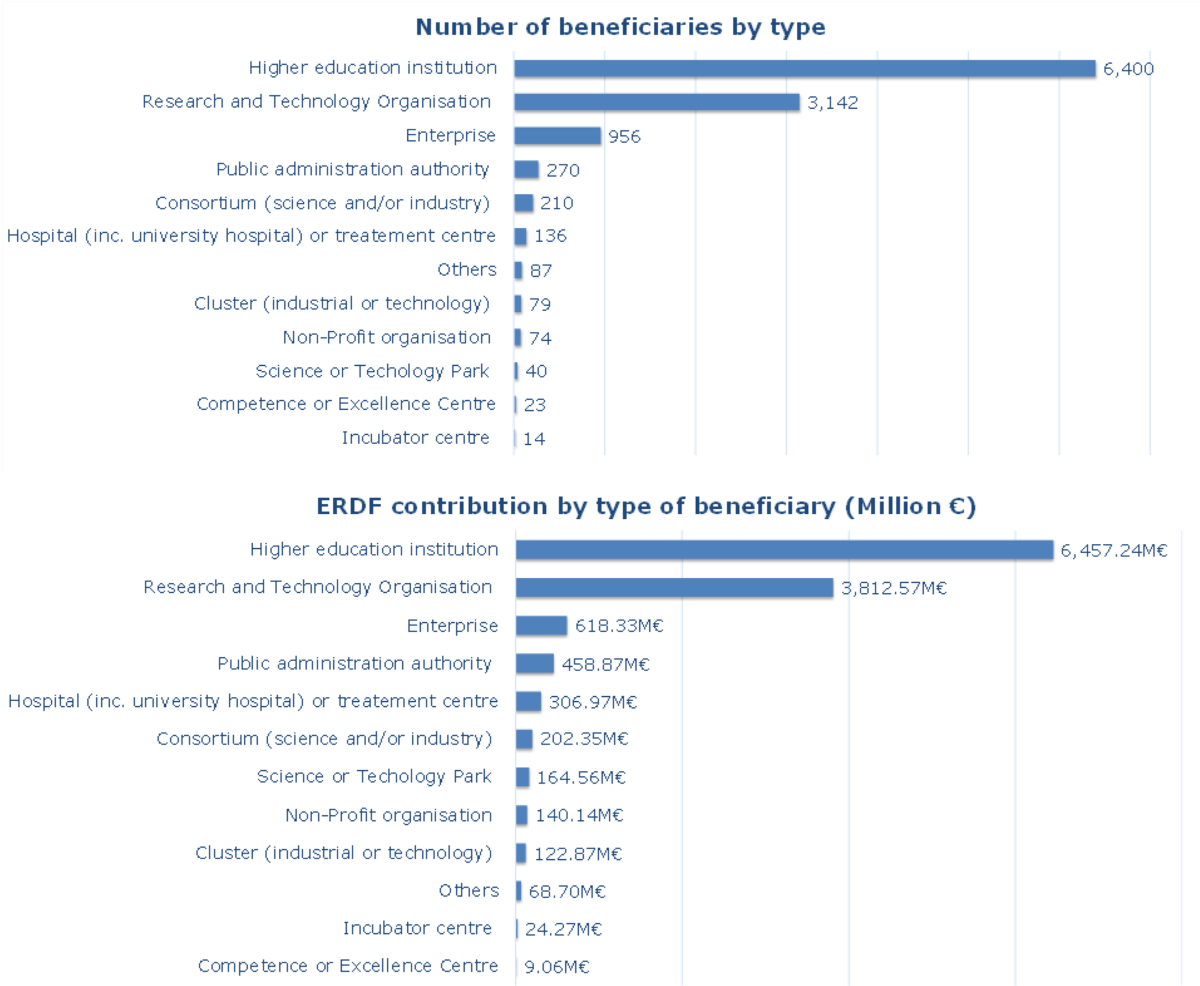
Science and technology parks are organisations the main characteristic of which is to support the firms located within their premises, promote networking among those firms, and support new firms in the park. Instead of performing RDI directly as RTOs and CoCs or CoEs, STPs are much more focused on meeting the innovation needs of a wide range of firms across the region (and even beyond), with an emphasis on knowledge exchange and collaborative research with firms rather than 'merely' business support.

5. Regional innovation clusters (RICs)

Although there is no universal definition of clusters, they can be defined as geographically proximate groups of interconnected companies and institutions in a particular field (Porter, 1998). They typically involve research institutes, business associations, and local authorities, linked by shared strategies and visions of development, common technologies, and skills. In general, their focus is on efficiently organising well-functioning localised (i.e., regionalised) value chains, and their scope is linked to their industry profile, i.e., the type of firm or branch they encompass. As such, they may not necessarily be focused on R&D, innovations and the technological change itself. They may, instead, deal with the facilitation of cooperation between all the actors in the ecosystem, finding common areas of interest for research and innovation.

Source: Authors based on the literature review

Figure 9. Type of lead beneficiaries, number and million EUR



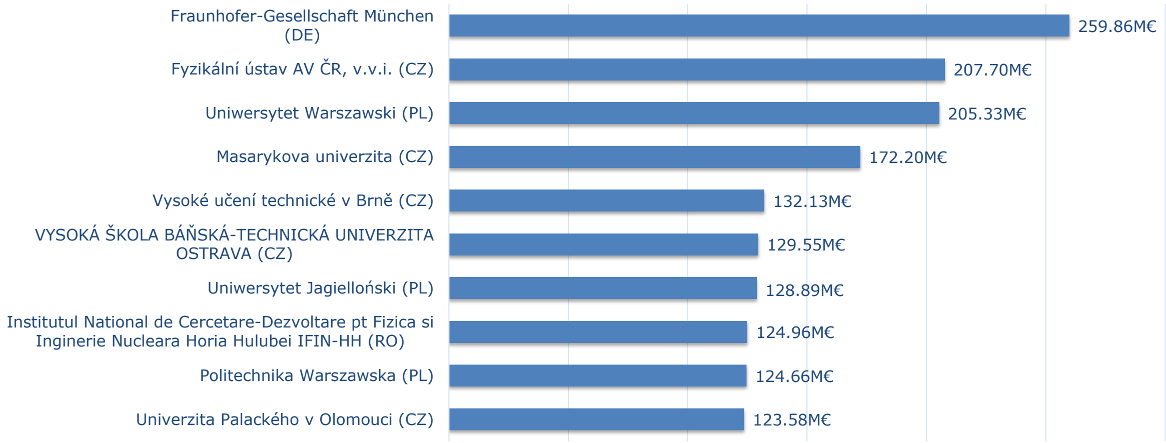
Note: The first figure does not count the number of institutions benefitting from RTD investments, but the total number of lead beneficiaries of the mapped projects (i.e., institutions that are leaders of more than one project are counted as many times as the number of projects they lead)

Source: Authors based on monitoring data from the 46 OPs, excluding the seven Spanish OPs

A total of about 4,000 different institutions (including enterprises) can be identified among the almost 24,000 lead beneficiaries (9,973 for the 46 OPs and about 13,000 for the seven Spanish OPs). When excluding the seven Spanish OPs, the total falls to **about 2,000 different institutions** (including almost 580 HEIs, more than 720 RTOs, nearly 470 enterprises). Nonetheless, data on the total ERDF contribution shows that **more than 13% of the ERDF support for RTD provided to lead beneficiaries**[14] **was concentrated on ten institutions, and more than 20% on twenty institutions**, with the Fraunhofer-Gesellschaft Institute in München (Germany) receiving more than 2% of the total. The other institutions where the largest share of ERDF contribution was distributed were, conversely, located mainly in the Czech Republic and Poland, the largest recipient countries alongside Germany.

[14] Excluding the seven Spanish OPs, the total ERDF contribution to lead beneficiaries amounted to EUR 11.7 billion.

Figure 10. Concentration of ERDF support among the top ten institutions (lead beneficiaries), million EUR



Source: Authors based on monitoring data from the 46 OPs, excluding the seven Spanish OPs

3.3. Rationales of infrastructure investments

Infrastructure investments were selected as a result of a top-down approach, with national authorities undertaking needs assessments, and national or EU roadmap exercises, as part of the implementation of the European Research Area (ERA). The extent to which the needs assessment was reflected in the selection of funded infrastructures varied. In Estonia, for example, 26 million euros of support for large-scale research infrastructure was targeted on nationally important research infrastructure, with a precondition for funding being included within the national research roadmap. The research infrastructure roadmap in Estonia was a long-term (10-20 years) planning instrument, including a list of new or modernised research infrastructures of national importance. This required joint efforts on behalf of the government and the research institutions in charge of developing the roadmap. It also forced institutions carefully to analyse their research capacity (i.e., human resources, research domains, funding) and critically assess future research domains and their potential for excellence[15].

Similarly to the case of Estonia, the Czech ‘Roadmap for Large Research, Development and Innovation Infrastructures’ was developed in 2010 and regularly updated, indicating priorities for the development of new R&D infrastructures of national and international importance in the country. It was funded predominantly via ERDF support. Unlike the Estonian example, for Italy being included in the national roadmap was not a condition for funding. Rather, infrastructure funding was seen as a way to pursue an upgrade in national facilities to allow a subsequent inclusion in national and European roadmaps.

The roadmap exercises also identified national infrastructure of pan-European relevance, contributing to the construction of the ERA and the ESFRI Forum. For example, the ELI Beamlines were planned as part of the European roadmap of next-generation major research facilities that the European Strategic Forum had identified for Research Infrastructures (ESFRI).

[15] See the Estonia case study for further details.

Exception in infrastructure planning and selection were represented by the **ICT-based infrastructures** in HEIs, and the Major Project analysed in the German case study. The former was **the result of a thorough bottom-up as well as top-down analysis**. On the one hand, in dialogue with the HEIs, the ministry identified needs in terms of research infrastructures within the HEIs (bottom-up). On the other hand, in the next step, the relevant ministry prioritised construction projects in light of their suitability for strengthening research, technological development, and innovation on a regional level in Thüringen (top-down). Concerning the **Major Project**, the renovation of the F.A. Weinhold Building at the Technical University of Chemnitz, it was concluded that the application process was largely a bottom-up process informed by priorities sketched out in the OP; the identification of specific investment needs was left to the beneficiaries.

The funded infrastructure projects differed in their underlying rationales. A more in-depth analysis of funded projects and relative beneficiaries showed a wide variation in their design and implementation, reflecting different objectives.

3.3.1. Infrastructure for research

In the Community Framework Programme for Research and Technological Development (FP7), and later within Horizon 2020, the term ‘research infrastructure’ referred to *facilities, resources, and services used by the research communities to conduct research and foster innovation in their fields. They include major scientific equipment (or sets of instruments), knowledge-based resources such as collections, archives and scientific data, e-infrastructures, such as data- and computing systems and communication networks, and any other tools that are essential to achieve excellence in research and innovation*[16].

This category of interventions absorbed the largest share of ERDF resources in the OPs under consideration, in line with the fact that most OPs indicated infrastructural failures as one of the key investment needs to be tackled by the OP in question. The specific nature of the projects funded ranged from support for new or reconstructed infrastructure, such as buildings, plants or laboratories, to investment in research-related equipment, such as lab instruments, machinery or highly specialised apparatus, as well as supporting infrastructure. These instruments addressed the lack of sufficient or modern physical and technological infrastructure, an essential component in fostering knowledge creation.

What the literature says - In a nutshell

High-quality research infrastructures are increasingly necessary for ground-breaking research, as they attract global talent and are essential (for example) in the context of information and communication technologies and key enabling technologies. They are regarded as offering solutions to many challenges beyond pure science, including major global societal challenges and the revitalisation of the economy in a context where science is increasingly seen as an essential engine of growth. The expected benefits of research infrastructures are diverse but are largely related to knowledge production (scientific publications, conferences, other dissemination activities), innovation and knowledge-transfer (patents, licences, new products, services and processes), human-capital formation (trained students and technical staff), cultural benefits (virtual and physical visitors, users of media and social-media output) (Florio & Sirtori, 2016; Florio, 2019). From a regional

[16] Article 2 (6) of Regulation (EU) No 1291/2013 of 11 December 2013

development perspective, RIs may constitute important markets for suppliers, encouraging firms to develop next-generation engineering solutions, machines and instrumentation (see Simmonds, 2016). The establishment of an RI in a given region can attract investment and provide opportunities for market development, contributing broadly to the socio-economic development of a given region. At the same time, they also present the challenge of ensuring that they can be operated sustainably. Therefore, adequate policy frameworks and support are also necessary to ensure the long-term sustainability of RIs (ESFRI, 2017).

Source: Authors based on the literature review

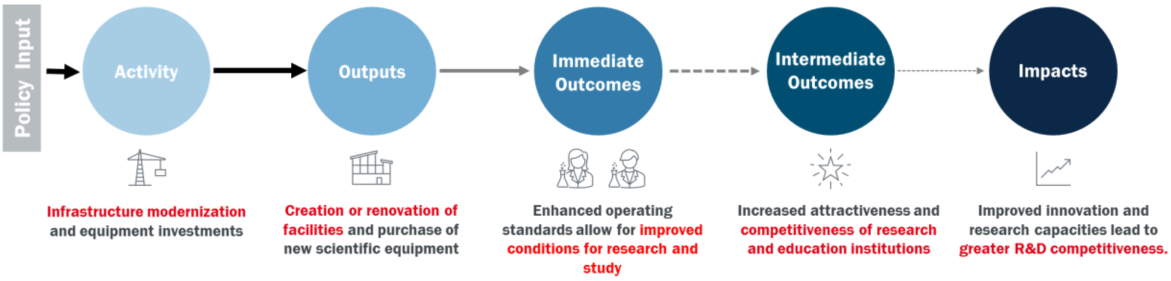
Among many of the newer Member States of the EU, there was a research infrastructure gap that impacted the effectiveness of the country's R&D capabilities. As highlighted by some of the case studies, research infrastructures were underfunded. They were thus not providing sufficient capacity and quality for researchers, as research equipment was outdated or not in accord with modern research standards.[17] This policy intervention aimed at upgrading existing infrastructure and equipment and replacing obsolete or outdated instances of these. In so doing, it sought to develop new research capacities that aimed to match the level of quality and research excellence at the European and international levels. The intervention was not seen as an end in itself but rather regarded as a mechanism that would improve the quality of research and the innovative capacity of economies.

In terms of the intentions and expectations declared by the OP or the Major Project applications, the establishment of new research infrastructures was expected to contribute to three categories of impact:

- **Scaling up research**. The goal of many Major Projects was to achieve more ambitious research projects with respect to research status in the region at that time. In some cases, the objective was even more ambitious, i.e., to promote world-class research with international standards of excellence in a specific topic. The goal of scaling up research was complemented by the necessity of scaling up facilities (new research buildings and equipment) and supporting their cost. Against these costs, several Major Projects were expected to attract increasing volumes of international research grants (both private and public), increase the number of research contracts, and build up knowledge-sharing networks.
- **Increasing collaboration with industry**. Most of the research-infrastructure projects funded in the 2007-2013 period were conceived with clear attention to facilitate a potential positive spill-over to the business environment and thus (also) possible benefits in terms of knowledge transfer, patenting and commercialisation of innovation.
- **Seeding early-stage researchers**. Some major infrastructural projects indicated educational activities and the training of early-career researchers as a priority.

[17] Case Study Report: Czech Republic - 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.

Figure 11. Generalised (hypothesised) Theory of Change of infrastructure investments for research

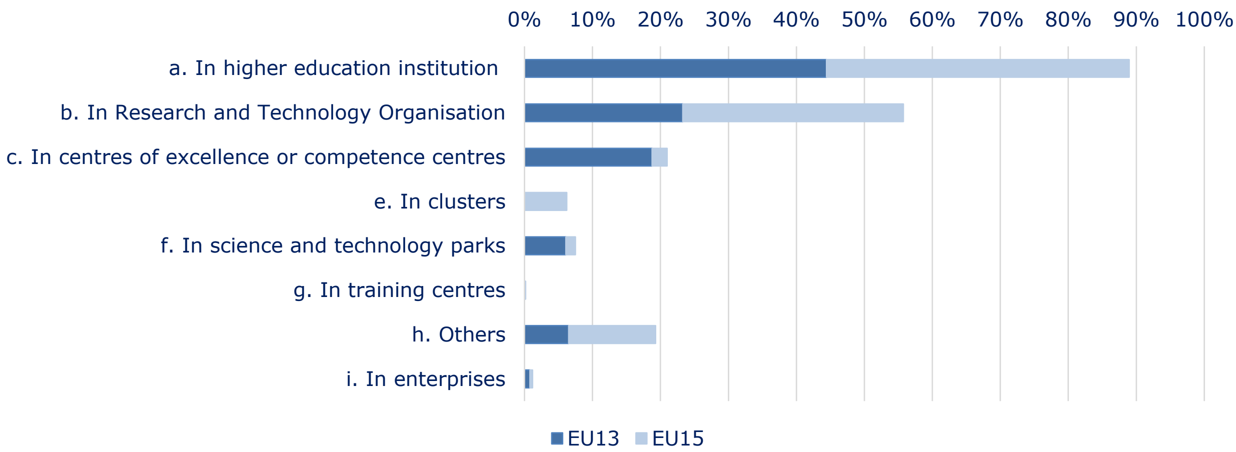


Note: Despite being part of the analysis, pre-conditions, supporting factors and risks are not included to improve the readability of the figure. They are listed in the generalised and tested ToCs in the following sections.

Source: Authors on the cross-case study analysis performed in Task 4

A total of 3,504 infrastructure investment projects[18] were identified for a total ERDF contribution of EUR 9.3 billion. **The largest share of such investments (80%) pertained to infrastructure development for research. 41% of the ERDF contribution was spent on HEIs,** while the remaining was allocated to RTOs and competence centres. The share of ERDF contribution for centres of excellence, competence centres and science-and-technology parks was significantly higher in the EU13 than in the EU15. This may indicate a need to catch in terms of the creation of infrastructures that were less present in those countries.

Figure 12. Distribution of ERDF contributions for infrastructure investments in research, by type of beneficiary and type of country, percentage of total ERDF



Source: Authors based on monitoring data from the 46 OPs, excluding the seven Spanish OPs

The **average ERDF expenditure** for infrastructure investment in research infrastructures **is EUR 2.6 million**. Out of the total expenditure in this category, there were 21 Major Projects with an average ERDF contribution of EUR 66.3 million. **Major Projects absorbed 18% of total ERDF expenditure for research infrastructures, i.e., EUR 1.4 billion**. The majority

[18] It was often not possible to distinguish between the construction of new infrastructures, the modernisation of existing ones and the purchase of equipment for either new or existing research infrastructures, either because the type of renovation work was not specified or because each project typically comprised a mixture of construction and equipment costs.

(15) of these projects were implemented in the New Member States (six in Poland, six in the Czech Republic and one each in Hungary, Lithuania and Romania), and six were based in Western European Member States (three in the UK, one in Germany, one in France and one in Portugal).

Most of the infrastructure investments started between 2007 and 2009 and were completed from 2013 to 2015; the average duration of the investment phase of the projects was six years. This does not necessarily mean that all the projects started their operations at the closure of the 2007-2013 period. The ELI projects in Romania and the Czech Republic, for instance, were phased and further funded for the 2014-2020 programming period. These projects operated across different scientific domains, although the most commonly covered fields were **the natural sciences, engineering and technology, and medical and health sciences**. The Portuguese project was the only one devoted to the social sciences, as it promoted research and scientific dissemination related to 'port economics' and maritime knowledge.[19]

3.3.2. Infrastructure for education

The analysis of the projects revealed that some infrastructure investments were geared more towards improving education facilities in universities than towards RTD laboratories. These investments followed a different logic. In response to barriers related to infrastructure failures and lack of human capital and skills, investments in education infrastructure in HEIs were supposed to fulfil a varied stimulative role. First, new or renewed infrastructure is considered necessary to implement modern education, particularly at the MSc and PhD levels. Second, it contributes to creating an environment and infrastructural base for more interdisciplinary study/research in selected fields of specialisation. The overall and ultimate intention is, and was, to attract more and better students, create new teaching opportunities, and improve the quality of education so as to produce a new generation of skilled researchers.

What the literature says - In a nutshell

Infrastructure investments to improve education strive to ensure an extended and equitable access to education supported by the availability of high-quality facilities and equipment (World Bank, 2014). These interventions include the construction of learning spaces (schools, universities, etc.) but also the maintenance of high-standard learning conditions in terms of security, teaching and access to learning resources. According to the literature review, there are a number of benefits to be derived from educational-infrastructure investments. These measures are meant to upskill the workforce across Europe and build better links between educational systems and the labour market to ensure that skills match companies' needs today and in the future. In the literature, failure specifically related to issues in the educational domain is further labelled as 'learning failure', i.e., 'firms or industries may not be able to learn rapidly and effectively and may be locked into existing technologies, thus being unable to jump to the new technologies' (Malerba, 1996). Daigneau et al. (2005) point out that information technology has made a shift from the traditional 'instructional' paradigm to a 'learning' paradigm possible. There is increasing evidence through empirical studies that students learn more effectively through active, enquiry-based learning, as long as this is structured via and alongside peer collaboration

[19] Only 21.3% of the expenditure of this project was classified under code 02, the remainder falling under code 30, which refers to port infrastructures.

and dialogic feedback. As also indicated in the OECD report (1998) on Redefining Tertiary Education, employers seek more creativity, initiative and problem-solving ability in new graduates. It is acknowledged that sensibly designed new buildings and equipment contribute to fostering learning and positive attitudes towards study.

Source: Authors based on the literature review

Within the infrastructure-investment projects identified in the OPs, **4.6% of projects and 10.6% of ERDF contributions were used for infrastructure investments for educational objectives**. This was a very specific type of investment, concentrated mainly in Poland, Slovakia and Estonia and benefiting HEIs. This type of project was targeted on single-site HEIs and aimed to renovate, expand or improve the facilities dedicated to teaching activities.[20] The ultimate beneficiaries of these interventions were students and researchers within the HEI.

Figure 13. Distribution of ERDF contribution for infrastructure investments for education by country, million EUR

Source: Authors based on monitoring data from the 46 OPs, excluding the seven Spanish OPs

3.3.3. ICT infrastructures

ICT-based infrastructures are another identified subgroup of the broader infrastructure investment for research. Under the influence of the increasing importance of data digitalisation and Open Science as means to improve the accessibility, interoperability and re-use of scientific publications and data, **ICT-based infrastructures provide digital-based services and tools for data and computing-intensive research** in virtual and collaborative environments. These environments offer services and tools that support whole research cycles and ease/foster the movement of scientific data across scientific disciplines. Moreover, open-data spaces can be created, and scientific workflows can be improved by connecting data sets from diverse disciplines. Researchers also have the opportunity to link with high-performance computational systems, and they can therefore improve the overall capacity and scope of their research (Thanos, 2010).

[20] It included a few projects where the distinction between research and educational goals was less clear, as these referred, for instance, to investments in university libraries.

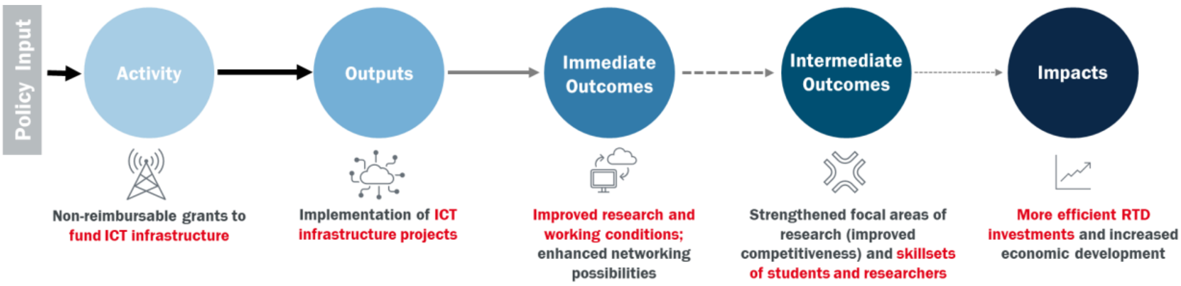
What the literature says - In a nutshell

According to the existing literature, the creation of ICT-based infrastructures and the expansion of Open Access can bring direct and indirect long-term benefits to research stakeholders (including funders of research activities, researchers and research-grant beneficiaries, as well as actors in other sectors, i.e., academic, private, public, non-profit) and might have a positive impact on the quality and the return on investment of research itself. Studies supporting the implementation of the EU Open Access policy principles report that these can i) reduce duplication in research, in terms of time, effort and funding; ii) promote more accurate management of digital resources and support researchers in meeting the expectations and requirements of their funding agencies; iii) support the exploitation of research results based on integrated and analysed existing data from multiple disciplines and regions; iv) enable research to focus more on adding-value activities such as interpreting the data, rather than on searching, collecting or re-creating existing data; and ultimately v) enhance the science infrastructure to support knowledge discovery and innovation.

Source: Authors based on the literature review

By their nature, ICT-based infrastructures are meant to support researchers in their work and serve various research communities. Generally, the literature suggests that ICT-based infrastructure investments positively affect innovation capacities since this infrastructure allows researchers to handle big data sets efficiently through the use of high-performance computational systems. Together with the improved dissemination of scientific output and exchange with other researchers, this means that innovative capacities increase (Thanos, 2010).

Figure 14. Generalised (hypothesised) Theory of Change of infrastructure investments for research



Note: Despite being part of the analysis, pre-conditions, supporting factors and risks are not included to improve the readability of the figure. They are listed in the generalised and tested ToCs in the following sections.

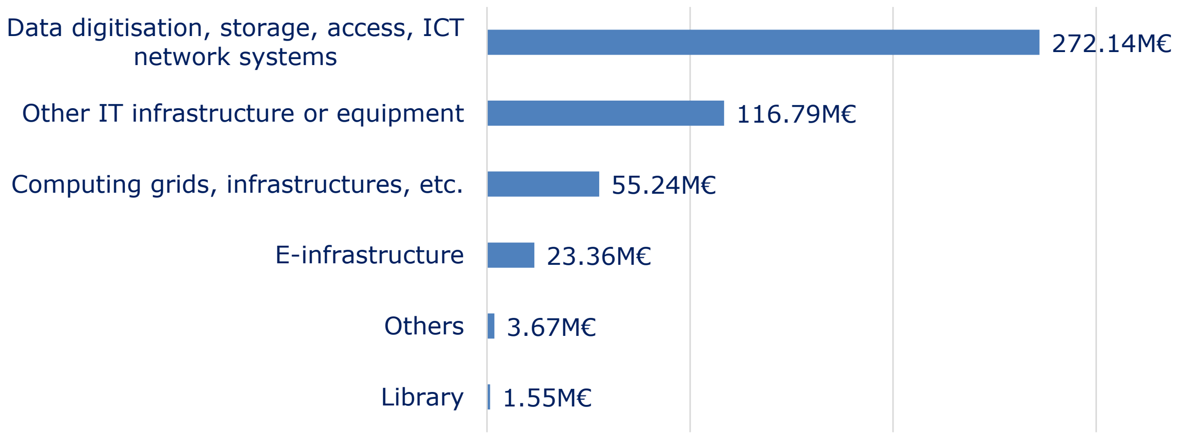
Source: Authors on the cross-case study analysis performed in Task 4

The ICT-based infrastructures identified across the OPs can be categorised as follows:

- Projects responding to advanced computing needs: computing grids and infrastructures/centres, supercomputers, computing servers, and similar phenomena;
- Projects to manage more effectively data creation, storage and access: these include data digitisation, data-storage centres, open-data infrastructures, and ICT network systems;
- E-infrastructures to deliver e-services (mainly in the health domain) and to connect existing resources to a central hub for research and development;

- Projects related to investments in other IT infrastructure or equipment for research, which do not fall under any of the previous sub-types.

Figure 15. Distribution of ERDF contributions for ICT-base infrastructures by type, million EUR



Source: Authors based on monitoring data from the 46 OPs, excluding the seven Spanish OPs

Most of these projects were implemented by HEIs (67%), followed by RTOs (26%). Based on the available information, at least 72% of these projects (corresponding to 68% of ERDF contributions to this type of projects) fell within the definition of **virtual infrastructures**.

3.4. Rationales of R&D projects

Unlike the research infrastructures, the **research projects generally followed a more bottom-up approach.** For individual research projects implemented in Germany, ERDF support was determined by research demand in an application process. Similarly, in Poland and Italy, evidence indicates that the RTD investments consisted primarily of instruments driven by research demands (i.e., bottom-up), with applicants able to put forward their desired project topics and apply for funding for RTD activities. Nonetheless, in the case of Poland, these projects were prepared and led by scientific organisations, the only actors eligible for ERDF funding, and therefore did not necessarily originate with the needs of industrial partners. In contrast, in Italy, the policy instrument was designed to privilege a specific industrial need. In practice, projects were prepared by both scientific organisations and enterprises, with the project idea generally stemming from an initiative of the research provider on a topic considered relevant for industry.

Different rationales underpin collaborative and individual R&D projects.

3.4.1. Collaborative R&D projects

Collaborative R&D projects support research activities carried out jointly by either research institutions/HEIs themselves or in collaboration with private-industry partners (referred to as science-industry collaborations). The latter is widely considered an essential driver of knowledge-based economies and societies.

What the literature says - In a nutshell

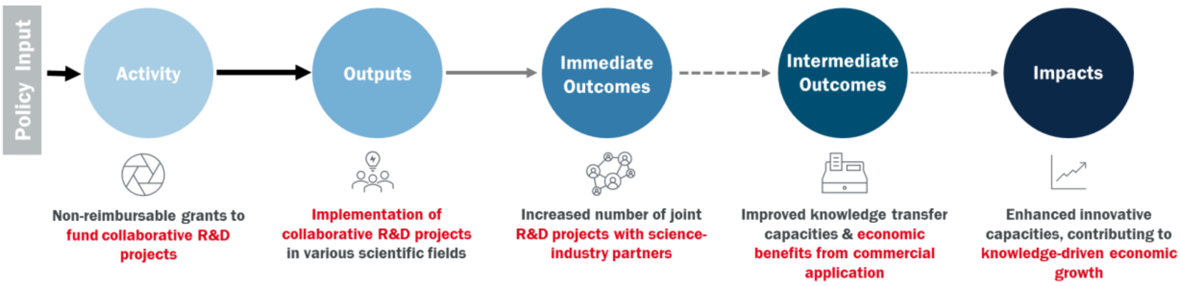
As described by Laudel (2002), a research collaboration can be defined as a system of research activities by several actors, related functionally, and coordinated to attain a research goal corresponding with these actors' research goals or interests. As Keraminiyage et al. (2009) proposed, research collaboration can be viewed as a system functionally to associate a group of researchers affiliated to different organisations to conduct research that brings mutually beneficial outcomes to all.

A specific form of collaborative project is that of science-industry collaboration. Science-industry linkages bring together research providers and research end-users and encourage the transfer of skills and knowledge and the translation of new ideas into products and services. Davey et al. (2018) state that this form of collaboration may have a significant impact, not only at the level of individual organisations but also upon the economy, which can help tackle societal issues. The literature underscores the importance of such collaborative R&D efforts. O'Kane (2008), for instance, describes that such projects allow for human and capital resources to be brought together with an ability to create an outcome that cannot effectively be done alone. Moreover, he states that such projects tend to produce higher quality and more effective, integrated and robust outcomes since each partner brings a differing perspective and experience to the process.

Source: Authors based on the literature review

According to the R&I State Aid Framework, in a collaboration project, at least two partners participate in the design of the project itself, contribute to its implementation, and share the risk and output of the project (European Commission, 2006). Collaborative efforts funded by this policy intervention had various aims, ranging from addressing industrially relevant or societal challenges to stimulating technological advancement in specific areas to boosting international cooperation by conducting internationally competitive high-quality R&D activities.

Figure 16. Generalised (hypothesised) Theory of Change of collaborative R&D projects



Note: Despite being part of the analysis, pre-conditions, supporting factors and risks are not included to improve the readability of the figure. They are listed in the generalised and tested ToCs in the following sections.

Source: Authors on the cross-case study analysis performed in Task 4

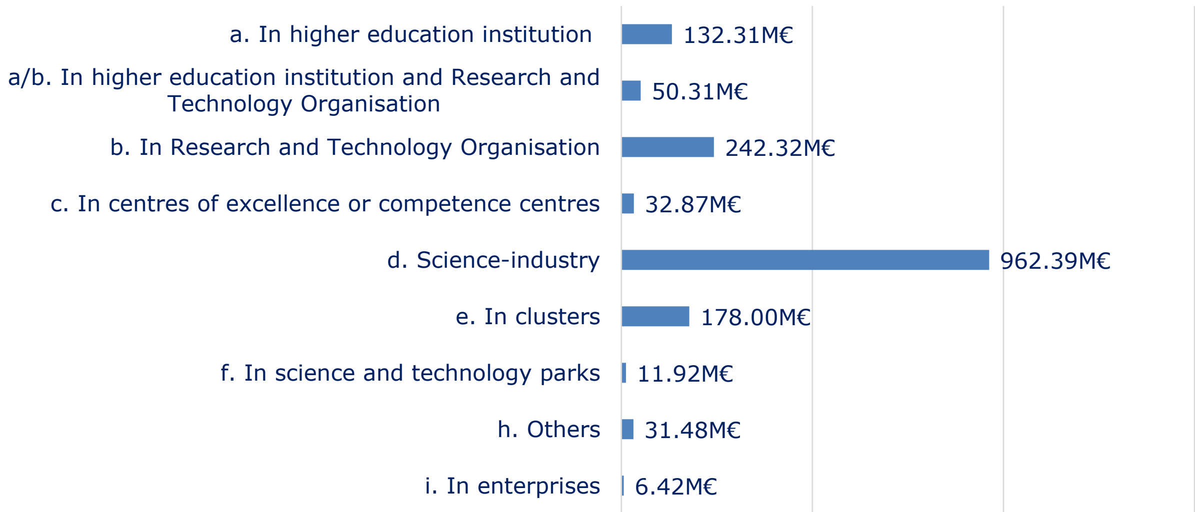
The immediate outcomes of the policy intervention were aimed at increasing the number of joint projects and activities, both between R&D institutions themselves and in collaboration with private-sector partners. Moreover, researchers across supported research institutions, and those in private enterprises, were expected to develop skills and competencies that would increase their scientific-technological knowledge. The research pursued by these collaborative entities would be expected to lead to technological advancement and thereby facilitate the improvement or invention of new products, processes or services. These immediate outcomes (during the project) were expected to be followed by more intermediate outcomes (after the project), such as the economic benefits stemming from the commercial valorisation of R&D results. Moreover, an enhanced knowledge transfer between science and industry partners was to be expected.

According to our mapping, **only 32% of the R&D projects were collaborative, but these nonetheless absorbed 56% of the ERDF resources** for R&D projects. Collaborative projects involved, on average, 3.7 beneficiaries. Limitations in the monitoring data related to beneficiaries[21] hamper a comprehensive assessment of the nature and composition of consortia. When one analyses the data for those OPs for which complete information is available, it emerges that the **consortia were for the most part comprised of research providers only** (either RTOs in partnership with HEIs, around 22%, or partnerships of only HEIs, 9%, or only Research and Technology organisations, 5%). In a minority of cases, partnerships involved enterprises (in partnerships with HEIs, 16% of total collaborative projects, or with both HEIs and RTOs, 13%).

Among the collaborative projects led by HEIs, 42% of that category (absorbing 67% of ERDF contributions received by HEIs for collaborative projects) involved business partners and were expected to implement research projects that fit a given industry's needs. The collaborative projects led by the RTOs were nearly equally split between those implemented between different RTOs and those implemented in partnership with industry.

Moreover, in terms of the end beneficiaries of all collaborative projects, **a substantial share of the ERDF contribution (58%) was devoted to science-industry collaborative projects**, i.e., projects involving one or more enterprises and one or more research organisations. Moreover, this share increases further if we also consider projects implemented within clusters, where a science-industry collaboration could be expected, or consortia involved firms and other actors.

Figure 17. Distribution of ERDF contributions for collaborative R&D projects, by type of beneficiary, million EUR



Source: Authors based on monitoring data from the 46 OPs, excluding the seven Spanish OPs

[21] Lists of beneficiaries are often incomplete for collaborative projects, indicating only the lead beneficiary and omitting data related to partners.

A large majority of collaborative projects (78%) involved partners located in the same region. Multi-regional collaborative projects could be found in the Czech Republic, Poland (national OP for Innovation), Slovakia, Ireland, Finland and the multi-regional Italian OP. Particularly interesting is the case of the Finnish, the Irish and the Italian OPs, which, despite targeting specific regions of the country, also allowed collaboration with other regions (non-eligible for funding under the same OP).

3.4.2. Individual R&D projects

Individual research projects were supported in various scientific fields to strengthen the region's scientific and technological capacity in question. This policy intervention consisted of support for existing research fields, for which applications were investigated, as well as for more 'exploratory' or 'foundational' research, which targeted areas that had great potential for innovation but were untapped. To some extent, the intervention also sought to improve the knowledge-and-technology transfer into the industry, which would involve the economic valorisation of new scientific or technological products and processes.

What the literature says - In a nutshell

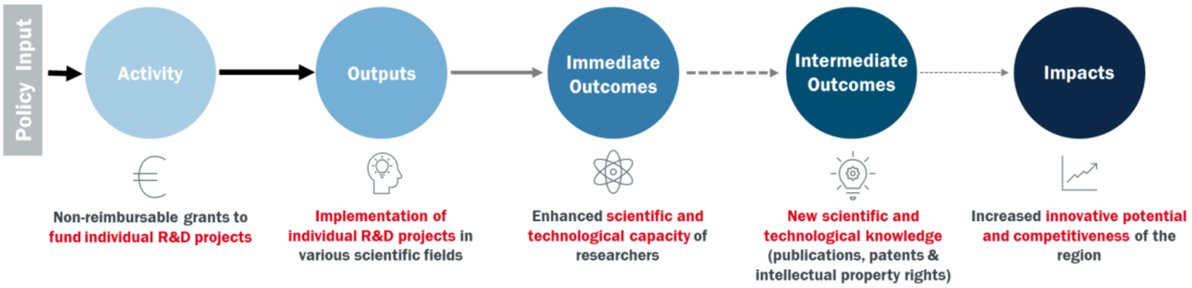
Knowledge generation and skill development are among the key expected outcomes of such interventions and are regarded in the literature as rationales for providing public funding for these research areas. Martin (1996) explains that the economically useful output of basic research is codified information, which has the property of a 'public good', as it is costly to produce and virtually costless to transfer, use and re-use. Therefore, it is efficient to make the results of basic or fundamental research freely available to all potential users. Moreover, the skill-development of researchers is also of economic value since trained graduates entering industry positions come equipped with advanced levels of training, knowledge and expertise. They are also 'plugged into' international networks of scientists and have experience in tackling complex problems.

According to the literature (Benneworth and Dahl Fitja, 2019), HEIs are more likely to engage in activities at lower Technology Readiness Levels (TRLs) that relate to basic science principles and the development of technology concepts to contribute to the scale-up of the quality of research and its internationalisation. Conversely, RTOs are expected to focus on industrial applied research and conduct research projects from TRL 2 (relating to analytical studies around the proof of concept) up to TRL 7 (system prototyping).

Source: Authors based on the literature review

This kind of R&D support was a central feature of the Lisbon National Reform Programmes (2006) since large disparities between the EU Member States and regions were observed, and a persistent gap existed at the global level compared to competitors. Early-stage (foundational) and exploratory research often do not have specific, predetermined commercial applications and rather serve to generate new knowledge and further develop innovative skills in research institutions; this is crucial for long-term, rather than immediate, R&D results. The fact that this type of research carries high risks and is therefore of reduced interest to private-sector investment is well-documented in the literature (European Commission, 2017a). The uncertainty relating to the return of investment, and the sunk costs involved in ensuring a critical mass in terms of knowledge and skills-accumulation, which is often a precondition for any meaningful R&D results, would otherwise induce underinvestment in such forms of research and innovation: this, therefore, underscores the significance of sufficient public investment in these areas.

Figure 18. Generalised (hypothesised) Theory of Change of individual R&D projects

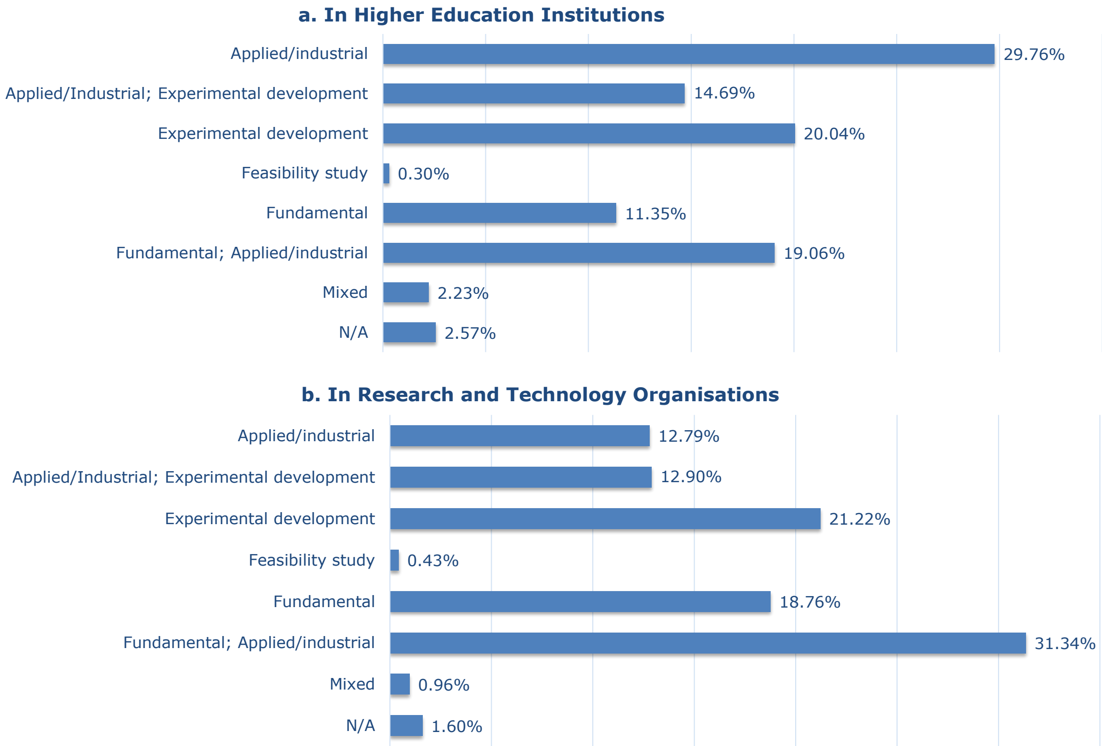


Note: Despite being part of the analysis, pre-conditions, supporting factors and risks are not included to improve the readability of the figure. They are listed in the generalised and tested ToCs in the following sections.

Source: Authors on the cross-case study analysis performed in Task 4

The majority of ERDF contributions to **individual R&D projects are implemented by HEIs**. RTOs, conversely, implemented 26% of the total number of individual R&D projects and received 28% of expenditure. In our sample, however, and unlike the scenarios presented by the literature, RTOs implemented a larger share of experimental-development projects (36% out of the total number of individual R&D projects, against 26% by the HEIs). Still, they were less focused on applied research projects than the HEIs (with about 10% of projects, against nearly 28% by the HEIs).

Figure 19. Number of individual projects by type of beneficiary and type of RTD, percentage of the total



Source: Authors based on monitoring data from the 46 OPs, excluding the seven Spanish OPs

3.5. Other R&D related activities

The classification process identified a residual category of interventions (absorbing less than 3% of the total ERDF expenditure for RTD) that could not be defined as either R&D projects or infrastructure investments but were still relevant in the RTD field. They included:

- **Internationalisation of research**, mainly including projects related to promoting international collaboration among HEIs and RTOs, or international mobility programmes for scientists and students.
- **Capacity building for research**[22], including projects addressing the development of researchers involved in R&D activities (including support for PhD programmes) or activities improving institutions' capacity to raise funds, increase international visibility, or better manage the research process.
- **Science dissemination to the general public**, including projects to increase public engagement in and awareness of science.
- Intellectual Property Protection Instruments, a very specific policy instrument implemented by the Polish OP for the Innovative Economy, benefiting those RTOs and HEIs that had previously implemented an industrial R&D project, supported by the same OP.
- **Operating subsidy**, providing generic support for the functioning of research-and-technology centres (either science-and-technology parks or RTOs), with no specific reference to implementing any RTD activity or infrastructure. These responded to a very broad and 'unspecified' logic, with no precise outputs and results expected beyond the operation of the research institute itself.

3.6. Policy mix and regional specificity

In order to address market and system failures, policymakers may either design a unique intervention or develop a 'policy mix' consisting of a synergic combination of different measures, combining different instruments to leverage interactions among them. While a policy instrument should achieve a specific goal, the individual implementation of different instruments may be insufficient to counteract certain systemic failures; policymakers should then seek to combine the instruments and make their targets complementary (Guy, 2007). The combination of policy instruments should reflect the key strategic objectives and main investment needs in the target territories.

Despite the wide variety of territorial contexts and research systems, the need to tackle infrastructure gaps and to facilitate improvements in science-industry collaboration comprised the logical foundation of the interventions of most of the programmes.

What the literature says - In a nutshell

The combination of the instruments should be consistent since, as stressed by Robin and Schubert (2013), a proliferation of instruments without clear coordination or synergies may generate confusion as well as multiple costs. In principle, it is expected that the combination

[22] Individual and collaborative R&D projects could also include a capacity-building component, although this was not the main objective of the project.

of instruments within a policy builds on a solid understanding of the key regional features and relates in a synergetic way to other existing policies. The presence or absence, the density and the nature of economic and institutional actors, and how they interact within the R&I dimension - all these aspects influence the ways regional R&I ecosystems react to the introduction of policy instruments. The presence of world-class research centres can build strong local knowledge that can be transferred to local firms facilitated by active intermediaries. The local productive fabric and inter-firm interactions are also important aspects. A high density of SMEs in the region may limit the absorptive capacity of the knowledge produced, while large and global businesses can have a pivotal role in driving regional innovation systems.

There is strong empirical evidence available from the literature that policy measures have to be in line with the level of development of the respective economy and local specificities. A traditional distinction is made between countries that work on or close to the technology frontier and those in a catching-up mode (Aghion, 2006). According to the European Commission (2008), countries far from the technological frontier should focus on technology transfer and the development of absorptive capacities through R&D and training. Conversely, in countries close to the technological frontier, the priority should be R&D aimed at a significant process or product innovations.

Source: Authors based on the literature review

Table 1 shows the correspondence between the types of rationale mentioned in the OPs and the territory's characteristics where the OP is implemented, as reflected by the results of the cluster analysis of EU regions (see Section 2.4). It emerges that regions that perform relatively worse for all (or the majority) of the considered variables have indicated more investment needs than the best-performing ones, pointing to several failures of the RTD systems, both from the supply and the demand side of research. In particular, they mentioned RTD capacities (lack of human capital, inadequacies in research institutions) and framework weaknesses more often than OPs belonging to better-off regions. These regions distinguish themselves for the low share of people employed in R&D and science and technology sectors and a still immature regional research and innovation system. Thus, **the investment needs identified by the OPs were somehow in line with the actual territorial features**.

Table 1. Matching investment needs and types of territories

	Cluster 1 Leader	Cluster 2 Strong business	Cluster 3 Moderate +	Cluster 4 Moderate -	Cluster 5 Modest +	Cluster 6 Modest -
Lack of sufficient physical (science and technology) infrastructure	67%	100%	74%	100%	93%	100%
Problems in the interaction and collaboration among actors in the innovation system	100%	75%	79%	100%	60%	100%
Risk aversion of the private sector	67%	50%	79%	60%	87%	50%
Human capital and skills deficiencies	33%	50%	74%	70%	47%	100%
Insufficient business capability	67%	75%	79%	90%	80%	91%
Inadequacies in research institutions	33%	0%	53%	70%	47%	100%
Weak or failing framework conditions	0%	0%	26%	60%	33%	50%

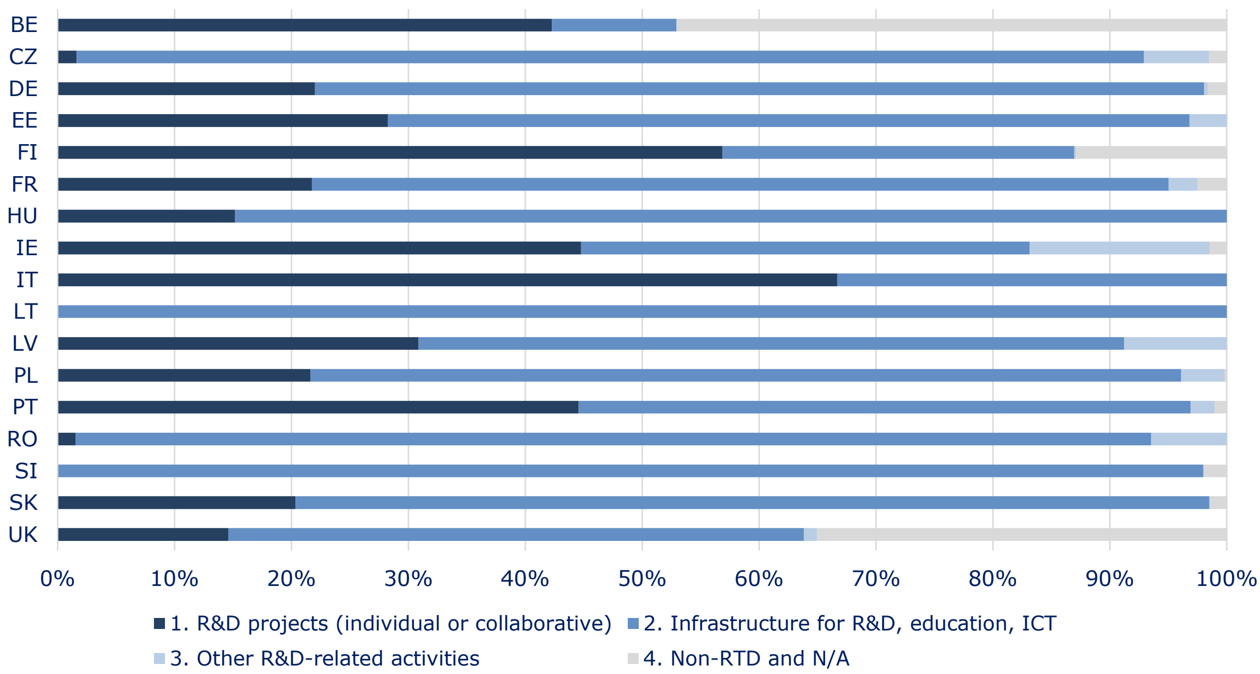
Note: The shares represent the number of OPs, by cluster group, that have mentioned a specific RTD investment need in their OP. For OPs covering regions that fall under different clusters, the prevalent cluster was considered. A more in-depth analysis, performed via the case studies, provides more nuanced evidence on this point. **There are indeed differences in the way broad strategic approaches are translated into policy mixes.**

Source: Authors

As described in the case studies, the need for strengthening the basic research system was translated into a **concentration of ERDF funding towards infrastructure investments**. In the Czech Republic, the ERDF-RTD policy mix focused almost exclusively on RTD infrastructures for research and education in universities and public research centres. In Poland and Estonia, by contrast, infrastructure investments for research and education were also prioritised, but in combination **with some effort to promote collaborative R&D projects.** In Estonia, this was done with the support of Centres of Excellence, with the aim of improving the quality of research, technological development and innovation for companies in growth areas. In Romania and Poland, science-industry collaboration was promoted through pioneering initiatives within collaborative R&D projects.

In **Portugal and Italy**, **a strong focus was put on research activities** (mainly individual in the former and collaborative in the latter). In Portugal, different and complementary policy instruments were designed to address research activities for research suppliers and for business. Instruments oriented towards the former were mainly individual R&D projects aimed at strengthening research capacities. In Italy, by contrast, the focus of support regarding research activities was decisively on enterprises. They had a key role in the collaborative R&D projects carried out in the field of applied/industrial research, the aim of which was to foster science-industry collaboration. In these two countries, ERDF supported RTD infrastructures, but only to a relatively small extent. In Portugal, regional OPs supported instruments targeted mainly at infrastructures. In Italy, a portion of ERDF funding was allocated to infrastructure investments further to increase their attractiveness, not only at the international level (coherent with the goals of the European Research Area) but also for industry, to lay the groundwork for public-private collaborations.

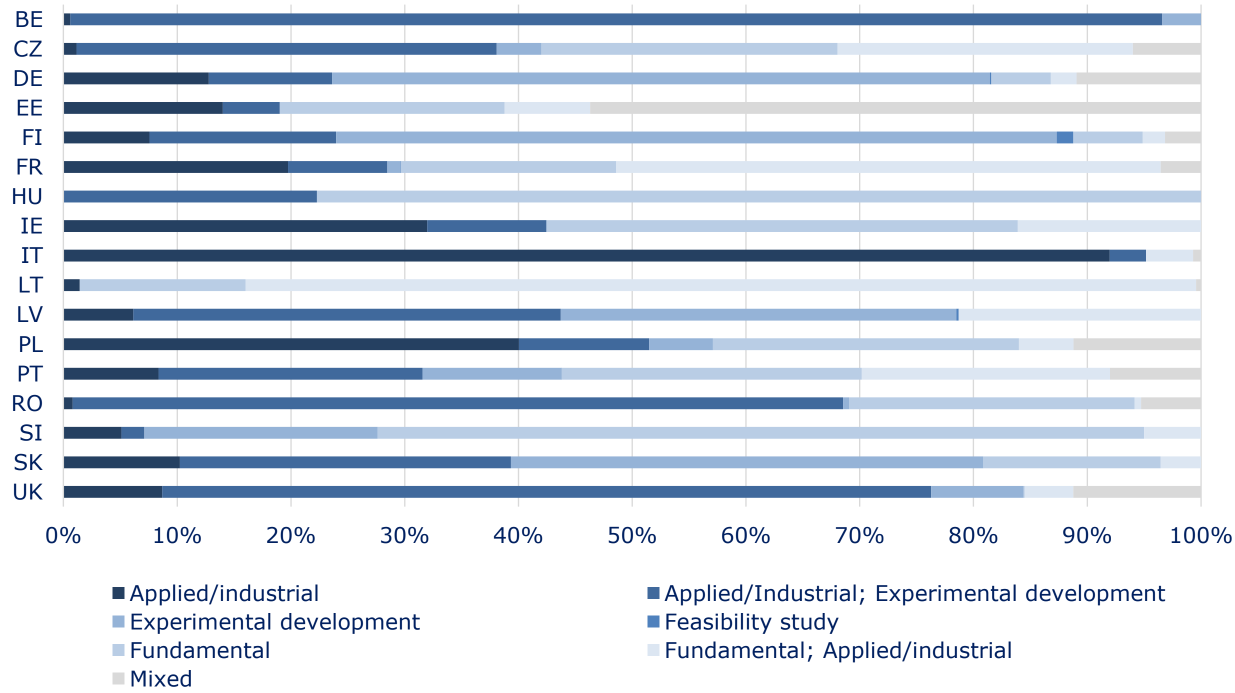
Figure 20. Total ERDF contribution by country, type of intervention, and percentage of the total



Source: Authors based on monitoring data from the 46 OPs, excluding the seven Spanish OPs

In some countries, such as Italy, Germany, France, Belgium and Ireland, the ERDF focus was not on funding scientific research but more on technology transfer to business, the valorisation of research and support for business R&D in selected domains. **Consistently, in these countries, the expenditure share for experimental development projects is higher** than for fundamental and applied research. Evidence from the case studies reveals that in Germany, in particular, there was a clear policy mix focused on fostering experimental research. This approach was intended to develop strong links between research and companies through technology transfer, especially in convergence regions. The focus on infrastructure investments, mostly in RTOs and HEIs, was explicitly linked with the logic of business-support investments. Some OPs, e.g., Berlin and Nordrhein-Westfalen, pursued a more balanced distribution of policy instruments and dedicated a considerable percentage of funding to individual and collaborative R&D projects.

Figure 21. Total ERDF contribution by country and type of RTD, percentages of the total



Source: Authors based on monitoring data from the 46 OPs, excluding the seven Spanish OPs

3.7. Excellence as guiding principle for targeting strategies

Evidence shows that, within a frame of geographical scope strictly determined by eligibility criteria, excellence objectives were the leading criterion for project selection and territorial targeting. Targeting strategies were mostly informed by considerations of existing R&D capacities and/or high-growth sectors with a competitive advantage and/or leading research centres and universities. Only in limited cases did trade-offs between R&D capacities and funds absorption require adjustments during implementation and territorial targeting. The result in most cases was a concentration pattern on more developed territories, more advanced sectors or technological fields and leading institutions, as evidenced by the analysis *of funds* concentration, presented in Section 5.3.1.

The in-depth analysis carried out in conjunction with the case studies confirms that broader territorial **targeting strategies were determined at the national level; they were driven by**

the eligibility of certain regions over others or in light of the budgetary allocation made to different regions of Member States. Nevertheless, **at the level of specific OPs** (especially nationally) **or instruments**, these did not include an explicit geographical targeting component and tended to be 'territorially agnostic', without specifying regions or territories where the expected outcomes were to be achieved. Thus, the funds were mainly addressed to strengthen existing territorial excellence, and their concentration reflected existing, regional scientific research-base and economic potential. The regional OPs for Sachsen, for example, sought to promote application-oriented research in high-tech fields, such as biotechnology, materials research, mechanical and vehicle engineering, micro-technologies and nanotechnologies, as well as energy and environmental technology. In this manner, the largest universities and research institutes in the region – such as the University of Leipzig, the Technical University of Dresden and the Fraunhofer Institutes (Leipzig and Chemnitz) – comprised the vast majority of beneficiary projects, with (as it transpired) a certain degree of geographic concentration after all. In Estonia, ERDF support was mainly concentrated in two of the county's largest cities - Tallinn and Tartu - which evinced the highest R&D potential in Estonia.

Even **countries with strong regional disparities in RTD did not adopt territorial targeting** and opted, instead, for the open promotion of excellence. For example, this was the case in Romania, which did not adopt a funds pre-allocation mechanism based on geographic criteria. In Poland, as with Romania, the distribution of ERDF support was not geographically driven. As a result, in Poland, the largest national OP concentrated funds in a handful of regions with stronger RTD potential: Mazowieckie (42.2%), Małopolskie (17.6%) and Wielkopolska (11.3%). By comparison, in the five regions of Eastern Poland, the support provided to beneficiaries within the OP IE accounted for only 6.3% of funding. The same pattern emerged in Romania, where 63% of funds addressed to RTD investment in the national OP were concentrated in RTOs and HEIs in the capital city (where more than 50% of all research infrastructure was located), and additional funds were allocated to a few other large university towns (Iasi, Timisoara, etc.).

An exception was provided by Italy, where geographic criteria for funds allocation were followed, due not only to eligibility criteria but also strategic choices for project selection. The ERDF placed a strong focus on convergence regions, where almost all funds were directed. In addition, in the multi-regional OP targeting of four different convergence regions, the project-selection processes (in conjunction with competitive procedures) adopted a regional pre-allocation of the total budget to ensure a territorially balanced selection. This was done at the *possible* cost of impacting overall quality, although no specific evidence is available on this point.

A tension between eligibility rules and the need to target lagging regions to reduce regional disparities was apparent only in selected cases. However, the Czech Republic provided one example, whereby a **clash between the objectives of pursuing territorial cohesion and world-class excellence created challenges in programme implementation** and thus had to be resolved. At the beginning of the 2007-2013 programming period, Czechia was characterised by pronounced regional disparities in R&D capacities and production between the competitiveness region of Prague and the rest of less developed regions. The Czech national authorities had to adequately strike a balance between the need for a concentration on top-class RTD with the obligation to comply with eligibility criteria. The initial strategic approach was focused on territorial cohesion, as the EC had strongly advocated: two billion euros of ERDF support for RTD were initially concentrated in convergence regions and only

EUR 107.63 million in the Prague region. However, the low absorption rate and the low quality of projects in the supported convergence regions required revision during implementation. Support was therefore rebalanced by allowing the possibility to support beneficiaries based in Prague (provided that the project was implemented in an eligible convergence region/s) and to locate two major infrastructure projects just beyond the border of the Prague region. Although it remained the second largest region in terms of beneficiaries, the Prague region recorded a slowdown of development thanks to the spill over effects in R&D human capital, which materialised in the convergence regions.

The same **logic of excellence was applied to the targeting of sectors**. In many cases, 'target priority' sectors and technologies were identified based on existing policy strategies and documents, either at national or regional levels. In some cases, this targeting reflected regional specialisation, anticipating to a degree the features of the smart-specialisation approach. For instance, in Germany, ERDF funding was concentrated mostly on engineering and technology, with some OPs also dedicating a visible share of funds to the natural sciences and medical and health services. Some others, meanwhile, allocated small shares of funding to agricultural and veterinary sciences, in line with regional research and innovation strategies. Regional differences regarding targeted fields of science reflected regional specialisation already identified in existing regional research, cluster and innovation strategies, e.g., the importance of Life Sciences in Nordrhein-Westfalen or the more prominent role of the energy sector in Brandenburg.

In Italy, collaborative science-industry research projects in convergence regions targeted the nine scientific-technological areas identified as strategic. This identification, already influenced by the pioneering design of regional Smart Specialisation Strategies, facilitated a concentration on strategic scientific and technological areas. Similarly, investments in Estonia related to ICT, biotechnologies, and material technologies are the three priority areas of the 2007-2013 national RDI strategy. Activities supporting these thematic areas aimed to cover at least 40.0% of funding for the relevant Axis. In the remaining countries, no specific target sector was identified in the OP strategic approach. In no case was a specific focus placed on those sectors in relative difficulty or those lagging behind. For example, in Portugal, little thematic pre-selection of the target sector was made.

As described in the case studies and as indicated by the mapped beneficiaries, in most cases, the target OPs funded beneficiaries with a competitive advantage, with a **high level of concentration within individual beneficiary organisations applied to leading institutions in their field**. This was notably the case in Hungary, Estonia, Lithuania and Ireland, where over 90% of ERDF funding was allocated to the top 10 beneficiary institutions. Even in Germany, where ERDF funding was completely decentralised and spread over a high number of OPs, the top 10 beneficiaries still accounted for 45% of ERDF support in the field of RTD. In Poland, a concentration of support can be identified in leading centres and universities where the country's strongest regional research ecosystems already existed. This was not the result of selection procedures that (e.g.) comprised the specific targeting of some beneficiaries rather than others. In all cases, projects were selected exclusively based on the research and innovation merit of the project proposal, irrespective of the merits of the applicant institution. The only exception was the intervention regarding excellent individual R&D projects in Portugal. This specific intervention was intended to support R&D centres of excellence in the convergence regions. Only Associate Laboratories and R&D entities rated as "very good" or "excellent" in recognised international ratings were eligible to apply for available funding.

4. Key achievements and missed opportunities

This chapter describes the main achievements detected in the target OPs, countries and regions. It combines, on the one hand, the evidence collected through the contribution analyses carried out for 21 selected policy instruments analysed in the case studies, with (on the other) the econometric analysis assessing the contribution of ERDF support to RTD investments via a number of outcome variables of RTD regional performance. The analysis of policy instruments attained 'depth' in the description of causal mechanisms of individual instruments, at the expense of 'breadth' in terms of the number of instruments analysed, providing a more qualitative description of how the intended achievements took place in selected observed cases. The econometric analysis, conversely, looks at the combined effects of selected types of instruments implemented in the target region, controlling for other relevant contextual factors (such as, for example, the public R&D expenditures in the regions), and expanding the validity of the anecdotal evidence of the case studies, but without more profoundly interrogating the causal pathways. Nevertheless, the combination of the two sources of evidence allows one to build a comprehensive picture of the achievements and missed opportunities and the causal mechanisms underpinning them.

4.1. Self-reported achievements

Monitoring indicators were reported by the Managing Authorities to assess the achievements of the OP. ANNEX V presents the core and common indicators associated with RTD investments across the 53 OPs, along with their initial target values. As confirmed by the analysis carried out in the case studies, monitoring systems, in general, provided a fair amount of quantitative evidence regarding instrument activity and output performance. They were much weaker in the context of long-term achievements.

According to the monitoring indicators, which were not specific for the categories of expenditure 01 and 02 but referred to the overall OP, the total number of research jobs created across the 53 OPs amounted to 20.5 thousand. Meanwhile, the total number of RTD projects supported was over 51 thousand, and the number of cooperation projects between enterprises and research institutions was 15 thousand. As compared to the initial target, the degree of achievement was mixed, and most of the OPs evinced an overachievement for some indicators and underachievement for others. Nonetheless, as already noted in previous evaluation studies, monitoring indicators are not the ideal source of information for assessing OP effectiveness[23].

This observation is confirmed by the evidence collected by the case studies. A number of the latter provided evidence indicating that output and outcome targets were exceeded as a result of ERDF support, which went above and beyond initial expectations. For instance, in Estonia, while initial expectations for the 'collaborative R&D projects in Centres of Excellence' instrument involved support for seven Centres of Excellence, an additional five

[23] 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

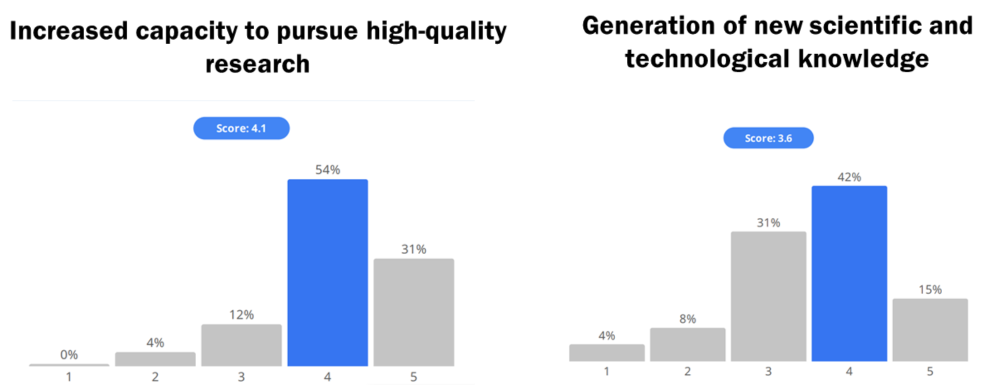
Centres were supported during the second half of the period, leading to a total of 12 supported centres (total budget EUR 40 million). On this point, however, a number of case studies did report better than expected results, sometimes as a result of additional financial allocations to the instruments, which allowed for more activities to be implemented without a necessary shift in performance targets. In other cases, it is not entirely clear how estimations for targets were developed, leading some evaluators to consider these targets somewhat subjective.

In general terms, the quality and robustness of ERDF RTD **performance measurement systems and accompanying indicators were found to be weak**. The amount of data available for evaluators to perform an assessment of selected instruments at this level was limited.

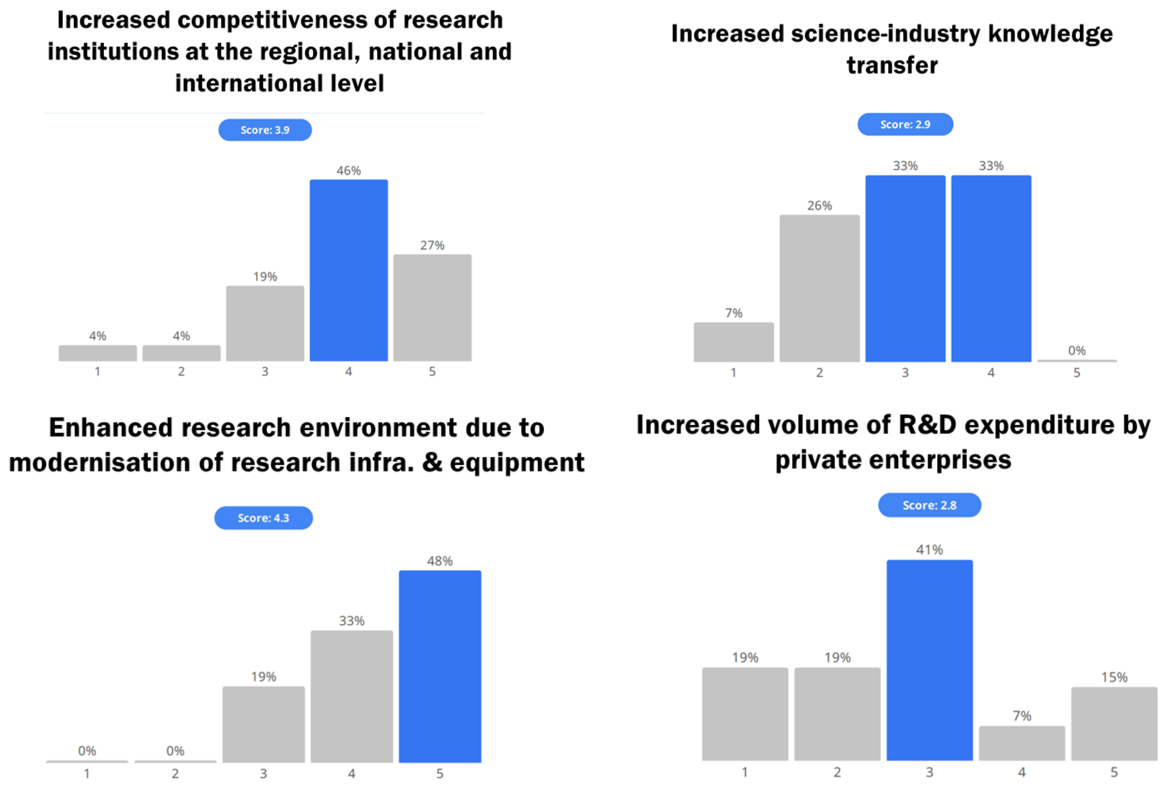
In some cases, the evidence from the monitoring indicators could be complemented by mid-term and ex-post evaluations conducted by the Managing Authorities or by external independent studies. **Impact evaluations on individual policy instruments or programmes carried out at the national/regional level are episodic**. Nonetheless, these studies, when available, can provide richer and more qualifying information on effectiveness[24]. The scope of the evaluation studies varies to a great extent (e.g., they may focus only on selected policy interventions and not on the overall policy mix for RTD). Equally variable are the adopted methodologies (counterfactual impact-evaluation studies, qualitative case studies, macroeconomic modelling, etc.). Overall, this evidence is not sufficient to provide conclusive information about overall OP effectiveness in addressing pre-existing RTD barriers.

Stakeholders' perceptions regarding achievements were collected during the seminar held as part of this evaluation. Although reflecting the views of a limited number of invited programme managers and representatives of beneficiaries, they provide an initial picture of the relevant achievements of the 2007-2014 ERDF support for RTD.

Figure 22. Rating of achievements for ERDF support in the field of RTD (2007-2013) – seminar consultation



[24] See for example the counterfactual impact evaluation discussed in the Italian case study or the ex-post evaluation of the Czech in the area of cooperative research, both expanding, better qualifying and sometime challenging the evidence on outcome collected by the monitoring indicators.



Note: These responses stem from a virtual validation seminar held in May 2020. More than 60 stakeholders, including representatives from Managing Authorities, R&D specialists and evaluation experts, and European Commission officials, participated.

4.2. R&D capacities: students and tertiary attainments

As illustrated in Section 2, a selected number of countries implemented policy instruments supporting infrastructure and investment for education to attract more students and improve the tertiary attainments in the region. The observed growth rate in the share of tertiary-educated people in the target regions was, on average, 7% in the period 2007-2017, from a minimum of -5% in the German region of Chemnitz (DED1) to a maximum of 18% in the region of Praha (CZ01).

In our sample of NUTS2 regions, only 29 (out of 104 in total) invested in R&D infrastructure for education. 21 of the 29 were in the EU13, and in particular, the Polish regions of Mazowieckie (PL12) and Pomorskie (PL63), together with Estonia (EE00), allocated a total of more than EUR 100 million to that instrument. **Evidence shows that ERDF investments in education infrastructures contributed to increasing the RTD capacity of the beneficiary regions** by supporting the increase the tertiary population attainment and the increase in people employed in science and technology.

The econometric analysis points to a positive and statistically significant correlation between that ERDF policy instrument and the **growth rate in the number of tertiary-educated people** (as a percentage of the population aged 25-64) in the period 2007-2017. The same positive relation holds for the **growth rate in the number of tertiary-educated persons employed in science and technology** in the same period.

The evidence of the case studies offers the description of the mechanisms underpinning this achievement. Beneficiaries underscored the high degree of satisfaction about the intervention, as it allowed universities, for the first time, to invest in the development of a holistic teaching and learning environment. The renovated and newly constructed buildings enabled institutions to **accommodate new equipment, creating a better environment and** attracting new students and researchers[25].

Improved infrastructure had an impact on the **quality of life at supported universities**. For example, thanks to numerous investments, the City of Brno became an antipole to the capital of Prague in terms of opportunities to gain a high-quality tertiary education, especially in certain fields. Investments helped dramatically transform the appearances of HEIs in some regional university cities, with positive effects spreading to local communities (e.g., further upgrades of the physical environment in particular city districts)[26].

Poland invested the highest amount in terms of ERDF contributions to the development of educational facilities. In the supported region, there was a steady and significant growth in students' choices of strategic (i.e., OP-supported) faculties from the academic year 2008/2009 until 2015/2016, while the total *number of students* decreased in the same period. One evaluation (EGO, 2013) indicated that the new infrastructure was used by a significant share of students attending HEIs who participated in the programme (32% of students overall and 83% of students of faculties directly supported by the project). Moreover, the evidence suggests that the **improved conditions and teaching environments helped attract students and researchers from abroad,** as evidenced by the increase in international students in Poland[27] and higher levels of cooperation with international partners. This has contributed to an increase in the internationalisation index of Polish HEIs, from 0.5% in 2005 to 5.63% in 2017.

The degree of achievement of this type of instrument also depends on factors other than ERDF. The econometric analysis shows that a positive and statistically significant contribution to the growth in the number of tertiary-educated persons (and employment in science and technology) was made by the initial level (in 2007). The growth rate (2007-17) of **R&D in the business sector**: regions with more advanced industrial fabric and higher R&D in the business sector experienced higher growth rates in the number of tertiary-educated people employed in science and technology. While ERDF support for RTD can increase the supply of researchers, demand-side effects related to the **absorption capacity of local labour markets** are crucial for the final success of such measures.

While there is plenty of evidence pointing to the fact that education has been improved, it is uncertain whether these improvements are in line with the needs of the labour market and potential employers; there are also questions regarding the extent to which improved education has led to higher employability and increased recruitment. In Poland, for instance, a recent peer review of Poland's Higher Education and Science system (European Commission, 2017b) suggests that the employment of recent HE graduates is above the EU average, but there are growing concerns about labour-market mismatches. In 2015, the employment of recent tertiary graduates in Poland stood at 85.1%, compared to the EU average of 81.9%. Nonetheless, a substantial and increasing number of tertiary-education

[25] Illustratively, in Estonia the number of PhDs increased from around 160 in 2008 to more than 230 in 2013, and most recently, this figure stood at 300 (2020). See the Estonia case study.

[26] See Czech Republic case study.

[27] Nearly 85,000 foreign students from more than 170 countries were pursuing their education in Polish HEIs in the academic year 2019/2020 (Perspektywy 2020), compared to only 8,500 in 2005.

graduates are in medium-or low-skilled jobs, pointing to labour-market skills mismatches (European Commission, 2016a). Nonetheless, the extent of 'over-qualification' remains significantly below the EU average, as evidenced by several studies (Cedefop, 2015).

Criticalities in the research labour market were also found in Romania, although it should be borne in mind that the country did not invest in education facilities but rather in infrastructure for research in universities. Even though there was a slight increase from 25.4% in 2008 to 28.2% in 2016, human resources in science and technology (HRST) remained lower than the EU average. One reason for this development, as illustrated by a recent JRC report (2018), was that staff in HEIs, as well as in the education, research and medical systems, remained strikingly underpaid in comparison with EU28 averages and with other categories of personnel (judges, local administration, police, army) in Romania.

4.3. R&D capacities: R&D personnel and researchers

The availability of more and better-skilled R&D personnel and researchers in a region improves its R&D capacities and makes it possible to increase both the volume and quality of knowledge production. Between 2007 and 2017, the average growth rate in the number of R&D personnel and researchers in the target regions was 40%, and the average regional ERDF expenditure on infrastructures and R&D projects in HEIs was about EUR 35 million. The econometric analysis shows that **ERDF investments in research infrastructures and individual R&D projects in HEIs contributed to an increase in the number of R&D personnel and researchers at the regional level.** Such a relationship was valid on average, i.e., without any statistically significant differences between the EU13 and EU15 or between Convergence and Competitiveness regions.[28]

The mechanisms through which this achievement was made possible are described in the case studies. One channel of effects was that triggered by **individual R&D projects**. Evidence indicates how funded projects facilitated an increase in the qualification levels of researchers and enabled the training of young scientists, as evidenced by the completion of around 70 PhDs as a direct result of the funded projects in Sachsen.

The main channel of effects, however, lay through infrastructure development. Evidence illustrates how support for **infrastructure investment in research** contributed to the **creation or modernisation of public R&D facilities and essential scientific equipment**; the evidence suggests that newly purchased equipment created more respectable research environments and increased research operating standards. Infrastructure projects, such as buildings, needed time to be constructed before they could generate useful outcomes, while acquiring research equipment and simpler infrastructure (such as laboratories) had more immediate effects. Beneficiaries confirmed that the access to modern research equipment contributed to the elimination of previous handicaps that had prevented research institutions from participating in research endeavours. Consequently, the beneficiary institutions' research potential and capacitie**s were perceived to have increased significantly**,

[28] In order to test the validity of this result, the analysis tested a set of interaction terms (first) between the dummy variable 'EU13' and the ERDF policy variable, (second) between the dummy variable 'Convergence region' and the ERDF policy variable, and (third) between the Type of Territory dummy variables and the ERDF policy variable. Interaction terms were never statistically significant.

becoming more attractive and competitive and gaining increased interest from students and researchers.

Increased research capacities in universities also led to **better awareness of, and interest in, industrial research needs and opportunities**. In Poland, a significant increase in the number of enterprise R&D personnel with doctoral degrees was observed. The ERDF policy intervention supporting cross-sectoral R&D collaboration played a crucial role in redirecting the career pathways of many scientists, who became aware of industrially oriented R&D research and the possibility of pursuing such research in private enterprises[29].

The **creation or modernisation of ICT-based infrastructure tackled** the urgent need for updated ICT infrastructure. For some institutions, basic ICT infrastructure elements, such as passive network components or phone systems, remained at the level of the 1990s. In other cases, some network elements (especially active components) were so outdated that no service was available from the suppliers. In Poland, a total of 59 projects funded 2,167 new or rebuilt laboratories. In Czechia, more than EUR 24 million of ERDF contributions were directed at new, developed, or modernised ICT information infrastructure for R&D, including repositories and storage capacities, optical networks, network optical elements, licences or databases. These outputs ensured a qualitative shift in existing services or, in some cases, the establishment of new ones.

Although ICT-based infrastructure projects need time to be constructed before generating useful outcomes, certain ICT infrastructures could be swiftly improved. Evidence from the case studies suggests that the building or modernisation of ICT-based infrastructure **created more professional research environments and increased the quality of education[30]**.

4.4. Scientific output

Scientific output is traditionally measured by the number of scientific publications. In the period 2007-2017, scientific publications almost doubled in terms of volume over the EU as a whole, but the **EU13 regions experienced a higher growth rate as compared to regions in the EU15** (145% against 96%), highlighting an ongoing catching-up process. In particular, some regions in Romania, Slovakia and Czechia experienced values higher than 400%.[31] Investments in research infrastructure and individual projects in HEIs have contributed to this achievement.

Evidence indicates that the ERDF investments significantly contributed to the catching-up process of the EU13 regions in terms of scientific output. This was partially due to the magnitude of the investments in HEIs (EUR 43 million in the EU13 against EUR 29 million in the EU15 regions) and certain other factors (national public expenditures in

[29] See the Polish case study.

[30] Many of the interviewees also pointed out that video classes and intensive streaming, especially important during the corona crisis, would not have been possible without the infrastructural improvements that took place during the ERDF funding period 2007-2013.

[31] The t-test suggests that the mean difference between the EU13 and EU15 was statistically significant at 1% level. In our sample, there were four NUTS2 regions with an extremely high rate of growth in the number of scientific publications. They were: RO12 – Centru (growth rate=1,005%); SK03 - Stredné Slovensko (883%); RO31 - Sud – Muntenia (723%); and CZ08 – Moravskoslezsko (549%).

particular)[32]. The analysis also suggests that lagging regions performed better than more developed regions in terms of growth in the number of publications, but this happened regardless of the ERDF investments in the type of instrument under scrutiny.[33] The higher growth rate recorded by the EU13 regions was mainly explained by their poorer starting positions with respect to more developed regions. For instance, the Romanian region of *Centru* recorded 101 scientific publications in 2007 and 1,116 in 2017, with an extraordinary growth rate in the period under assessment. Indeed, the regression analysis shows a negative and statistical significance of the coefficient associated with the initial number of scientific publications in 2007, pointing to 'diminishing returns to scale' concerning the evolution of the number of publications over time.

The regression analysis indicates a **positive and statistically significant relationship between ERDF support for research infrastructure and HEIs, on the one hand, and the growth rate in the number of scientific publications:** on average, the higher the ERDF expenditure, the higher the growth rate in the number of scientific publications in the period 2007-2017.

Evidence from the case studies helps to qualify the findings on scientific output. One channel of effects stemmed from **individual R&D projects consolidating existing knowledge or expanding it to new research fields**. Individual R&D projects played a significant role in contributing to the increase of scientific and technological output since, in some regions, they were the main source of support for individual R&D projects during this period. The immediate outcomes of individual R&D projects included an increase in researchers' scientific and technological capacity, **allowing researchers to enhance existing expertise and develop new areas of inquiry.** The reinforcement of teams with more human resources, and the acquisition of essential materials and services, ensured that the beneficiaries could enhance conditions to develop their main research lines. In Portugal, almost all projects (over 99%) funded under the assessed policy instrument supporting individual R&D projects produced publications, whereas, in Germany, it was estimated that around 76% of the funded projects did so. These results echoed broader national trends. In Portugal, for instance, from 2005 to 2014, the contribution to published knowledge (i.e., in the form of publications) more than doubled, with an average annual growth rate of 11%.

Another channel of effects developed from investments into upgraded research facilities and equipment. Beneficiaries confirmed that new infrastructure, modern equipment, and first-class instruments attracted students, researchers, and professors, both from the country and from abroad[34]. The analysed ICT-based infrastructure project, for example, brought a **profound shift in quality** in provided services, as it operated and developed the national e-infrastructure for science, research and education, encompassing a computer network, computational grids, data storage and a collaborative environment in a 'radical' way. The

[32] It should be acknowledged that during the 2007-2013 programming period the publishing system of Eastern journals was revised, and this may also have had an impact on the observed publication trends.

[33] In order to test whether the ERDF policy variable was more effective in lagging regions, we tested a set of interaction terms between the dummy variable 'EU13' and the ERDF policy variable, between the dummy variable 'Convergence region' and the ERDF policy variable, and between the Type of Territory dummy variables and the ERDF policy variable. Interaction terms were never statistically significant.

[34] See the Czech case study

newly developed infrastructure lifted the system towards the wider European level and opened a **gateway to European cooperation.**

General improvements in research infrastructure and R&D management capacities were also reported, which enhanced the quality of the research outputs and allowed for greater internationalisation efforts, such as participation in international scientific conferences and the publication of more peer-reviewed articles.

Another positive implication of increased scientific expertise and international visibility was that funded entities **were more empowered to apply for ambitious projects and also evinced improved chances of obtaining third-party funds** from federal as well as international (EU) sources (see Section 5.1.4 for further details on the participation to EU Framework Research Programmes and the German and Portuguese case studies for details on third-party funds).

In Estonia, the interviewed policymakers and research-institution representatives confirmed that **investments in research infrastructure** played a crucial role in increasing Estonian research quality and visibility, with additional observed effects in the subsequent programming period. Increased access to modern research infrastructure led to higher scientific production, strengthened collaboration between R&D institutions, increased ability to conduct high-level research, and increased capacity and competitiveness throughout the entire Estonian research system. Stakeholders agree that the level of Estonian research has significantly improved and that investments in the physical research infrastructure throughout the 2007-2013 programming period played a crucial role in this development.

However, the econometric analysis found that **there was no statistically significant relationship between ERDF investments in HEIs and scientific excellence.** When looking at the 2007-2017 rate of growth in the share of regional publications in both the top 25% and the top 10% by citations worldwide, the analysis suggested that scientific excellence was mainly driven by the level of R&D development in the region in the initial year (2007), measured by the level of regional GERD in that year, and by long-term investments in R&D in the following decade. This finding is in line with the analysis presented by the European Commission (2020), indicating evidence of a catch-up process among the Eastern regions in terms of quantity of scientific output, but not yet in terms of quality, a process that may take longer. The production of high-quality publications currently remains concentrated in some western and northern EU regions.

4.5. Technological development and innovation

From the improvement of R&D capacity to the production of scientific output, a further step in the causal pathway would manifest itself in follow-up projects, patents and intellectual property rights, as the effects of possible transfers and further developments of these scientific findings by commercial partners. The reconstructed theories of change indicated that, among the expected impacts of some policy instruments, there was the ambition to support the development of innovation and technological-production capacity in the region as a consequence of improved scientific capacity and production. Policy instruments more directly addressing this objective were those implemented by RTOs, science parks, competence centres, cluster organisations (both infrastructure and R&D projects) and science-industry collaborative projects.

When looking at the hard technological output, as measured by patenting and public-private co-publications,[35] the econometric analysis confirms the results already highlighted in the case studies. T**here is no statistically significant relationship between the ERDF support provided to policy instruments** targeting applied scientific activities and science-industry collaborations (either infrastructure investments or activities implemented by RTO, enterprises or centre of excellence) **and the growth rate of technological output** in the period under scrutiny. This holds true even when considering different model specifications with different context variables and controlling for the average ERDF investment in that policy instrument (e.g., amount of ERDF expenditure/N of beneficiaries) [36]. This finding emerges against a more general pattern of dynamic patenting activity of EU regions in the period under assessment and against some convergence patterns of eastern regions (European Commission, 2020). The average value of the growth rate in the number of patents in the period 2008 –16 in the sample of regions was 48%: four regions experienced an increase in the number of patents higher than 500% (RO12 – Centru; PL34 – Podlaskie RO22 – Sud-est; PL43 – Lubuskie).[37] By contrast, a set of regions, located mainly in Germany, Italy, the UK, Czechia, and Belgium, recorded negative growth rates. The case studies on selected policy instruments **confirmed the anecdotal evidence that pointed to limited uptake of the scientific results of supported R&D projects**, with poor results in terms of improved innovation and technological development.

Anecdotal evidence from the case studies supports a range of possible interpretations. Evidence from the case studies indicates that collaborative projects were highly appealing for target beneficiaries, and the calls for proposals reported a very large response, often beyond the available budget[38]. In the same country, however, problems were encountered with the other policy instrument. **Some implementation issues were reported.** In one Romanian project, of the 111 selected beneficiaries, 49 gave up during the pre-contractual stage, and 25 terminated the financing contracts because they were unable to obtain bank guarantees for pre-financing or co-financing bridge loans. A further four beneficiaries requested termination of financial contracts due to other difficulties in implementation. Financial-capacity issues of private partners were also reported in Italy, where the economic crisis put extremely high financial pressure on the capacity to ensure project sustainability. Delays in project selection were another cause of implementation issues.

Implementation issues were, however, limited, and overall, the projects were successfully completed. Immediate outcomes included an increased number of joint projects between R&D institutions and collaborations with private-sector partners. The evidence suggests that the funded R&D projects played a significant role in **increasing scientific and technological knowledge and competencies among beneficiaries** since many private

[35] We used i) the growth rate in the number of patents between 2008 and 2016; (ii) the growth rate in the number of public - private co-publications in the period 2008 – 2015.

[36] This holds true: i) when considering different model specifications with different context variables and controlling for the average ERDF investment in that policy instrument (e.g. amount of ERDF expenditure/N of beneficiaries); ii) when removing groups of countries (e.g., with or without regions with 0 EUR invested in the ERDF policy instrument) and/or outliers; iii) when considering ERDF investments in infrastructure for research and in Collaborative R&D projects as two separate policy variables; iv) when considering, as alternative outcome variables, 'the growth rate in the number of patents per million inhabitants in the period 2008-2016' or the, 'growth rate in the number of public - private co-publications' during the period 2008 – 2015.

[37] For instance, the Romanian region of Centru (RO12) had only one patent in 2008 but 17 in 2016.

[38] See for example the Italian, the Estonian or the Romanian case studies.

companies gained access to new ideas and became aware of new technologies. At the same time, through their collaboration with industry partners, research centres were also able to explore business partners' needs and develop skills needed for industrially oriented and applied R&D.

Results, however, may remain unfeasibly distant from an industrial application. This issue may apply in a number of cases when fundamental research was the focus of funded activities. Although this applies to a limited share of projects (see section 3.1), it can be part of a broader situational explanation. In many cases, research results were simply not relevant for the industry, or no follow-up projects had been intended. In the Polish case study, scientific partners reported limited interest among industry partners due to changes in business strategies that made the R&D results useless; alternatively, limitations related to insufficient technological readiness were combined with a lack of funding to continue the technological development. Consequently, as of 2013, R&D results had been successfully implemented by companies in only four cases for the policy instrument under assessment (Re-Source, 2014).

Another explanation for the lack of relationship between ERDF support and technological output is that of **time lag**. As the literature points out (see, for example, Finardi, 2011; Bastianin *et al*., 2021), it may take some time for research activities to generate a technological output, so the results of research activities implemented in the 2007-2013 programming period may be visible far beyond 2017. This may be even more true regarding infrastructure development. Infrastructure investments supported by the ERDF may have facilitated the setup of a suitable environment, enabling more intensive and productive exchanges between science and industry. This phenomenon, however, takes time to be consolidated and lead to results[39]. While an increase in collaboration between scientific institutions and commercial partners can be observed from the evidence, the transfer of results from R&D projects to external users for economic and social valorisation occurred to a more limited degree.

The most convincing explanation regarding the lack of relationship between ERDF support and the growth of patents is, however, the consideration that ERDF support alone may not have been enough: other supporting factors were probably necessary for a noticeable shift in technological capacity. Rodriguez Pose (2020) noted that innovation in the EU regions is linked to four main factors: investment in R&D, population density, a higher share of population with tertiary education, and governmental quality. The econometric analysis confirms this hypothesis and indicates that **the main drivers of patent growth were the R&D investments carried out by firms and the maturity of the R&I industry system** in the region, as proxied by the initial level (in 2008) of regional R&D investments in the business sector. Thus, the contribution of ERDF to technological production may be more indirect. One viable hypothesis is that the ERDF policy instrument positively influenced the R&D expenditure variation in the business sector and, through this channel, had an indirect impact on patents. Overall, private R&D expenditure still increased in all convergence regions, reaching the target defined by the OP. In 2007, private R&D as a proportion of GDP amounted to 0.22%, while in 2015, it reached 0.32%, and by 2017, it had fallen back fractionally to 0.31%.

[39] See for example the Italian, Czech and Romanian case studies

Thus, the econometric analysis also tested whether ERDF policy instruments evinced an indirect link with the rate of growth in the number of patents via the R&D expenditure in the business sector. Nonetheless, the regression analysis **rejects any statistically significant correlation between ERDF policy instruments and increases in business R&D expenditure** in the target regions during the decade 2007-2017. While this is more disappointing than the previous results regarding patents, there are also explanations available here. Other factors can play a more direct and significant role in triggering business R&D expenditure, including ERDF support to business R&D (out of the scope of the present evaluation), other forms of direct support to business R&D, or more contextual factors. Among the latter, the role of the economic crisis should not be overlooked, and this will be discussed in the next chapter. In addition, building trust and a positive relationship between science and industry may not be achieved via a single project; more effort is needed. In Poland, the case study describes that few follow-up R&D contracts or joint R&D initiatives between industry and scientific partners were pursued upon completion of the funded projects. Most interviewed representatives of both scientific and industrial organisations confirmed that no joint R&D projects were carried out with the same partner following the conclusion of projects. Polish enterprises gradually reduced their funding of external R&D projects performed by scientific organisations for reasons concerning legal challenges related to intellectual property and technology transfers – challenges that themselves resulted from overly bureaucratic frameworks. Scientific partners also pursued different objectives upon project completion, focusing more on publications and broad knowledge dissemination rather than commercial developments.

Hence, **the contribution of ERDF support for R&D collaborative projects to the competitiveness of the regions may occur through more indirect and, especially, 'softer' effects** than through an observable shift in patent or business R&D. Improvements in the competitiveness of local industry may come from improvements in R&D management, increased interest in the pursuit of innovation strategies and an enhanced understanding of new technologies and international technological trends, than from the successful commercialisation of the R&D results of the projects[40]. Another, more indirect link to innovation may have occurred through the effect on the education sector and the share of the population with tertiary education, as discussed earlier.

The role of ERDF support in fostering behavioural change among the target beneficiaries has already been highlighted by previous evaluations (European Commission, 2016b). The Romanian case study points to a 'soft' impact, such as 'paving the connecting road' between large and powerful industries operating in Romania, alongside profound changes in the organisational culture and management style of scientific research organisations and higher education institutions inherited from the previous economic regime.

Following this line, the econometric analysis tested correlations between the ERDF and 'softer' innovation outcomes. The analysis suggests that **ERDF support[41] positively and significantly correlated with the growth rate of EU trademark (EUTM) applications** in the period 2007 – 2015. Interestingly, in addition to ERDF support for RTD investments, additional drivers were the level of **ERDF expenditure on business support and R&D**

[40] See the Polish case study

[41] The analysis considered the expenditure on infrastructure for research and in collaborative R&D projects.

expenditure in the business sector (as a percentage of GDP)[42]. Although not conclusive evidence in itself, this finding seems to confirm the impression that the role of ERDF is more related to behavioural changes and less to technologically intensive innovation.

The role of ERDF in triggering behavioural changes among its beneficiaries is supported by evidence from the case studies, and it is indicated in some instances as, perhaps, one of the most lasting effects of ERDF support in the field of RTD. There is widespread consensus that ERDF played a key role in strengthening beneficiaries' capacities and that this has lasted well beyond the period during which they benefited directly from ERDF support. These effects have also ripple into others, such as the capacity to engage in collaborative research activities or participate in international research programmes. Still, it is worth noting that these factors mainly concern public organisations such as Higher Education Institutions or Public Research Organisations[43].

4.6. Summary of the contribution analysis of selected policy instruments

Evidence from the case studies shows that the great majority of instruments completed their planned activities and delivered both intended outputs and immediate outcomes (e.g., projects and grants were provided, buildings and new research infrastructures were developed, collaborative projects were completed, etc.). This was also reflected in the high level of disbursements of ERDF funds, which indicated that **activities** and work originally foreseen in the framework of Operational Programmes **were successfully executed**.

The great majority of intended outputs and immediate outcomes identified in the reconstructed Theories of Change were duly observed by the case-study teams. Instances in which projects originally selected to receive ERDF support were then cancelled due to poor performance or other implementation challenges were extremely limited. Italy is perhaps the most important exception to this general finding, given that various output and immediate-outcome goals have been only partially met, given the delays in ERDF funding execution.

The causal link is then diluted along the pathway towards impacts. When one considers effects that were observed far beyond the life cycle of the policy intervention, it must be acknowledged that various other factors – not directly related to the policy intervention of 2007-2013 – exerted a significant influence; these 'other factors' combined their effects with the ones produced by the ERDF in many ways. Such contributing factors, pre-conditions and risks, and the way they influenced the causal pathways are discussed in the next chapter. This dilution effect may also be the reason why evidence regarding intermediate outcomes and impacts is more limited.

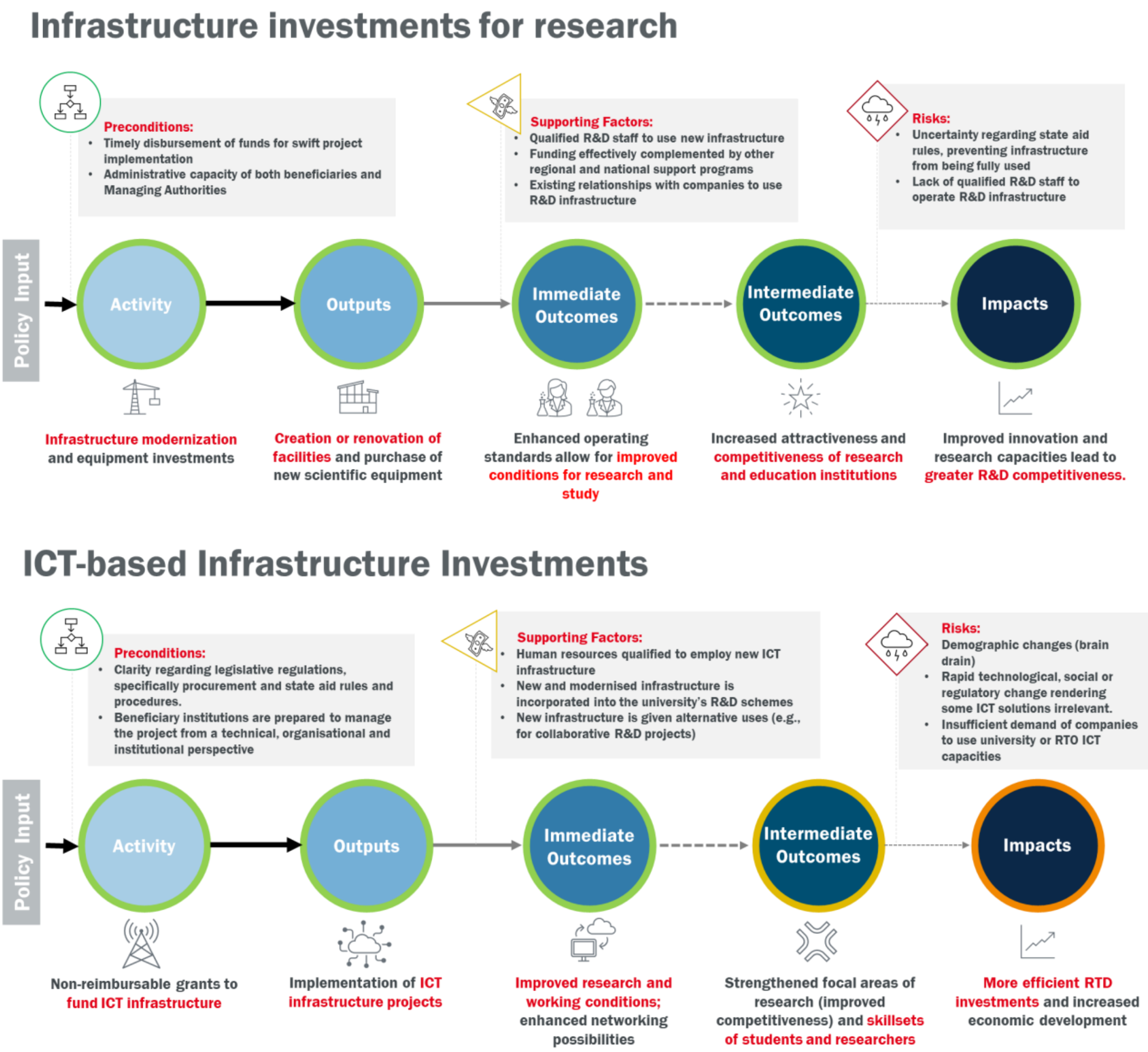
[42] Other context variables such as the type of R&D, type of territory or membership of EU13/EU15 played no role in shaping the relationship between the ERDF support and the growth rate in the number of EUTMs applications.

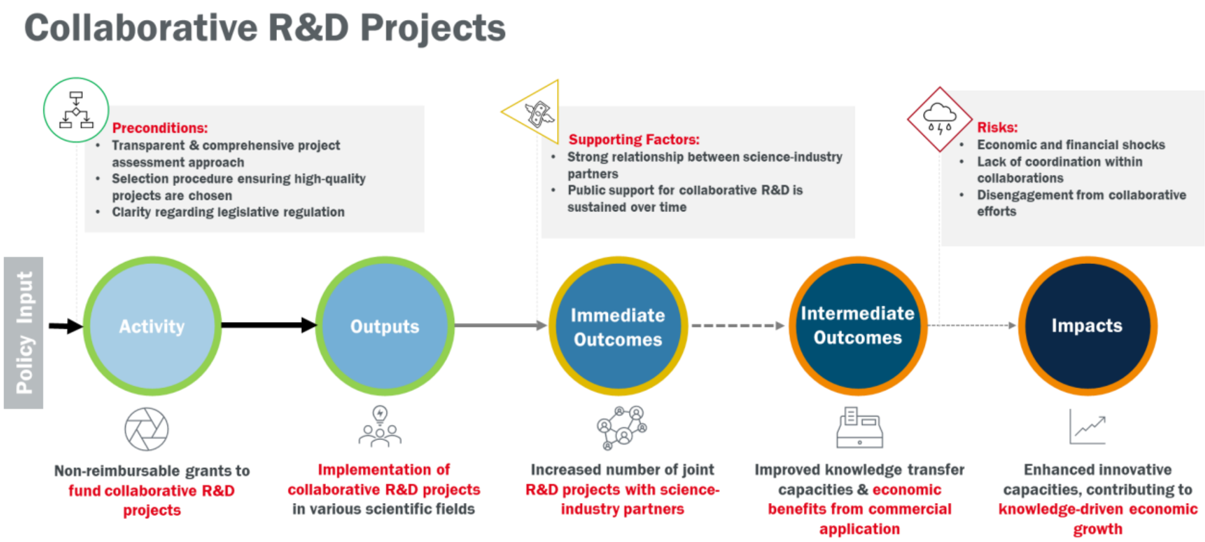
[43] Many examples are available on these types of effects, including: demonstration effect on the importance of science-industry collaboration (Italian case study), increase in national and international standing of beneficiaries (German case study), organisational changes to support project management (Portuguese case study), increased capacities relevant to implementation of subsequent support measures under the current programming period (Polish case study), pioneering role in facilitating mutual understanding and the creation of much stronger bridges of communication between R&D and the economic sector (Romanian case study).

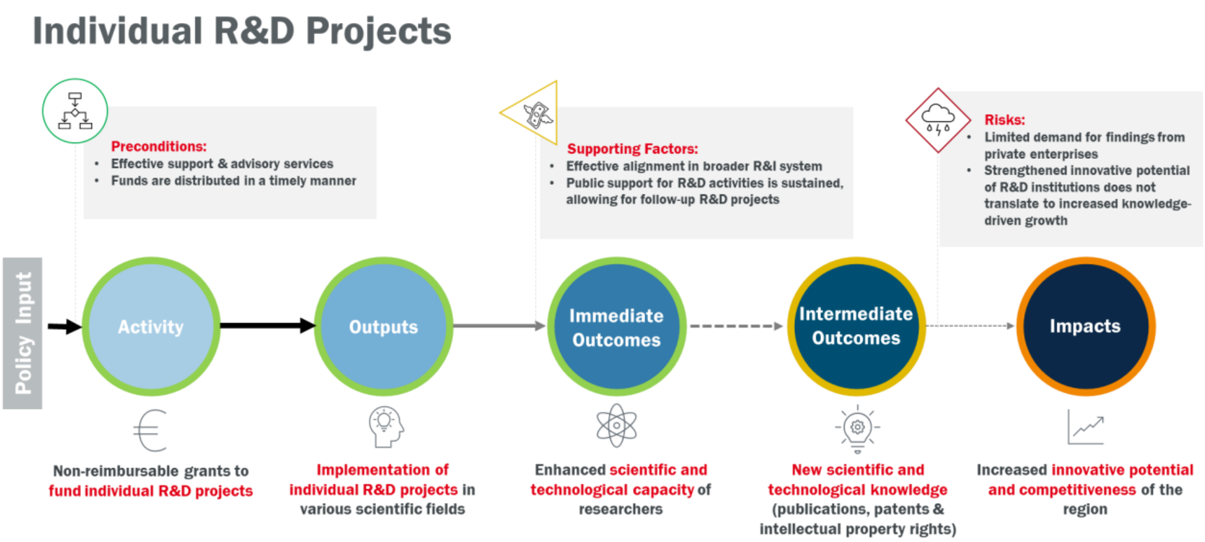
The **main positive outcomes** identified within the case studies relate to **improvements in funded beneficiaries' scientific capacity and performance**. This is visible through an increase in students and graduates, an increase in R&D personnel and researchers, and the higher production of research outputs such as publications. It is also confirmed, however, by more qualitative aspects not immediately captured by indicators. These aspects relate to the increase in scientific standing and visibility (also internationally) of the beneficiaries, increased participation in international-research collaboration networks and projects, and reported increased capacities to plan, execute and manage research projects and infrastructure according to international best practices and standards.

Most important, however, is the relatively **limited existence of evidence and data pointing to any uptake in private-sector innovation** as a result of the work performed based on ERDF support for RTD investments. The case studies only identified a handful of instances in which data, knowledge or infrastructure stemming from ERDF projects either directly or indirectly benefited the private sector, thereby developing innovations that were later introduced to the market. Even though private-sector innovation was a common intended outcome of many of the instruments analysed, in hindsight, this does appear to be one of the major blind spots of ERDF support for RTD during the 2007-2014 period.

Figure 23. Generalised and tested theories of change







Note: On a spectrum from green to red, green indicates that the effect occurred, while the gradients of orange indicate that the effects occurred to a progressively more limited extent

Source: Authors on the cross-case study analysis performed in Task 4

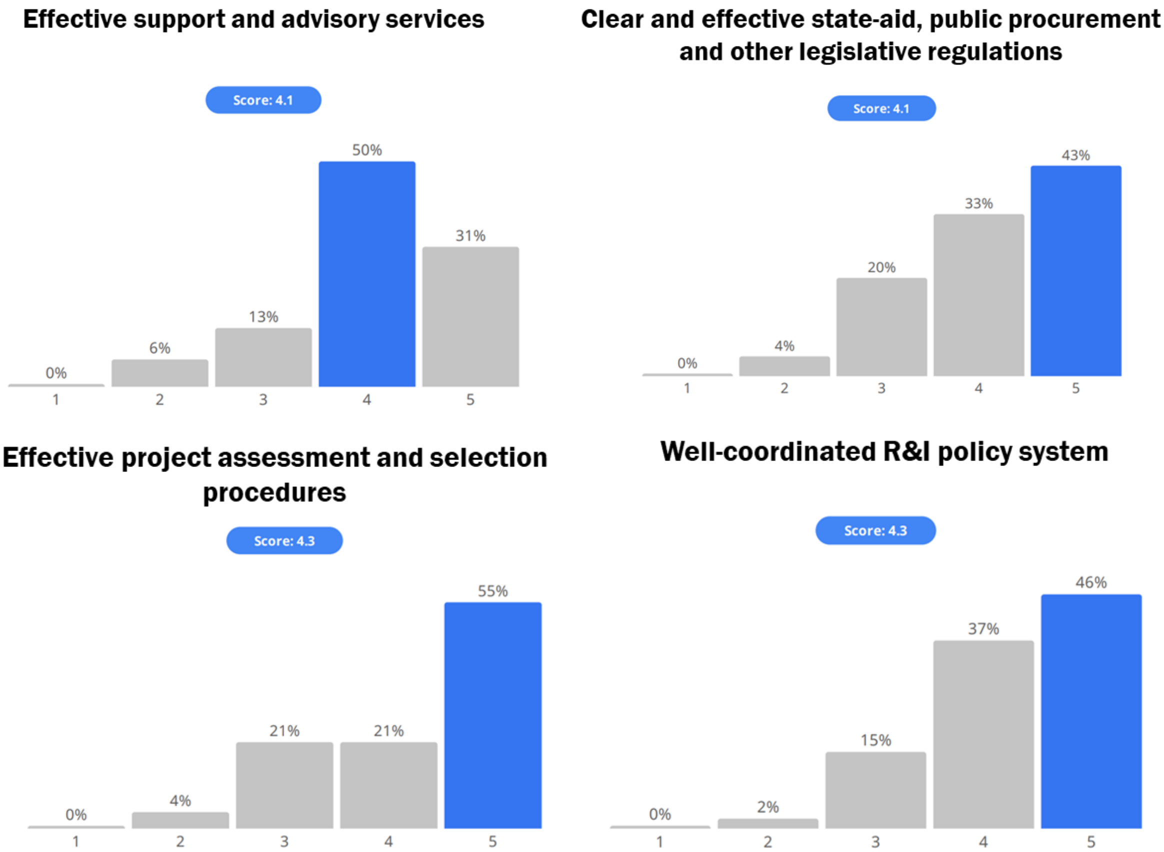
5. Underlying factors for impact generation

In line with the contribution approach, this chapter builds on the evidence collected regarding the broader contextual elements (supporting factors, pre-conditions and risks) that affect the materialisation of results. Some of these have already been referenced in previous sections, notably in the discussion of observed achievements, but here, they are addressed more systematically.

The importance of contextual factors in assessing the effects of R&D funding is widely discussed in the literature. Indeed, it is acknowledged that **any discernible long-term impact of research and innovation is dependent on a set of factors**, such as macroeconomic stability, long-term commitment of financial resources, the availability of human capital, broader framework conditions or the economic and technical structure of a region, which together significantly influence innovation creation and diffusion.[44]

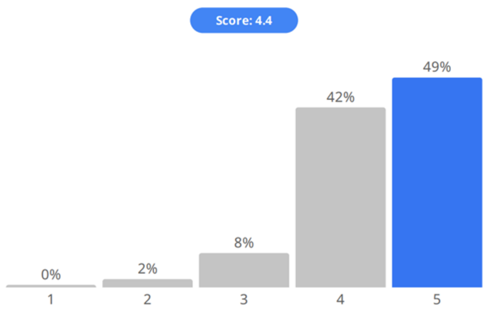
This study has identified various contextual factors that play, and played, a crucial role in explaining what works and how. Such factors were also discussed during the seminar, and the latter confirmed their importance and relative standing.

Figure 24. Significance rating: contextual factors for effective RTD policies

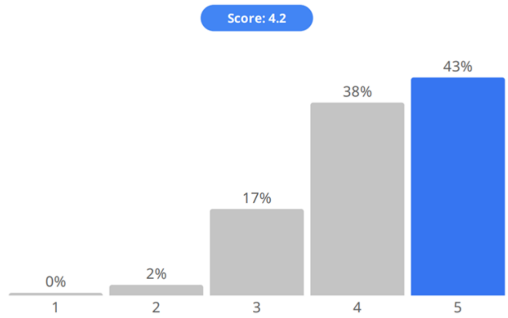


[44] Aghion *et al.*, 2014 ; Fercuri & Jalles, 2017; Mohnen, 2017 ; European Commission, 2017.

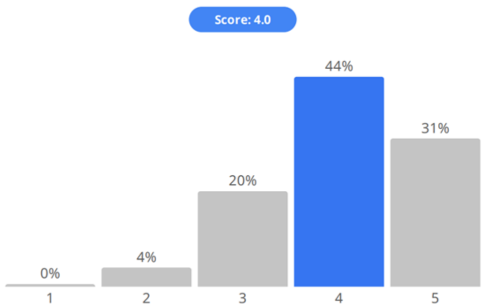
Sufficient and highly-qualified human resources



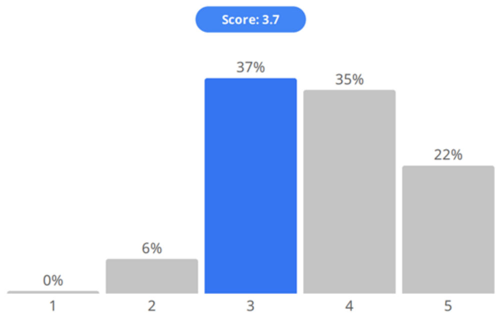
Strong relationships between science-industry partners



Sustained public investment support for R&D instruments



Resilient financial and economic systems



Note: These responses stem from a virtual validation seminar held in May 2020. More than 60 stakeholders, including representatives from Managing Authorities, R&D and evaluation experts, and European Commission officials, participated.

5.1. Broader and long-term commitment to RTD investments

One of the main drawbacks observed via the analysis of achievements was the lack of systematic follow-up investment projects to build on research results. In public and private organisations, this was due to changes in investment strategies and a consequent lack of funds. External shocks, such as the economic crisis that occurred during the period under scrutiny, were among the principal disruptions undermining continuity in the research and innovation journey. Continued public investment in research institutions is essential, as it allows for follow-up projects that strengthen existing capacities to take place and the development of new ones. This also ensures that the most suitable human resources are provided to manage and perform research activities. However, private investments are also important to improve the technological and innovation capacities of the industry as it builds on research results.

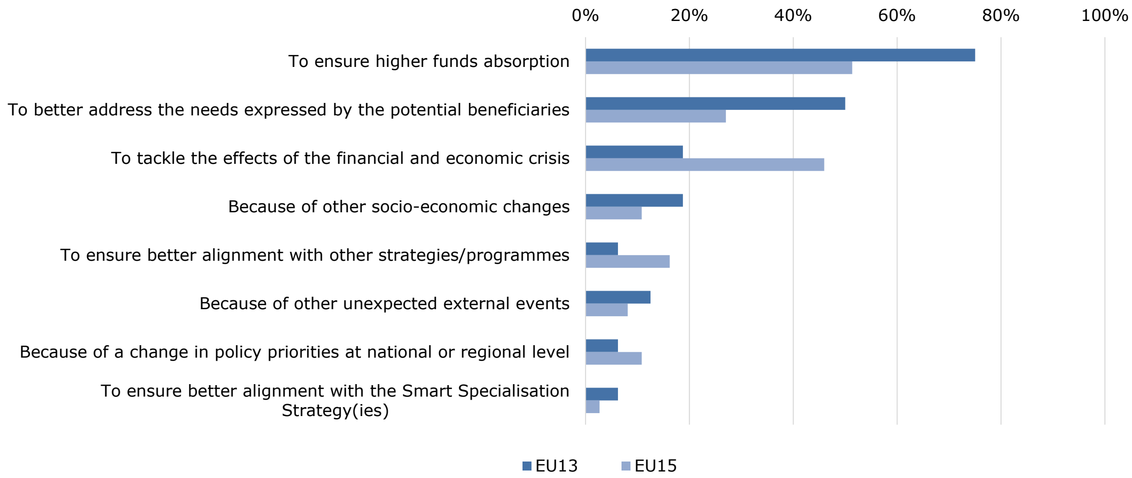
Continuity and complementarity among all R&D funding mechanisms were necessary to guarantee that various programmes did not compete but rather complemented each other to offer a comprehensive funding framework. At the same time, perfect separation of roles or competencies among fund providers may not necessarily be desirable, as there is a risk of fragmented interventions not building ‘one upon the other’ in a synergetic way. This becomes even more important when external shocks occur and bring financial pressures in their wake.

This section examines how the economic crisis impacted the capacity of beneficiaries, both public and private, to ensure continuity in their R&I investment strategies. It also discusses the role of ERDF within a sustained RTD strategy in a wider policy mix, including national public R&D expenditures and other EU sources.

5.1.1. Building resilient strategies and programmes

During implementation, programmes may deviate from the initial intended logic for several reasons, including administrative challenges related to funds absorption, better alignment with emerging needs and changes in national or regional priorities. The evidence collected by this study indicates that, while no significant deviations were detected in the overall intervention logic of programmes and policy instruments during implementation, some delays, absorption and capacity problems emerged. The economic crisis also represented a reason to re-think the budgetary allocation.

Figure 25. Reasons for reprogramming - share of OP citing the reason (multiple answers were possible)

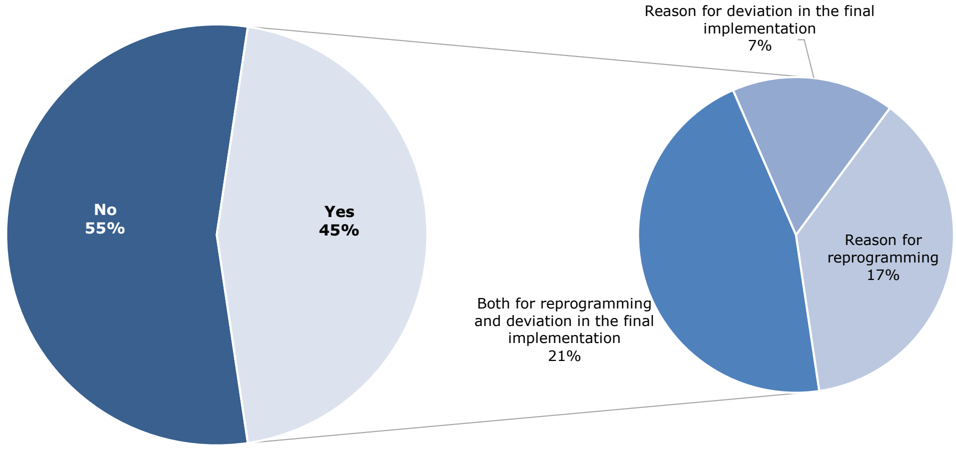


Note: The percentage is calculated as the number of EU13 (EU15) OPs, mentioning the factor in question over the total number of EU13 (EU15) OPs. The total number of EU13 OPs was 16, while the total number of EU15 OPs was 37.

Source: Authors' review of the OP reprogramming documents

More than 90% of OPs saw a reprogramming of the planned expenditures. The reprogramming did not necessarily imply a change in the overall logic of intervention but potentially also pointed to a **financial reshuffle among interventions with the same logic**. Interestingly, there was a sharp difference between the reasons mentioned by the EU15 and **EU13 OPs**, with the former being mainly related to the external shock of the economic crisis. Conversely, the latter were more influenced by the need better to target the funds to the instruments considered more attractive by potential beneficiaries, thus showing a better performance in terms of funds absorption. Since this was the first full programming period for those countries, it is reasonable to conclude that planning and administrative capacities were still less developed in the EU13 than in the EU15.

Figure 26. Share of OPs mentioning the economic crisis as a reason for reprogramming or deviation in the final implementation



Source: Authors' review of the OP reprogramming documents

In the period under assessment, the economic crisis negatively affected investments in RTD infrastructure and activities**.** The impact of the crisis across the EU regions was asymmetrical. It is possible to identify a core continental area wherein RTD efforts were affected only to a limited extent by the crisis or could recover relatively soon. This was true of Germany[45], most of Poland[46], and neighbouring regions such as Slovakia. By contrast, one can discern a more peripheral area that was impacted the most: Ireland, Spain, parts of Italy, Greece, Cyprus, Lithuania, Latvia and Estonia[47].

Observations regarding the asymmetric effects of the crisis highlight how external shocks may undermine intervention functions in different settings. Above all, the crisis impacted firms' financial capacity and resources to undertake investments, with a risk of limited fund absorption, especially for those OPs that allocated large resources to collaborative research projects. This underscored the need for **adaptive strategies to cope with changing socio-economic contexts**.

Of the 53 OPs analysed, not all of which were hit by the economic recession, in 14 cases, **the crisis determined a change in the OP policy mix for RTD**. In most of the observed cases, the Managing Authorities decided to **increase the resources allocated to RTD investment** (both R&D projects and infrastructures), considering this a means to sustain business development and innovation and ensure job creation and economic competitiveness in the long run (two Spanish OPs, the three Portuguese OPs[48] and the Slovenian OP). This is in line with what the literature suggests, indicating that maintaining or

[45] Compared to other EU MS, Germany evinced a relatively fast economic recovery and was nicknamed an 'engine of growth' in the years after the financial and economic crisis.

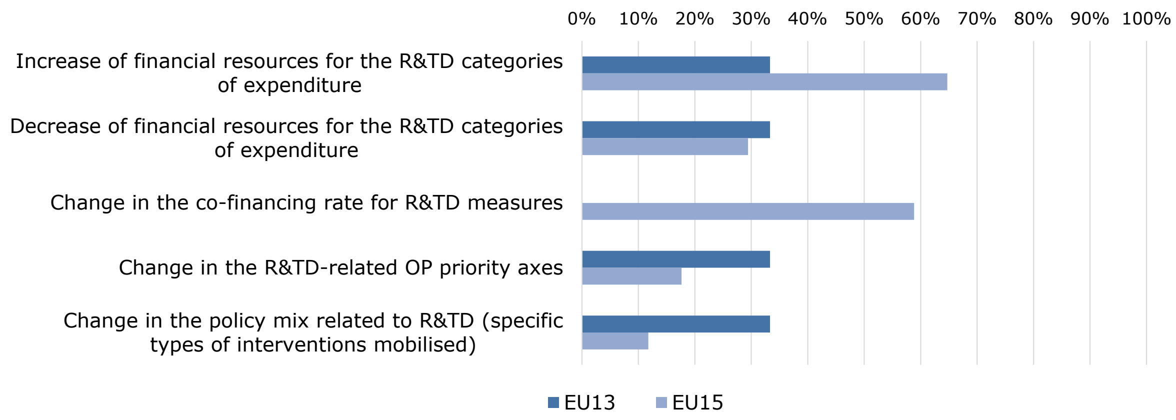
[46] Poland's economic growth was not as significantly affected by the slowdown as the other EU countries to which it was linked, as the country benefited from an influx of foreign investments, the internationalisation of businesses, changes in skills and human-resource availability, the growing importance of innovations in the economy and reforms of the science sector.

[47] Countries such as Italy, Romania, Portugal, the Czech Republic and Estonia experienced budget cuts at the public and private level, leading to significant effects on the capacity of private firms to undertake planned investment, and on that of public authorities to ensure co-funding.

[48] For example, in Portugal the original OP funding for knowledge and technological development was increased from EUR 500 million to EUR 642 million during the course of the programming period (2007-2013).

even increasing investment levels remains crucial during economic downturns.[49]In a minority of cases (especially the Italian OP for the Southern regions, the Latvian OP and, to a lesser extent, the UK West Wales and the Valleys OP), **resources allocated to RTD interventions were cut and moved to direct business support** to mitigate the impact of economic recession, especially on SMEs, in a countercyclical role.

Figure 27. Main responses to the economic crisis in those OPs mentioning that crisis as a reason for reprogramming, by type of country covered - share of OPs mentioning the item against total OPs



Note: The percentage is calculated as the number of EU13 (EU15) OPs mentioning the item over the total number of EU13 (EU15) OPs. The total number of EU13 OPs is 16, while the total number of EU15 OPs is 37.

Source: Authors' review of the OP reprogramming documents

Evidence from the case studies better shows how the ERDF helped cope with the effects of the crisis during project implementation. In Portugal, for example, public or private non-profit research entities were entitled to be 100% financed – with 70-85% of this sum originating from ERDF funds and the remainder from national public funds. Since during the height of the crisis, the Portuguese government was unable to guarantee its contribution. A loan was obtained from the European Investment Bank (EIB), which removed all financial and operational constraints and ensured that the calls for proposals were effectively implemented.

Although different reactions to the crisis were adopted in different Member States, there was a **generalised decrease in national public expenditure for RTD investments, which the ERDF partially compensated**[50]. This impacted both the sustainability **of newly created research centres**[51] (as the business sector reduced its demand for contract research) and the private sector (due to the reduced capacity of industry actors to provide co-financing and firms' creditworthiness dramatically diminishing). Administrative payment delays affected the smooth execution of research projects, especially those involving SMEs with low economic and financial capacity as beneficiaries. Lack of funding also affected the possibility of undertaking follow-up projects, which were neglected even in cases where the potential for

[49] Pellens, Maikel, *et al.* (2018). 'Public investment in R&D in reaction to economic crises - a longitudinal study for OECD countries.'

[50] See in particular the Italian, Czech Republic and Estonia case studies.

[51] As described in the Romania and Portuguese case studies.

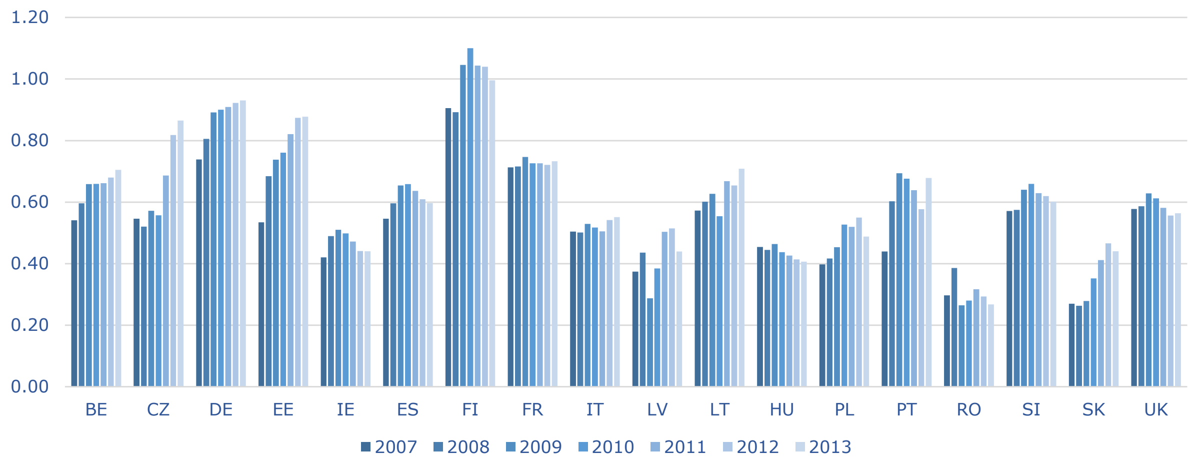
commercial application existed. By contrast, projects led by large firms and research organisations generally proved to be more successful in light of their economic solidity, propensity to organise research activities according to a long-term research agenda and ability to collaborate with a consolidated network of SMEs as subcontractors.

ERDF support for RTD helped public research infrastructures and businesses withstand the crisis, and this was true in particular in those countries and regions most severely affected. It provided a significant source of funds, sometimes palliating a decrease in national public support, **representing in many cases a 'safety belt'** for targeted beneficiaries hit by the crisis and thus playing a useful countercyclical role. However, ERDF funding only played a substitutive role in some instances, making up for a decrease in ordinary support measures from national and regional governments. This was the experience of Italy, where the ERDF was used more to preserve the *status quo* rather than initiating a restructuring process. In this way, the role of the ERDF as an instrument for transformation was possibly diluted, and it risked delaying a painful but necessary restructuring of the regional systems.

5.1.2. Coherence with national public R&D support

In the period under assessment, the evolution of R&D public expenditure as a proportion of GDP in the Member States provides different stories concerning the capacity of different MSs to ensure a long-term commitment to RTD investments. Overall, public R&D expenditure during the period remained highly concentrated in those countries where most regions with high R&D intensity were located (i.e., Finland, Germany and France). Nevertheless, a generally positive trend was recorded, primarily in the newest Member States, such as the Czech Republic, Estonia, Lithuania and Slovakia. Regarding the oldest Member States, only Germany and, to some extent, Belgium and Portugal showed a slight improvement, while public R&D expenditure remained stable in France and Italy. Italy, in particular, experienced budget cuts to public R&D during the economic crisis.

Figure 28. Evolution of R&D public expenditure as a percentage of GDP (2007-2013) in the 18 MS covered by the study



Source: Authors

Portugal experienced continued public investment in science, technology and innovation. The evidence shows that, in combination with ERDF support, **this was a key supporting factor in explaining the country's positive performance regarding levels of tertiary education and the number of persons with a tertiary education** employed in science and technology[52]. A range of instruments, both within and beyond the ERDF support, sought to support the scientific and technological system entities throughout this period. Still, the most important aspect was that the R&D system benefited from increased R&D expenditure, with the latter growing by 34% from 2007 to 2010. R&D expenditure as a share of GDP rose above 1.5% for the first time in 2009 (1.58%), compared to 0.73% a decade earlier.

A positive environment for long-term commitment and complementarity was also evident in Sachsen, where the intervention under inquiry continued into the subsequent programming period (2013-2020). In addition, this was complemented by other R&D support mechanisms at the *regional* and *national* level, such as the State Excellence Initiative or the High-Tech-Strategy 2020, respectively.

A virtuous circle in research funding was also reported in Estonia, where the supported entities explained that the funding allowed them to focus on high-level research, reducing the burden of finding sufficient financial support. Furthermore, due to the quality of research produced, researchers were able to secure funding in the succeeding programming period and thereby continue their research projects.

Sustained public support for research institutions is key for sustainability. In Italy, financial issues within public research organisations prevented hiring additional human resources, which limited the effect of the newly established infrastructure. Because of cuts in the university budget, additional researchers could not be hired to operate the labs effectively.

In a number of cases, and especially in the new Member States, **the ERDF support represented a significant share of the support provided for RTD-related goals.** In that sense, it represented the main instrument of national and regional strategies. The magnitude of ERDF support in RTD, compared to other national RTD support resources, is presented in the following table. In cases where ERDF represented a limited share of the total national R&D spending but with a high regional concentration (e.g., in convergence regions), its role was crucial in the design and implementation of RTD investments. This was notably the case with Italy, where a high share of ERDF support for RTD investments was concentrated in Convergence regions that, as compared with Competitiveness regions, suffered from a higher decline in public expenditure for RTD, and in which ERDF expenditure accounted for a major share of public expenditure on RTD.

Evidence collected via the strategy analysis indicates that the **RTD programmes supported by the ERDF were often closely linked to objectives of industrial competitiveness**, as indicated by the strict links between the ERDF interventions for RTD and those of national and regional strategies for cluster development, business innovation and support. The ERDF was also **instrumental in supporting national and regional strategies of economic conversion or transition** from an industrial economy towards a diversified economy, such as in Lorraine, Nord Pas-de-Calais (France) and Wallonie (Belgium). The RTD-driven measures that focused on enhancing and polarising the research potential in selected fields were synergic with interventions for business creation, skills development and technology transfer to SMEs, designed to stimulate interest in research and innovation adoption.

[52] See the Portuguese case study.

Table 2. The magnitude of ERDF contributions to RTD (categories of expenditure 01 and 02) over national R&D expenditure across the 17 MS

Country covered by the study	Total ERDF contribution to RTD (01 and 02) over total R&D expenditure (2007-2013)	Total ERDF contribution to RTD (01 and 02) over public R&D expenditure (2007-2013)
Belgium	0.30%	0.80%
Czech Republic	8.10%	18.60%
Germany	0.40%	1.30%
Estonia	11.80%	25.50%
Finland	0.20%	0.50%
France	0.20%	0.60%
Hungary	1.10%	3.00%
Ireland	0.50%	1.70%
Italy[53]	0.80%	1.90%
Lithuania	10.00%	13.60%
Latvia	14.80%	20.90%
Poland	10.90%	16.40%
Portugal	2.60%	6.00%
Romania	6.30%	9.90%
Slovenia	1.50%	5.10%
Slovakia	19.40%	33.50%
United Kingdom	0.30%	0.80%

Source: Authors based on monitoring data from the 46 OPs, excluding the seven Spanish OPs and on EUROSTAT data

In terms of the regional strategies that were potentially complementary to the ERDF OPs, special mention should be made of the Smart Specialisation Strategies (S3). Even if these strategies were drafted towards the end of the programming period, **clear synergies and mechanisms to ensure coherence between the S3 and the ERDF 2007-2013 OPs were detected in some OPs**. Full synergy between the ERDF and the S3 was ensured when they adopted coherent sectoral priorities. In some countries, especially the New Member States, the investment carried out in the 2007-2013 period directly informed the selection of priorities for the next S3. In other cases, the S3 influenced the design and implementation of the OP.

The case studies expand on previous findings. While pointing to a **significant level of strategic coherence** between ERDF support in the field of RTD and existing local (i.e., national or regional) support instruments, the case studies highlight the fact that ERDF support **was not, generally, explicitly linked to other** (i.e., non-ERDF) **national or regional policies or programmes from an operational standpoint**. At best, there was a

[53] This is a national average but there were huge regional differences, for example:

- The value for the total ERDF contribution over total R&D expenditure was 9.5% in Campania, 14.4% in Puglia, 29.9% in Calabria and 9.5% in Sicily;
- The value for the total ERDF contribution over public R&D expenditure was 17.1% in Campania, 20.8% in Puglia, 32% in Calabria and 13.2% in Sicily.

tacit understanding and recognition of the different goals that each different category of policies was meant to achieve. This was perhaps best illustrated by Germany, where the case study found little coordination between RTD strategies and programmes at the national level and regional innovation strategies and programmes for the 2007-2013 period (or their predecessors). In many cases, however, authorities ensured that ERDF support actively contributed to the RTD goals established either at the regional or national level.

Generally speaking, linkages between ERDF and non-ERDF support for RTD were visible through the co-financing requirements established by ERDF. Beneficiaries, and public entities, in particular, made use of regional or national financial resources to ensure they complied with ERDF co-financing rules and obligations.

5.1.3. Coherence with other ERDF support

Evidence collected from the case studies indicated a **significant degree of coordination across interventions carried out within the ERDF framework**. This applied to coordination across different ERDF OPs (national and/or regional) and the different axes, measures, and instruments implemented in the framework of the individual OPs.

Within individual OPs, beyond investments for RTD infrastructure and activities, other interventions potentially contributed to strengthening the regional RTD systems, particularly as far as the objective of improving the systemic relations of regional actors were concerned. In the context of those additional resources, expenditure[54] for these interventions represented a significant portion of the ERDF contribution in the period under evaluation (more than EUR 26 billion)[55]. If one also considers these additional investments, the overall picture of funding under some target OPs changes dramatically. In Hungary, for instance, the expenditure classified under the 01 and 02 codes amounted to EUR 109.7 million, i.e., 4.5% of the OP according to the Final Implementation Report. Nonetheless, in the context of projects supporting research in SMEs and knowledge-and-technology transfer activities, the total ERDF expenditure amounted to EUR 1,045 million, i.e., 43% of the total OP. The figure below shows the share of RTD expenditure related to science-industry cooperation networks and business RTD and innovation activities in the 53 OPs.

This additional share of ERDF funding was particularly relevant in countries like Germany, France, Belgium and Finland, where the ERDF focus was not on funding scientific research but more on technology transfer to business, the valorisation of research and support for business R&D in selected domains.

Case studies show that there were no overlapping or duplication of efforts between the two types of instruments in terms of design and implementation. A typical distinction was made in terms of target beneficiaries: while instruments supported by 01 and

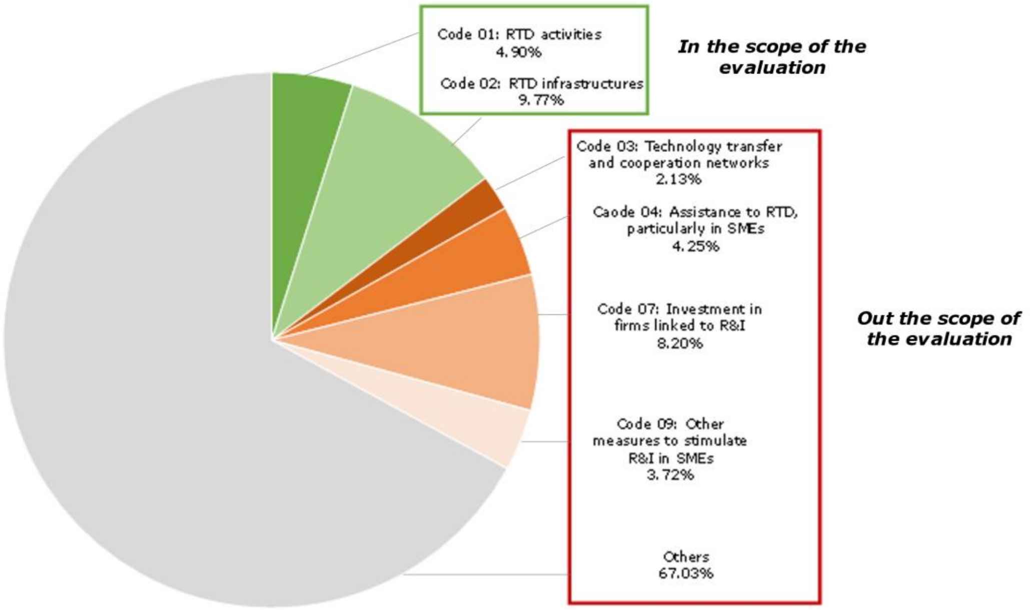
[54] Relevant codes beyond 01 and 02 are the following: Code 03 - Technology transfer and improvement of cooperation networks; Code 04 - Assistance to R&TD, particularly in SMEs (including access to R&TD services in research centres); Code 07 - Investment in firms directly linked to research and innovation; Code 09 - Other measures to stimulate research and innovation and entrepreneurship in SMEs.

[55] It is worth noting that Work Package 13, 'Geography of Expenditure', of the Ex-post evaluation of Cohesion Policy programmes 2007-2013, in the analysis of the ERDF contribution to RTD, actually referred not only to codes 01 and 02, but also to codes 03, 04, 07 and 09. Similarly, the categorisation of ERDF expenditure for the 2014-2020 programming period aggregated these six codes under the same umbrella category of 'Research and development and innovation', because of the strong linkages between them.

02 categories of expenditure mainly targeted research providers to improve their capacities, the other codes primarily reflected the targeting of SMEs, with the principal aim of supporting innovation processes. In Romania, for example, to reduce the risk of overlapping interventions across different ERDF OPs, the Managing Authority developed and implemented guidelines for establishing a demarcation line between the OPs, based on the scope of activities, project values, type of beneficiary, etc. Complementarity was also actively pursued. For example, some of the actions initially implemented as part of ERDF RTD instruments were eligible to receive subsequent funding from other complementary ERDF RTD instruments implemented during the same period.

Therefore, the function of these complementary interventions is particularly relevant in an assessment of the role of ERDF in bridging the gap between the provision and use of research results.

Figure 29. ERDF allocation for the 53 selected OPs by code of expenditure

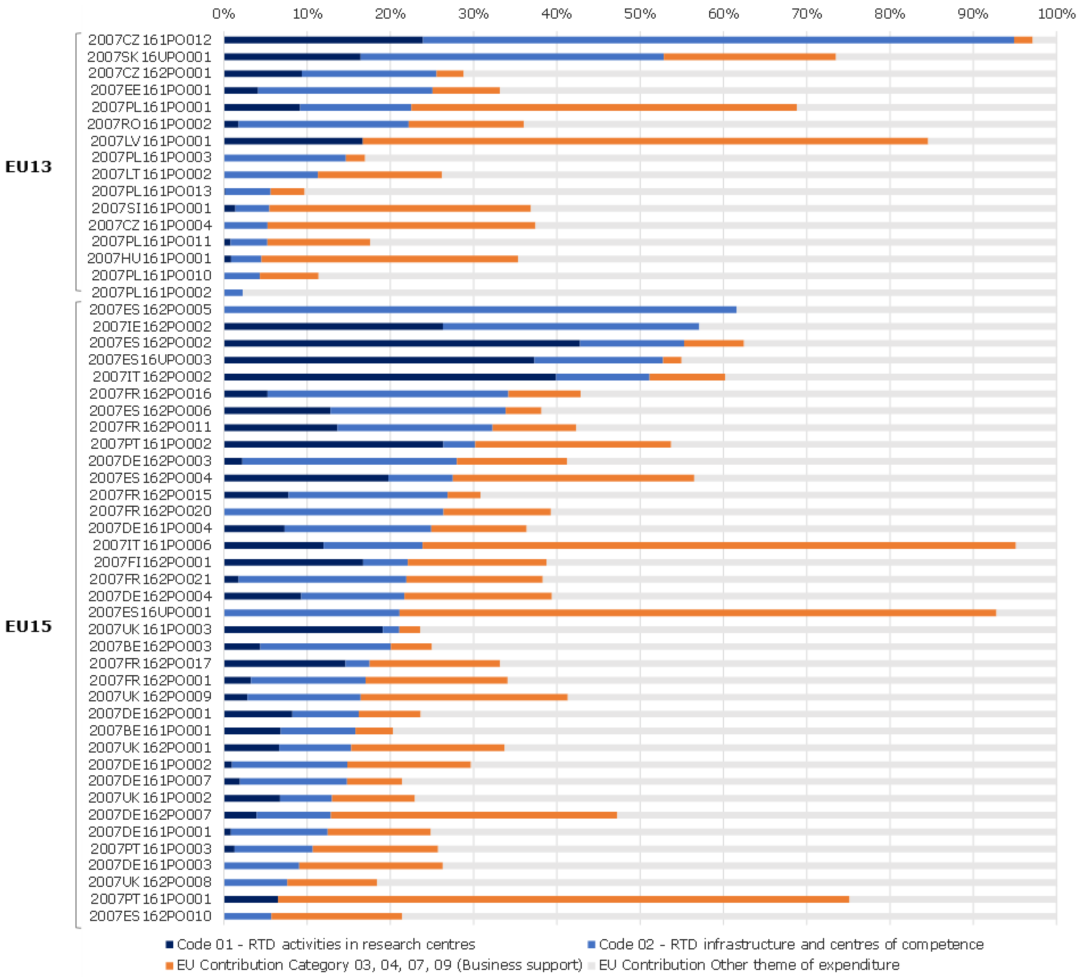


Source: Authors' elaboration based on DG REGIO 2007-2013 Cohesion data from closure reports

Beyond ERDF measures funded within the same OP, expenditures were also planned in other OPs but targeted the same territories, notably when regional ones complemented national OPs. In many cases, the case studies found that **adequate complementarities across ERDF support actions and programmes in the field of RTD played a key role in achieving the expected results**, either as necessary pre-conditions or as key supporting factors[56].

[56] See Czech Republic and Estonia case studies.

Figure 30. ERDF allocation for the 53 selected OPs by OP and code of expenditure



Source: Authors' elaboration based on DG REGIO 2007-2013 Cohesion data from closure reports

Countries such as Italy and Portugal **went to great lengths to ensure a strategic complementarity across different OPs and** a high degree of coherence between actions taken by national and regional ERDF OPs. In Italian convergence regions, while the regional OPs supported RTD investments with a strong local significance, the national OP was designed to support larger-scale and more ambitious RTD investments with an interregional perspective and national relevance[57].

In Portugal, to ensure the necessary articulation between the national and the regional operational programmes, all operational programmes **adopted a thematic structure** that allowed the implementation of common support instruments and principal project typologies in the RTD and innovation fields. The distribution of competencies between national and regional programmes was based on the following main principles: actions that benefited from management closer to the beneficiaries, or which were to be implemented under a regional or local intervention logic, were supported by regional OPs; conversely, actions that required critical thresholds, implied some kind of coordination or resulted from national strategies were funded by the national OP for Convergence regions.

[57] See the Italian case study

5.1.4. Coherence with the European Research Framework Programmes

In the 2007-2013 programming period, the European Commission supported and encouraged research in the European Research Area (ERA) through the 7th Framework Programme for Research and Technological Development (FP7). According to data reported on the Cordis portal[58], the programme funded more than 25,000 projects for a total value of EUR 65.5 billion and disbursed EUR 46 billion against an initial allocation of EUR 50 billion.

In principle, the excellence-based rationale of EU research policies, such as the 7th Framework Programme (FP7) and Horizon 2020, aimed at supporting European 'champions', can be seen as a beneficial complement of the purpose of the ERDF, which aims to support certain EU regions in closing the R&I gap between them and more advanced regions. Synergies have always been advocated and promoted to render the use of EU funds more efficient.

The reviewed literature examining the interlinkages between European Structural and Investment Funds and the European Research Framework Programmes distinguishes between two main types of synergy models (JIIP, 2017): upstream (i.e., synergies depart from ERDF investments and determine the strategic choices of other programmes and strategies) and downstream synergies (synergies depart from another programme and are integrated into the ERDF OP). Nevertheless, the literature also recognises that the differences in funding principles, programming and implementation procedures, and selection criteria (especially of the geographical scope) for proposals and consortia, may generate unintended discrepancies vis-à-vis the overall objective of increasing innovation activities and output (see, e.g., Foray *et al.,* 2018).

Upstream synergy

The analysis of programming documents detected ambitions for upstream synergies within the majority of the OPs: **ERDF investments were expected to enable the subsequent participation in FP actions through different causal pathways:**

- infrastructure support could pave the way for more advanced research by making available technologically upgraded facilities and equipment;
- ERDF-funded research projects were expected to improve the capacity to prepare and implement research projects, together with improved support for human resources in R&D. These changes were expected to facilitate preparation for FP7 projects, as well as their subsequent management;
- by supporting the creation of networks based on the cooperation of RTD players, the ERDF projects were often seen as a way to structure and consolidate local partnerships, enabling them jointly to apply for other funding schemes.

Both infrastructure development and R&D projects would, in turn, favour increased participation in the European projects. This was highlighted, for instance, in programming documents for Italy, Hungary, the Aquitaine region and the Czech Republic.

[58] https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/horizon-dashboard

The in-depth assessment carried out in the case studies corroborates this finding. With hindsight, a number of Member States reported that the ERDF support received during the 2007-2013 period – particularly when it came to investment in research infrastructure – directly influenced their subsequent capacity to engage with and participate in FP-supported projects, notably by providing enabling conditions. On the one hand, the ERDF supported the technological upgrade of scientific facilities and equipment, enabling more advanced research. On the other, it funded the improved capacity of research projects to manage and implement collaborative projects, paving the way for increased participation in more complex European projects.

An opposite sequential pathway was, however, identified in some of the more developed regions under the Competitiveness and Employment objective (as, for instance, in the UK, the Lowlands and Uplands of Scotland, and Germany): a clearer distinction between the FP7 and the ERDF programmes was set. While the FP7 was meant to focus on transnational 'blue-sky' research projects, the ERDF programmes were especially used to support the industrial application of technologies. Case studies confirm that in some countries, such as Germany, ERDF support for RTD investments in some cases acted as a complementary source of funding for other EU-supported research and innovation projects, despite the strong operational demarcation between FP and ERDF.

Nevertheless, despite ambitions to build on the relative added value and to implement projects in continuity between the two funds for selected target areas or beneficiaries, **no specific arrangements were designed to facilitate and promote active synergy**. No special coordination mechanisms were put in place in the implementation of programmes and specific instruments, mainly because the two funds still followed quite different implementation mechanisms (e.g., the modality of selecting the interventions and the objects of the latter).

A **simultaneous combination of funding** from the ERDF and the FP7 was sought only in a few cases, such as in Finland and the Cornwall region, where ad hoc agencies were in place to facilitate the coordination between programmes. Another positive example of closer alignment was the regional OP Emilia-Romagna, which included activities that supported the preparation of proposals for FP7 and Horizon 2020 with a dedicated call for tenders, launched in 2014. The call aimed to fund feasibility studies based on research results already achieved by the technopoles and research labs, which could, in turn, be further expanded in the context of research programmes eligible under Horizon 2020.

Despite there being no active strategy for combining the two sources of funds, matching data from the ERDF beneficiaries mapped by this study[59] with FP7/H2020 beneficiaries from the CORDIS database[60] shows that the proportion of ERDF beneficiaries that also benefited from FP7/H2020, at least in some countries, was rather significant.

[59] A systematic mapping was not possible for all the mapped beneficiaries because of data-quality issues: the duplication of records, misspellings and inconsistencies in the way beneficiaries were reported in the monitoring systems did not permit an automatic and systematic matching for all the mapped OPs. An exemplar data matching, done almost manually, was carried out for the sampled OPs of the case studies.

[60] https://cordis.europa.eu/it

Table 3. Participation rate in FP7 and H2020 projects amongst ERDF beneficiaries

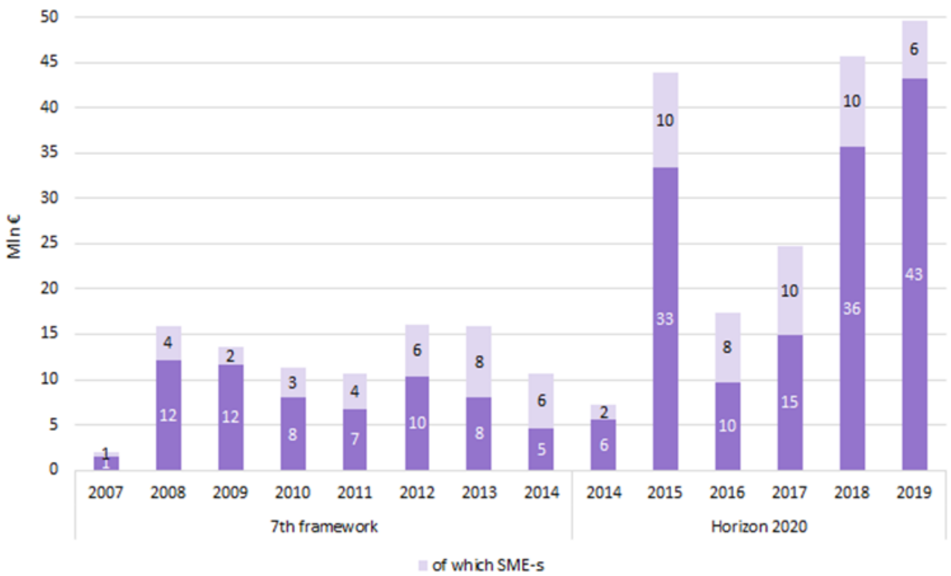
	PARTICIPATION RATE (%)	
	FP7	**H2020**
Estonia	27.6	27.6
Italy	22.3	15.7
Germany	22.0	21.3
Poland	62.9	62.5
Czech Republic	33.3	39.8
Portugal	46.8	48.4
Romania	25.9	26.5

Source: Authors matching ERDF beneficiaries' data with Cordis data

Downstream synergy

The expected impact from ERDF investments in research infrastructure and activities could duly be observed, albeit with some delay. Evidence shows, for example, that in Estonia during 2007-2013, the participation of Estonian researchers in the FP7 programme remained stable but rapidly increased within the subsequent H2020 programmes during 2014-2020.

Figure 31. Estonian participation in European Framework Programmes (EURm)

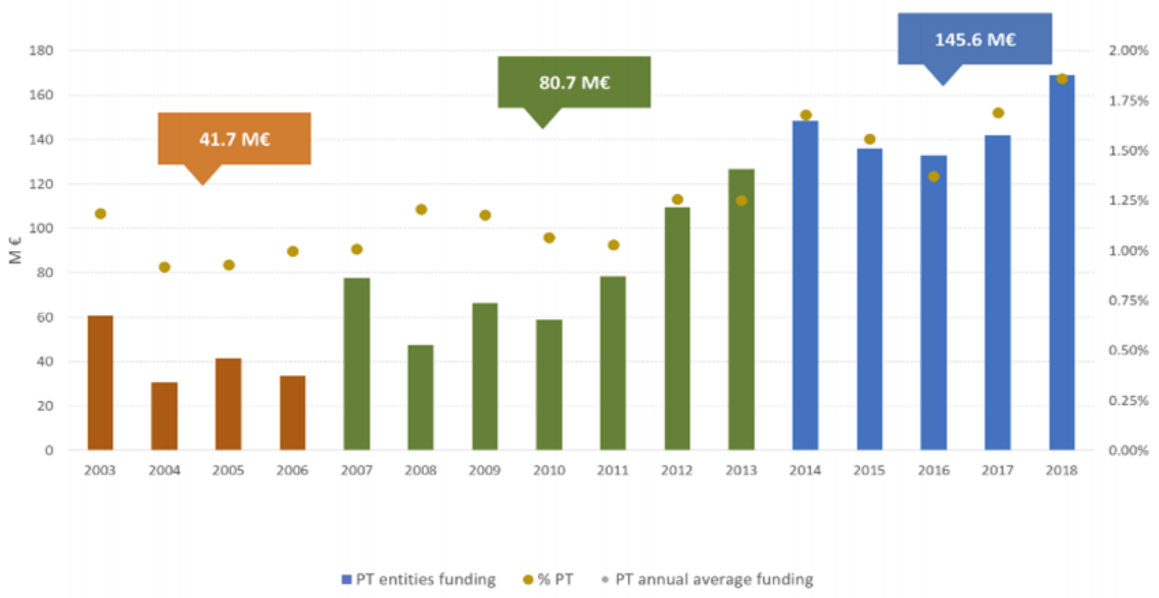


Note: Light purple represents the participation of SMEs

Source: Estonian Research Council based on eCorda: https://www.etag.ee/tegevused/uuringud-ja-statistika/statistika/raamprogrammide-statistika/ (retrieved on 20 November 2020)

Increases in participation in FP after the 2007-2013 period were also reported in the Portuguese case.

Figure 32. Portuguese participation in European Research and Innovation (EUR m and %) Framework Programmes



Source: ANI - National Innovation Agency

For the Czech Republic, an ex-post evaluation of the R&D support in 2007-2013 (EACE 2018) suggests that 'the overall success rate in 2014-2017 in H2020 calls for institutions that were beneficiaries of the ERDF OP RDI project was significantly higher (on average, 15.1%) than for institutions without an ERDF OP RDI project (average 3.7%).' Although the higher success rate for the calls of the H2020 programme cannot be attributed only to the ERDF support, this at least indicates that the ERDF managed to support institutions with a better scientific performance.

There were also fewer positive cases. In Italy, for example, an analysis of Cordis and OpenCoesione data shows no evidence of increased participation of ERDF recipients in research projects at the European level after the end of the 2007-2013 programming period, especially regarding those funded by convergence OPs.

Overall, ERDF and EU Research Programmes were seen as serving related but quite different purposes: while the former mainly provided funds for ensuring the enabling conditions to carry out excellent science (through infrastructure investment) and for supporting applied research benefitting local R&I systems, the latter provided funds for excellent, EU-wide research activities, mainly in fundamental and basic research. No explicit ways of linking these two roles effectively and successfully were systematically put in place in the period under examination.

5.1.5. Synergies with ESF in the higher-education sector

Synergies with the European Social Fund consisted in funding training activities directly related to the RTD projects by applying the principle of complementarity between Structural Funds (art. 34 of Reg. (EC) 1083/2006). The latter allowed the use of the ERDF to finance actions that fell within the areas of intervention established by the ESF, up to a maximum of 10% of the Community contribution of the priority axis.

The analysis of regional strategies shows positive examples of the **combination of ERDF and ESF funding**. In Emilia Romagna (Italy), the construction of a new competence centre (technopole) specialising in industrial, biomedical research was accompanied by establishing a new two-year course on biomedical subjects at the regional secondary-level technical institute funded by the regional ESF.

Not surprisingly, synergies were particularly strong in the regions where the ERDF emphasised infrastructure investment in tertiary education, as in Poland, Estonia and Slovakia. **Complementary training programmes funded by the ESF** were implemented primarily in Poland. Significant investments in the modernisation and expansion of Polish HEIs' facilities were accompanied by synergic ESF measures to develop human potential in faculties of key importance for the knowledge-based economy, the same faculties targeted by the ERDF OP. For instance, the Voivodeships of Lubelskie and Podlaskie (Poland) implemented scholarship schemes for PhD students.

In Slovakia, the link between the ERDF OP R&D and ESF OP Education supported the growth of competitiveness of the individual educational institutions and the regions, using synergic effects in tertiary education. The main focus of the ESF was the provision of soft activities to the same target group/beneficiaries that profited from the infrastructure support ensured by the OP R&D (mainly students and teachers).

The in-depth analysis carried out with the case studies further expands on this point. Several instances have been identified in which national and regional authorities **developed coordination to ensure that ERDF and ESF operations contributed to achieving common goals**. In Portugal, the complementarity between ESI funds – specifically between ERDF and ESF - allowed the financing of advanced training (e.g., PhDs), reinforcing the internal capabilities of scientific organisations and human capital accumulation. In many of these cases, complementary support channelled through ESF to ERDF RTD beneficiaries was identified as a driver of some of the key achievements and results tied to the ERDF support for RTD.

5.2. Stability and clarity of the legal framework

5.2.1. Legal framework for RTD

Evidence from the implemented instruments illustrates that clarity regarding public procurement, intellectual property rights, technology transfer, state aid and other important regulatory areas is an essential pre-condition for smooth project implementation. Legal frameworks determine how actors within the RTD system interact and participate in projects of common interest. Therefore, lack of clarity or transparency, or any instability in those rules, affects actors' timing and relative incentives in the RTD space.

In Romania, **legal regulations regarding partnership formation** limited the ability of projects to include both research and commercial partners. As a result, few enterprises actively collaborated in the research process, with other commercial partners only receiving the R&D results upon project completion. Moreover, it was noted that, with the regulatory process for acquiring the patent and the corresponding wait for intellectual property rights being exceedingly long, industry partners were discouraged from commercialising potentially interesting research results.

In Poland, legal challenges faced by industry partners were cited among the reasons for the reduction of industry funding of external R&D projects performed by scientific organisations. Research organisations also reported **difficulties relating to intellectual property and technology transfer resulting from overly bureaucratic frameworks**. Scientific partners were also found to pursue different objectives upon project completion, focusing more on publications and broad knowledge dissemination rather than commercial developments.

A facilitating legal framework promoting the use of research results and the protection of their commercial exploitation is crucial. In this respect, the open access policy to research results may be a limiting factor. As confirmed by some interviewees, some interesting research results were *deliberately not patented* or even reported in final technical reports in order not to inform competitors of innovative results of research projects.

Uncertainties regarding public-procurement rules negatively influenced the implementation of projects in Czechia. The rules were changed twice during the programming period, leading to ineffective project-management processes. The relevant case study posits that a lack of expertise on the part of the responsible Managing Authority was one reason for this type of confusion. Beneficiaries noted that the requirements and parameters for public tenders were overly demanding due to immense administrative burdens, causing substantial delays in the majority of realised projects. Moreover, legislative changes meant that all construction sites were practically frozen for one year in 2013 due to different interpretations of rules related to ‘extra works’, which frequently occur in construction projects. Altogether, these factors created an unfavourable environment and hindered the seamless realisation of projects. Nevertheless, all projects were eventually finalised within the eligible time period.

5.2.2. State-aid rules

State-aid rules represented a very specific legal aspect since their understanding and application limited businesses' access to calls for tenders and even to funded research facilities.

The role of state aid was more explicit in the implementation than the design of policy instruments. Coherence and consistency with state-aid rules were identified as a precondition for success for most of the policy instruments analysed. Managing authorities adapted their instruments to avoid any potential conflicts with or infringement of such rules. In the great majority of cases, this meant that *only* public organisations were eligible to receive funding through ERDF grants to avoid the notification process and allow the possibility of providing 100% grant support. Not only did private-sector organisations seldom benefit from ERDF support in a direct way, but they were also constrained in their subsequent involvement (for example, in commercial practices) vis-à-vis new infrastructure developed with ERDF support for higher-education infrastructure. This implied limited beneficiary capacity to collaborate with the private sector or diversify the sources of income and revenue for the supported infrastructure.

Some of the challenges reported by newly accessed countries, such as Poland and Romania, were also **attributable to scarce experience with the application of the new legislative framework and relatively stricter interpretation by national authorities.** As a result of these strict interpretations, and to avoid further problems, the initial design of some instruments included certain specificities relating to open access for research results[61]. Unclear interpretation and changes in legislation over the period hampered the smooth implementation of many interventions and caused delays and underperformance of some instruments. Researchers and the responsible Ministry in Estonia explained that differences of opinion and understanding around this ERDF regulation hampered their collaboration with companies[62]. In some cases, the situation was worsened by the perceived differences in the interpretation of state-aid rules across different European Commission Directorates-General.

A specific problem was also reported in the transfer and commercialisation of knowledge stemming from ERDF-supported research projects. In Germany, conscious of state-aid regulations, the beneficiaries of application-oriented projects funded in Sachsen could not produce factual findings that would result in a competitive advantage for certain companies. Thus, the funding was focused on preliminary research that did not necessarily have concrete application destinations. The **consideration of legal regulations concerning state aid thereby inhibited a stronger interlocking between research and industry**.

Clashes between cohesion and competition policy were the most significant challenge to the coherence of ERDF with other EU funds and instruments during 2007-2013. Other evaluations pointed to such problems specifically for what concerns RTDI and regional aid[63]. A fitness check evaluation of several Commission guidelines, including those on RDI, indicated that some aspects needed clarification, simplification and updating to reflect evolving technology and market conditions. In 2014-2020, there was a revision of the relevant legislation[64] , and recently, the European Commission published the new Regional Aid Guidelines for the period 2022-2027[65]. Nonetheless, improvements in the legislation do not necessarily go together with improved implementation on the field. **The understanding of the extent to which the legislative framework for state aid may still be a limitation** in the implementation of RTD investments and, in particular, the smooth relationships of the actors in the system **deserves great attention by EU policymakers**.

5.3. Efficiency in the allocation and use of funds

Efficiency considers the relationship between the resources used by intervention and the changes generated by the intervention (both positive and negative). With reference to this evaluation, while the more traditional value for money argument is not particularly relevant or feasible, efficiency in the use of funds concentrated on two specific aspects:

[61] In Poland, for example, the MA first did not allow commercial partners to use R&D infrastructure, but later allowed 20% of the infrastructure capacity to be used for commercial purposes. Moreover, from 2008 to 2011, private companies were not considered eligible for collaboration with research institutions on R&D projects. As a result, projects intended to stimulate science-industry collaboration did not include industry partners.

[62] The rule stated that if equipment was used more than 20% of the time for business purposes, grants to research institutions might have to be reimbursed.

[63] See for example the Retrospective evaluation of state aid rules for RDI and the provisions applicable to RDI state aid of the GBER applicable in 2014–2020 (European Commission, 2020), the Retrospective evaluation of the regional aid framework (European Commission, 2019).

[64] COMMUNICATION FROM THE COMMISSION Framework for State aid for research and development and innovation (2014/C 198/01)

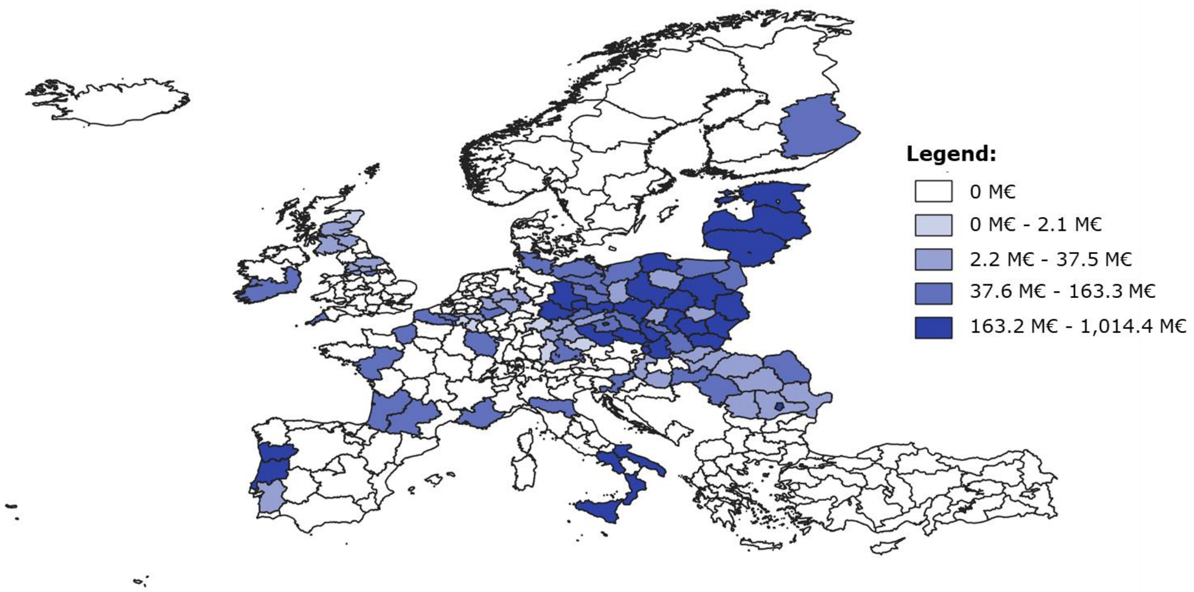
[65] They can be accessed at: https://ec.europa.eu/competition/state_aid/regional_aid/RAG_2021_adopted_communication.zip (visited on July 27th 2021).

- The scale of funding and its **degree of concentration** (aid intensity): evidence of past evaluation shows that when funding is spread too thin, there is a waste of resources since no critical mass in terms of investments is reached. This issue is particularly relevant when looking at RTD investments.
- The **efficient use** of financial resources under the angle of the efficient management and implementation of interventions, strictly linked to the administrative capacity issue.

5.3.1. Funds concentration

Financial concentration is often seen as a desirable outcome of policy action and an indication of efficiency. The volume of funding should be sufficient to generate significant and lasting change. At the same time, **this does come at a certain cost**. It may lead, for example, to a 'winner-takes-all' dynamic that needs to be addressed with policy action to reduce gaps between winners and losers.

Figure 33. ERDF expenditure on RTD investments by NUTS2 regions in the targeted OPs



Note: expenditure of national or multiregional OPs was regionalised based on the location of project beneficiaries

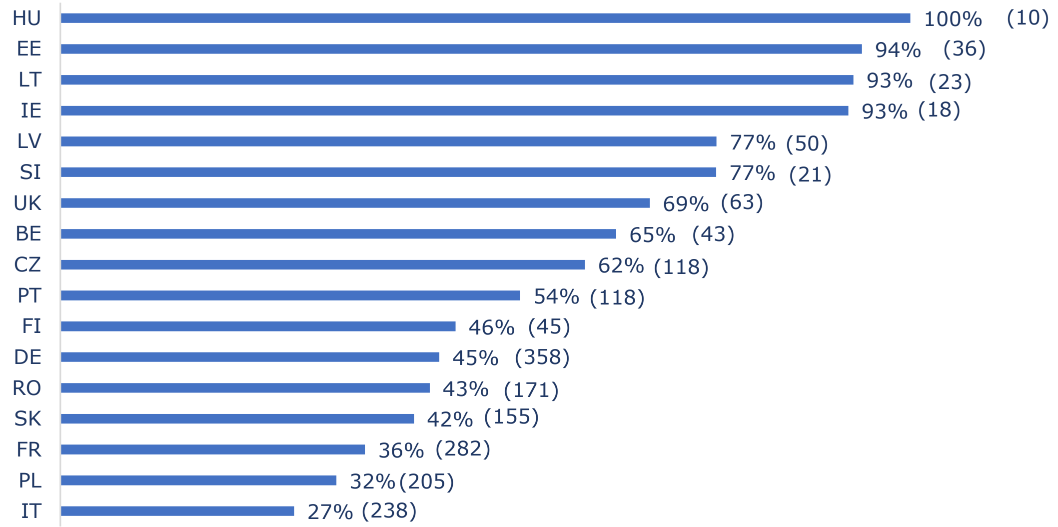
Source: Authors based on monitoring data from the 46 OPs, excluding the seven Spanish OPs

Evidence on expenditure on RTD infrastructures and activities **highlights patterns of territorial concentration** as a result of eligibility rules on one side and territorial concentration of RTD capacities on the other. More than 50% of ERDF expenditures in the selected OPs were concentrated in Poland, Germany and the Czech Republic, while 70% were concentrated in Convergence regions and 64% in urban areas.

As discussed in Section 3.7, targeting strategies were guided by a general principle of supporting the leading territories, sectors and institutions, rather than the laggard ones. While this responds to a general rationale of building on existing assets and ensuring a critical mass in funds absorption, it also raises concerns of exacerbating inequalities, especially from a geographical point of view.

The same concentration pattern can be observed in funded beneficiaries, with **individual leading institutions in their** field absorbing significant shares of funds, especially in some countries, as shown in the Figure below. In most cases, however, this resulted from selection procedures targeting the project proposal's research excellence and innovation merit. This approach benefitted those applicant institutions already holding advanced capacities of project preparation and good records. In order to cope with this potential bias, some OPs offered technical assistance activities and other measures and facilities to support capacities in project preparation as part of the policy mix (see more on this in Section 5.4).

Figure 34. Percentage of total ERDF contributions concentrated on top ten institutions and by country (in brackets, the total number of beneficiaries in the country)



Note: In parentheses, one may see the total number of institutions by country. The percentage and numbers refer to lead beneficiaries.

Source: Authors based on monitoring data from the 46 OPs, excluding the seven Spanish OPs.

5.3.2. Administrative capacities of programme managers

The importance of sound administrative capacity was highlighted in a number of cases as a key supporting factor, especially at the beginning of the implementation process. The assurance of a timely and smooth project assessment and selection procedure can improve the quality at entry of funded projects and increase the probability of success.

In the Italian case, many of the reported implementation problems were related to administrative capacity issues with the Managing Authority. In addition, long and cumbersome selection processes led to late project approvals. This negatively impacted the timely disbursement of funds and thereby prevented a smooth implementation of the projects. In some cases, advance payments, sometimes up to 80% of the total project cost, were not provided on time.[66] Payment delays imposed critical financial stress, especially on smaller firms already facing the consequences of the economic crisis. Financial stress was not the only consequence of delays, however. Interviews with beneficiaries highlighted that in

[66] OP Final Implementation Report, June 2017.

some cases, project results' commercial and industrial relevance was negatively affected by the project implementation and funding delays within the intervention since research results and commercial application opportunities can be time sensitive.

Capacity constraints in Italy were also related to the appropriate staffing of the MA, or rather, a lack thereof. Interviews indicated the lack of a sufficient number of permanent officials responsible for the OP and a massive presence of technical experts with no decision-making roles. This had a direct impact on the quality of selection procedures. An inspection of the project-evaluation procedure detected that the time allocated for evaluating applications was too limited[67]. Moreover, investigations by the Italian judiciary further discovered that the selection of projects did not always conform to insights generated within the selection process, due probably to faults in eliminating conflicts of interest among evaluators. This resulted in weak projects being selected by the committee, even though they had negative evaluation assessments or did not comply with economic and financial requirements.[68]

Administrative difficulties were also identified in Romania, where they led to the **delayed implementation of projects**. The existing institutional system responsible for programme management could not always ensure projects' timely and efficient implementation. In particular, high staff fluctuation caused delays in:

- Developing guidelines for applicants and contracting technical assistance.
- Completing the preparation of major projects.
- Verifying reimbursement requests and making payments to beneficiaries.

Moreover, the **long duration of the evaluation and selection process for projects** further contributed to significant delays. As a result, the first calls were only issued in December 2007, with a deadline of March 2008. The second and third calls were pursued in 2009 and 2013, respectively. The last eight projects were only approved in 2015 – the last admissible year. Moreover, many appeals against public-procurement procedures further delayed implementation since time was required for judicial procedures (National Council for Appeals Resolution and the Court of Appeal) to take place.[69]

In Portugal, initial implementation delays were also reported, with beneficiaries stating that the time between proposal submission and contract signature could be more than a year in some cases. The crisis plausibly contributed to this problem since the country's financial capacity was initially undermined, at least before the approval of a financial assistance programme by the International Monetary Fund.

In the case of the Czech Republic, there was a significant delay to the start of the OP RDI (due to belated and long-lasting preparations, including long negotiations with the EC and the insufficient initial capacity of the Czech authorities) that negatively impacted the entire implementation.

[67] For instance, a total of 222 applications were assessed in three working days, providing a wholly insufficient average of 7.5 minutes per application.

[68] ANPRI, 'Newsletter 8 del 30 aprile 2015'. http://www.anpri.it/wp-content/uploads/2015/05/Newsletter-8-2015.pdf

[69] Case Study Report: Romania - 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.

In Estonia, the administrative capacities for implementing ERDF programmes were at first not entirely in place since this was the first full programming period for the Member State. Nevertheless, prompt restructuring within the Ministry of Education and Research resulted in a dedicated Structural Funds Unit equipped with the necessary staff. Overall, evidence from the case study suggests that the implementing body provided effective support to beneficiary institutions. The interpretation of ERDF rules did lead to some disagreements between the MA and beneficiary institutions, however, such as with the requirement for every cost to be sufficiently justified by the research institutions.

5.4. System approach and actor's capacity

In order to ensure that new products, processes, and technologies find long-term commercial applications, an **effective science-business collaboration system** needs to exist and be maintained over time. Good and effective science-industry relations would ensure that the scientific community was more aware of industry needs and the funded research findings more effectively communicated. The cultivation of a strong association between the two parties is essential for an effective transfer of knowledge. The importance of trust, commitment and good relationships is also described in the literature (Barnes *et al.,* 2006), as these are essential factors for successful collaborative projects.

As highlighted in the Italian case study long-term relationships, and mutual knowledge and trust between organisations helped facilitate negotiations about the types of competence and skill to be shared among partners. ERDF funded projects proved to be a testbed for the development of such relationships. When successful, collaborative R&D projects between science and industry partners provided access to new ideas, competencies and technological solutions. At the same time, research centres were also able better to explore the needs of business partners and develop skills needed for industrially oriented, applied R&D. At the same time, collaborations should not be episodic and linked to funding opportunities but should be maintained over time in a structured way. Collaborative attitudes cannot be imposed via eligibility criteria but should be underpinned by genuine shared interest. A decline in interest may lead to financial difficulties, misunderstandings with other partners, a lack of returns, and a lack of mutual trust among partners[70].

In order to strengthen the system, active measures to facilitate a structured dialogue among the local players can be promoted. In Portugal, countrywide **initiatives to connect scientific and business communities took place** and soon had a positive effect; they included the creation of technology-transfer offices in R&D institutions and the support of business innovation, in which scientific and technological entities took part.

Long-lasting commitment to collaborations is also a matter of **adequate capacities in project management** and awareness regarding public-fund resources. The evidence suggests that beneficiary institutions with dedicated departments for identifying funding measures and providing consequent support allow for an effective application process. Furthermore, supportive Managing Authorities that show a high level of commitment and assistance and effectively coordinate the needs of the scientific community have been

[70] Many examples of opportunistic collaborations leading to unsustainable projects were offered by the Italian and Polish case studies for example.

proven to play a crucial role. In this context, transparent and effective funding-application rules facilitate a smoother process. Beneficiaries underscored the instrumental support offered by the Managing Authority, as this showed a high level of commitment and willingness to assist in the application process while coordinating the needs of the scientific community effectively. They also highlighted the transparent and effective implementation of the funding-application process[71].

[71] See for example examples in Portugal, Germany and Czech Republic.

6. Sustainability of effects

Sustainability refers to the capacity of a policy intervention to produce long-lasting effects, which may persist even after the provision of public support has ceased. In this evaluation, the sustainability analysis has focused on whether the observed results linked to the analysed instruments were likely to be sustained after 2013. This question can be assessed from different perspectives:

- the results of research projects, regardless of whether they were individual or collaborative;
- research collaborations and partnerships, which were driven by the support provided by ERDF (mainly through the collaborative R&D instruments);
- infrastructure financed by the ERDF. Given the importance of investments in infrastructure in the portfolio of projects, this dimension of sustainability is critical in the present evaluation. Concerning major infrastructure projects, the evaluation criterion refers to the project's capacity to guarantee its long-term financial sustainability, i.e., to achieve its research goals and produce the intended objectives without the risk of running out of cash, both during the investment and the operational stages.

6.1. Sustainability of research projects

As noted in previous sections of this report, there is a **consensus that the collaborative R&D policy instruments were not fully successful** in ensuring the sustainability of the results of the research projects. These weaknesses mainly stemmed from the less intensive translation of research results into practical innovations. For instance, despite the consolidation of coordinated R&D activities in Italy, the delayed disbursement of funds and the limited propensity of small firms to patent generally prevented the translation of research results into commercial applications. Deficiencies in research-knowledge transfer and uptake by broader societal sectors appear to have been the Achilles heel of most collaborative research instruments analysed as part of the case studies.

Germany, however, appears to be a notable exception to this rule, given the strong sustainability of the application-oriented projects analysed in Sachsen. The evidence collected around this instrument shows that the policy instrument's effects were sustained within the case study, as illustrated by the high number of follow-up research endeavours that occurred after the funded research projects ended. Whether actors continued directly with the research topic, initiated new individual or collaborative projects based on the research findings, or even obtained new R&D contracts, the funded research projects led to a wide variety of follow-up activities. When one assesses a sample of projects, it transpires that each funded project led to five such follow-up research activities, ensuring the sustainability of research findings. Moreover, some projects also allowed relationships between scientific and industrial partners to emerge, as research findings were translated into new products, processes, or technologies.

The sustainability of collaborative R&D projects was also considered high in Estonia. Indeed, a slightly more positive assessment can be made to support the internationalisation of research in Romania. However, in comparative terms, the sustainability of policy interventions providing this type of support in Portugal was neutral. More critical assessments may have been made in MS and regions with long traditions and experience implementing collaborative RTD interventions.

6.2. Sustainability of research partnerships

Many of the analysed instruments sought to consolidate research partnerships, either among research partners from the same country or region or among partners from the beneficiary and third countries (e.g., the internationalisation of research instruments).

In some cases, such as in Italy, the support for technological clusters provided a determinant contribution, affording an initial boost towards reinforcing existing clusters and creating a few new ones. Nevertheless, the sustainability of these clusters, in the long run, is uncertain. In Poland, the sustainability of the newly developed research partnerships appears to have been short-lived. Not many follow-up orders for contract R&D or joint R&D initiatives were pursued after the completion of projects. There were no reported cases of subsequent collaborations among the project partners after the end of the supported projects. In some cases, the experience of participating in the ERDF-supported projects may even have *dissuaded* industrial partners from engaging in subsequent projects of a similar nature.

6.3. Sustainability of RTD infrastructures and major projects

The support provided by ERDF for infrastructure development covered capital expenditure costs. This implies that the need to find alternative financing sources to cover operational expenditure was, and is, of great importance in ensuring research-infrastructure sustainability. In general, the long-term sustainability of infrastructure projects was not perceived as a major issue by interviewees. In most cases, it was found that the necessary financial resources would be available for infrastructure to operate and be maintained in the immediate term. This support was expected to be provided by either host institutions, their internal budgets, or the public sector. Nonetheless, as noted in previous chapters, government funding for public research organisations should not be taken for granted.

The limited use of ERDF-developed infrastructure by the private sector and external users does weaken the financial sustainability of this body of infrastructure. Such a high degree of dependence on public funding for the operation and maintenance of the infrastructure implies that any drop or significant fluctuation in the availability of such resources will, inevitably, pose a grave threat to the long-term sustainability of the infrastructure. This situation emerged, for instance, in the case of the National Graphene Institute, funded in Manchester. During the first years of operation, the project faced difficulties in establishing partnerships with industry due to two factors: the limited private domestic demand, with only a small number of firms in the UK well placed to exploit graphene in commercial applications, and a weak IPR Protection system, enforced by the Institute, that made it less attractive for firms to collaborate on research projects.

The Institute Jean Lamour, funded in Lorraine (France), is another example of a Major Project that is not fully exploiting its revenue-generating potential. In this case, the problem seems to be the *excessive* production of the beneficiaries in their efforts to develop the commercial use of the investment by engaging in collaborative work with the companies. This is done to keep the revenue generation under a certain threshold and (thus) to avoid any decrease in public co-financing.

Financial sustainability issues were identified concerning implementing the Major Project in Wrocław (Poland), intended to establish a new, publicly co-funded research organisation EIT+ (Lower Silesian Centre for Materials and Biomaterials, Wrocław Research Centre EIT+). The organisation faced problems with the financial sustainability of the built infrastructure and the limited embeddedness in the regional/national innovation ecosystem, mainly due to the lack of demand for specialist research services or opportunities for commercial uses of the infrastructure. Almost all the other Major Projects funded in Poland in the same programming period experienced similar problems. Meanwhile, in Lithuania, financial sustainability issues were detected in the operational phase of most newly built or modernised infrastructures. The huge investments designed to help build new, open-data research centres in Lithuania resulted in the oversaturation of the RTD ecosystem and problems concerning the need to cover amortisation costs associated with these infrastructures, together with the operational costs of preventing the infrastructures from becoming outdated over time.

Case studies of two illustrative examples of major RTD infrastructure projects shed more light on the strategies implemented to ensure sustainability.

Recognising the challenges around maintaining sustainability, the MA funding the Extreme Light Infrastructure in the Czech Republic emphasised the maintenance of quality, international relevance, and connection to the ESFRI network in the project call. This infrastructure represented a strong commitment from public budgets (on the national and European levels) due to its reliance on public financing. The ELI management was aware of this, and they worked on a concrete strategy to mitigate the potential risk. The strategy focused on maximising the diversification of financial resources for the operation and development of the ELI site, highlighting the EU research programmes (e.g., Horizon 2020), the incomes generated from users of beamtime (during open calls) and the expansion of cooperation with industry. Dedicated and nationally funded programmes to ensure sustainability were introduced, supporting other, newly developed RTD infrastructure.

The Wielkopolska Centre for Advanced Technologies (WCAT), funded in Poland, faced many challenges related to low institutional funding, insufficient coverage of operational costs by competitive funding grants, and insufficient income generated from R&D services and access to research infrastructure. Recently, institutional funding changes have occurred, notably via the Research Infrastructure Maintenance Support Programme (pl. PANDA), overseen by the Ministry of Science and Higher Education. Following the second cycle of the competition, PANDA 2, in 2017, a new maximum limit was set for financial support per infrastructure project. In preparation for the new programme-successor to the PANDA programme, there are plans to introduce other criteria to consider investments such as the WCAT.

7. EU added value

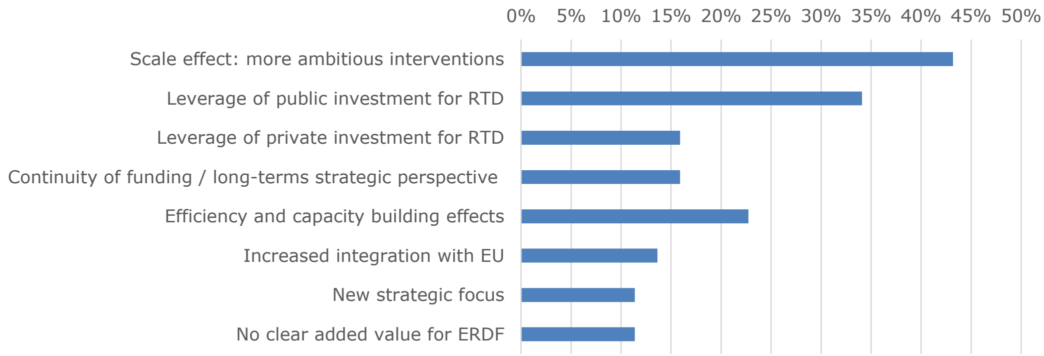
The notion of EU-wide effects can be interpreted from different perspectives. Here it refers to the following aspects:

- the perceived added value recognised by MAs as to what the ERDF allowed them to do compared to other available funds.
- the increased cooperation among regions and MS at the EU level.
- the changes made to EU-level RTD capacities meant not as the sum of individual Member States' RTD capacities, but rather as the additional capacities generated through the collaboration of RTD communities and actors from different MS, contributing to the development of a European RTD system.

7.1. Perceived added value of the ERDF

The ERDF added value in the wider policy mix was answered through semi-structured interviews with the Managing Authorities of all 53 OPs.

Figure 35. The ERDF added value for RTD in the reviewed OPs – share of Managing Authorities mentioning the item



Source: Authors

For more than 40% of the reviewed OPs, the interviewed Managing Authorities recognised a scale effect. Access to the ERDF resources allowed the implementation of more ambitious interventions, which otherwise would not have been possible. Such an effect was mainly acknowledged in the EU New Member States (Poland, Estonia, Lithuania, Czech Republic, Slovenia and Slovakia), where the volume of ERDF financing was significant, not only in absolute terms but also about the national and regional financial envelope allocated to RTD, as noted previously in Section **Error! Reference source not found.**. In the EU13, the Cohesion Policy programmes represented the first systematic set of interventions addressed to the research field after years of underinvestment and limited political priority. National and regional budgets were considered insufficient to fund sizeable investments in higher-education facilities, especially in Poland, the Czech Republic and Lithuania. In Slovakia, the ERDF was used for structural investments because national resources were instead spent on structural reforms.

Scale effects were also reported in some French regions (Lorraine and Pays de la Loire) and the South of Italy. In France, the ERDF was used as a complementary form of support to concentrate resources on selected types of beneficiary (HEIs and RTOs) and fields of science to maximise impacts. In Italy, EU co-financing permitted the implementation of RTD projects in the less-developed regions of the South.

This finding is corroborated by data analysis regarding the financial weight of ERDF vis-à-vis total public R&D expenditure. EU added value was generally perceived to be higher in countries where the ERDF contribution as a percentage of the total public R&D expenditure was significant (i.e., over 10%), but also where there was a high regional concentration of this spending (e.g., in Convergence regions, notably in the case of Italy). In addition, even in Member States such as Germany, where the ERDF contribution to RTD represented only 1.3% of the total public R&D expenditure over the period, there is still ample evidence regarding the perceived added value of ERDF support at the regional level. For instance, in the case of the application-oriented research projects under the OP Sachsen, the research projects would not have taken place without ERDF support, since other funding sources were not available for these specific areas of inquiry.

Besides financial scale, another relevant aspect of EU added value was indicated by a significant **leveraging, catalysing effect for public RTD investments** (30% of the reviewed OPs). In Scotland, the ERDF resources acted as a catalyst to support significant projects that underpin RTD in the region’s key sectors. Moreover, by focusing on RTD and innovation issues, they shaped regional policy priorities more widely. The Spanish and Romanian authorities reported a similar leveraging, catalysing and targeting effect. This was often associated with benefits in terms of capacity building and the more efficient use of funding, as emerged in more than 20% of the reviewed OPs. **Capacity-building effects were particularly relevant in the new EU Member States**. For instance, in Romania, there was an increase in efficiency and efficacy in the management of implementation, monitoring and evaluation procedures, and public-procurement rules.

Meanwhile, in Latvia, the ERDF co-financing improved the institutional governance of research institutions and research-industry collaborations. In Poland, a learning process took place while the OP was being implemented, and the Managing Authorities used the mid-term reprogramming to refine the portfolio of policy measures, taking into account dialogue with stakeholders and the identified opportunities to strengthen the expected impacts of interventions. For instance, collaborative R&D projects were introduced to foster more direct involvement by enterprises in research activities. Some pilot initiatives were launched, including targeted support for selected industries (aviation, innovative medicine) and technology demonstration/prototypes funding. These policy experiments played a critical role in developing the foundations for the design of the subsequent OP in the 2014-2020 perspective; they also helped test the possibility of targeting selected smart specialisations and thematic priorities.

For some OPs that focused on business-research support and collaborative research projects, **the positive leverage effect of the ERDF was especially notable for private investments**. Specifically, this was observed in Belgium, Spain and Scotland. In Belgium, funds from the 2007-2013 programming period made it possible to continue efforts made during the previous programming periods, capitalise on their achievements, and amplify the leverage effects on public and private RTD investments. In the same vein, the ERDF co-financing of the Spanish OPs was expected to stimulate public and enterprise R&D activity.

The intensifying and broadening of public-private research collaboration in Scotland improved the ability of the enterprise community to make use of, develop and commercialise innovation.

Another important aspect was that the ERDF seven-year time frame ensured **continuity in funding** that would not necessarily have been possible through national strategies, as evidenced in the previous chapter. More than 15% of reviewed OPs, especially in Italy, Estonia, Germany and the Czech Republic, reported this added value. In a country characterised by a generally unstable political situation, such as Italy, the Cohesion Policy programming made it possible to make commitments that could endure, despite possible changes in the national government. This was instrumental in helping the region of Emilia Romagna design and bring forward an ambitious and forward-looking strategy for RTD, centred on the creation of a network of competence centres to stimulate applied research in selected fields of specialisations; this approach also fed into the following Smart Specialisation strategy of the region. A similar situation was evident in Estonia, whose national funds could not ensure long-standing, stable financing for R&D investment projects, and in the Sachsen (Saxony) region of Germany. According to the interviewees, Sachsen exploited ERDF multiannual planning to formulate a medium-term binding RTD strategy for all the key actors in the territory.

For a minority of OPs, the key added value of ERDF co-financing was an increased **integration with the EU market** (benchmarking, collaboration and internationalisation). The ERDF programmes entailed the opportunity to purchase start-of-the-art equipment and make RTD infrastructures more attractive, thereby helping researchers scale-up research and connect their work to international research projects (e.g., in Poland, Portugal and the Prague region). In Aquitaine (France), thanks to ERDF funding, the laser and photonics sectors increased their participation in European research and economic networks, thus helping the region internationalise the scope of (originally) merely local activities.

7.2. EU-wide effects

The generation of EU-wide effects was not generally identified as an expected outcome of the policy instruments analysed. No reference was made to any intended EU-level changes within the Theories of Change developed for individual instruments. As a result, the beneficiaries' territorial scope and expected (and actual) outcomes were generally limited to the regions or countries where the instruments were delivered. As already noted in section 3.4.1, partnerships of collaborative R&D projects were mainly regional or, albeit only in selected cases, multi-regional within the same country (the Italian OP that sought to benefit Convergence regions had the explicit aim of fostering interregional cooperation, including cooperation with non-convergence Italian regions). Nonetheless, as witnessed by the interviewed stakeholders, EU-level cooperation on research projects was undertaken mainly through the FP7/H2020 programme. At the same time, ERDF was essentially seen as an instrument for regional and national cooperation. Therefore, it is not surprising that the impacts produced predominantly demonstrated a national and regional scope rather than being EU-wide. For instance, the ERDF support for RTD activities and infrastructure generated regional effects in Germany and Italy more than EU-wide ones. Where international collaboration was an intended goal of the instruments (e.g., grants for research internationalisation in Portugal), only local organisations were eligible to benefit from ERDF funding (i.e., the international counterparts did not benefit directly from the funding).

The contribution of ERDF to EU-wide effects was, in fact, more indirect. In certain cases, ERDF-supported RTD projects were seen to contribute to developing a stronger, more resilient and more vibrant EU-level RTD system. These results can be broadly categorised as follows:

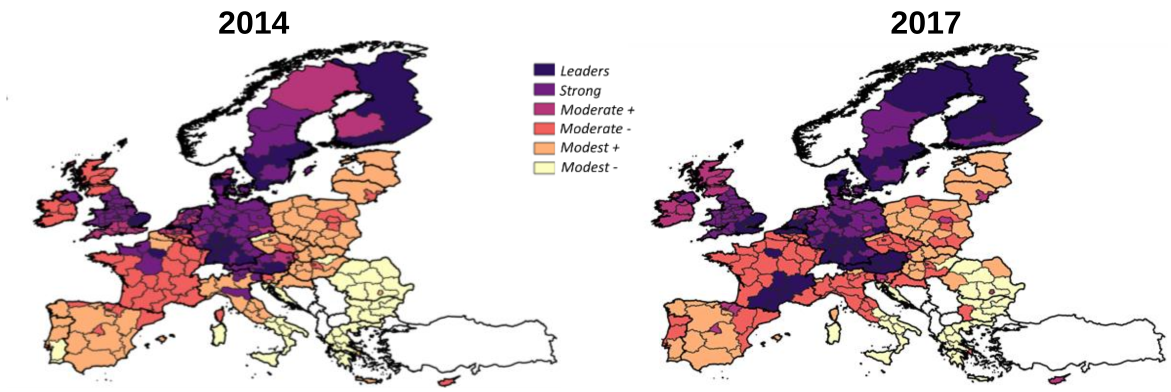
- The contributions made by major infrastructure projects to the **development of EU-level research communities and collaborations in specific fields** strengthened the position of EU research in these fields and on a global scale. Perhaps the clearest example of this was the financing of the ELI Major Project in the Czech Republic. In this case, the attraction of new countries as observing partners of the ELI consortium and other cooperating institutions enabled the rapid, worldwide enhancement of the added value of EU research capacities. The project's development was based on research demand, identified at the European level, and it was launched by a consortium of European partners. In essence, the project was designed to generate benefits for parties outside the Czech Republic. In Germany, the Major Project created the necessary conditions for the TU Chemnitz's participation in other funding programmes, including FP7 and H2020.
- Some of the infrastructures funded by the ERDF were included among the **roadmap projects of the European Strategy Forum on Research Infrastructures (ESFRI): projects that were, in essence, infrastructures with a recognised EU scientific relevance**. In Italy, some of the newly built or modernised infrastructures were included in the strategic ESFRI roadmap as recognised research infrastructures of pan-European relevance, 'that fill an existing gap in research capability or capacity at the frontiers of knowledge'. For instance, KM3NeT was included in the European and Italian ESFRI roadmap from 2006 onwards. Moreover, the NAFASSY infrastructure project focused on the construction of a unique infrastructure in Europe, originally proposed by the Italian National Agency for New Technologies, Energy and Sustainable Economic Development (*Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile* - ENEA), by the name of ENFASI; this was duly included in the Italian roadmap of research infrastructures of pan-European interest.
- The ERDF support led to the internationalisation of researcher communities, particularly at the European level. Although this was not directly foreseen as a planned outcome, the improvements in research capacities and infrastructure conditions often allowed ERDF beneficiaries to increase their exposure to and involvement in European research collaborations. In a limited number of instances, this was illustrated by the increased participation of beneficiaries in the FP and Horizon programmes, as discussed earlier in section 5.1.4. In such cases, with Estonia and Portugal being the most notable, improvements in research capacity and research conditions in the country are believed to have played a major role in national partners' subsequent participation **in European and international research projects,** thus enriching the European innovation ecosystem.
- Because of the strong emphasis placed by ERDF support for RTD on improving higher education and because of the importance of higher education institutions in the ERDF beneficiary pool, the ERDF also led to improvements in the internationalisation of certain higher-education systems. This point was also discussed earlier in Section 5.2

7.3. ERDF contributions to catching up of EU regional performance

It is worth asking to what extent the ERDF support for RTD investments contributed to regional RTD performance, particularly by transforming national RTD systems, contributing to knowledge-driven economic growth, and perhaps even facilitating convergence upward at the EU level. While this study does not aim to provide a specific answer to this question, the evidence collected can shed light on these points and provide an initial, tentative answer, which will need additional research to form a more conclusive assessment. The discussion draws on the description of the evolution of the RTD capacities of EU regions in the period under examination. It then points to the consideration of how the ERDF may have contributed to observed trends based on anecdotal evidence regarding the role of the ERDF in transforming national RTD systems.

A dynamic analysis found that a decade after the launch of the 2007-2013 programming period, **around half of the European regions (151) had not changed their relative position against the other European regions[72]**. A *decline* in relative RTD performance was observed for 35 regions, mostly located in France and Spain, but 90 regions improved their relative position compared to Europe.[73] These were mostly located in the regions with strong or leading positions in Belgium, Germany and France. Nonetheless, a catching-up process was also visible in some regions of Poland, the Czech Republic, Lithuania, Hungary, Romania and Slovakia.

Figure 36. Evolution of RTD regional contexts



Source: Authors

This trend is confirmed by the results of the Regional Innovation Scoreboard, which comprises more significant dimensions for innovation features compared to the cluster analysis performed here. The European Commission itself (2020) noted that stronger convergence patterns were reported in transition regions, i.e., low-performing regions engaged in catching up. In the majority of cases, these were Central and Eastern EU

[72] The total number of NUTS2 regions considered was 276.

[73] We defined a change as *slightly positive* if the region moved up by one cluster, for instance from 'Moderate – to Moderate +'. A positive change was identified if the region moved up by two positions, for instance from 'Moderate – to Strong'. The same method was also applied to (slightly) negative changes.

regions, typically capital ones. Indeed, some of these regions were examples of best-performing regions in terms of improved RTD performance. They included Bucuresti – Ilfov, Nord-Vest and Vest in Romania, Prague in the Czech Republic, and certain Polish regions such as Mazowieckie, Małopolskie, Pomorskie and Podkarpackie.

In **Romania**, the increased performance of the capital region and the Nord-Vest and Vest regions was mainly driven by an increase in business R&D expenditure and an overall improvement in research skills and capacities, as the positive trends in terms of the percentage of the population with tertiary education, of employees in science and technology and total R&D personnel over the period 2007-2017 demonstrate. The case study showed that it was indeed in these three regions that the ERDF for RTD was concentrated. Beyond the capital city, in which were concentrated a high number of universities of national relevance, the Nord-Vest and Vest regions, with their strong industries and higher-education communities, succeeded in attracting a broadly similar volume of RTD investment.

A similar picture could be discerned in **Poland**, where some of the regions where most of the ERDF investments for RTD were targeted showed an increase in RTD performance, according to the results of the cluster analysis (i.e., Mazowieckie, Małopolskie, Pomorskie and Podkarpackie). A positive change in terms of research skills and capacities was also recorded in these regions between 2007 and 2017.

Conversely, in the Czech Republic, the regions that evinced a leap in RTD performance were the capital region of Prague and the Northwest region, where only a minor share of ERDF funds was concentrated compared to the others. Although all the other regions displayed a stable performance, evidence from the case study reveals that the ERDF support for RTD played an essential role in building, developing and modernising R&D infrastructure in the Czech Republic. Moreover, the support enabled a transition by the R&D infrastructural capacities in the country to a qualitatively different level, comparable to wider European standards. Nevertheless, it is also true that, while the case study reflects a broad consensus and robust evidence, that infrastructure investments succeeded in eliminating the significant deficiency in Czech research infrastructure as compared to EU standards, the degree to which a sustainable contribution to the growth of the knowledge-based economy was achieved is more doubtful.

In **Estonia**, meanwhile, the ERDF is seen as one of the main drivers for developing an increasingly international research community within the country. ERDF investments have played an important role in modernising the Estonian higher education and research environment and have caused a significant shift in the quality of Estonian research. There is a wide consensus that the country would not have undergone such an important shift in research quality within such a short period without the ERDF.

The cluster analysis also showed that **Western European countries are characterised by higher variability in the evolution of RTD performance** compared to their Central and Eastern counterparts. In **Germany**, most of the regions improved their relative performance, including those covered by a convergence OP (i.e., Brandenburg, Mecklenburg-Vorpommern and Sachsen-Anhalt). Although ERDF support for RTD represented only 1.3% of public R&D expenditure over 2007-2013, the case study showed that ERDF support for RTD activities and infrastructures was significant in volume. It was often the key source of such investments in the German Länder, except for Bayern and Baden-Württemberg, where there was extensive innovation funding from other state funds. This reflected the paramount importance of the ERDF for the implementation of innovation funding in the Länder, primarily but not exclusively in the Eastern German Bundesländer.

In **Portugal**, only the Norte and Centro regions improved their relative RTD performance. These, indeed, were the regions where more than 98% of the total amount of ERDF for RTD was spent. The case study confirmed that the ERDF played a key role in funding the capacity building of scientific organisations and firms, laying the foundations for the consolidation of national scientific and innovation systems. Indeed, the improved RTD performance in these regions was mainly driven by positive trends in terms of the percentage of the population with tertiary education, employees in science and technology, and total R&D personnel over the period 2007-2017. An increase also assisted the improvement in total R&D expenditure.

Nevertheless, the evidence does not reflect a clear increase in knowledge- and technology-intensive activities in target regions. In Portugal, for instance, the gross value added (GVA) of sectors with low, medium and high shares of technology remained unchanged throughout the period 2008 to 2015. A closer look at some of the components of the Innovation Scoreboard in Portugal helps shed light on why the observed increase in the innovative nature of R&D institutions may not yet have generated a similar degree of knowledge-driven economic growth. Indicators relating to the R&D environment, such as the attractiveness of the research systems, the innovation-friendly environment or the presence of foreign doctoral students, have all steadily increased (in relation to the EU average) over the past decade. Nonetheless, indicators that reflect the degree to which such an R&D environment generated economic valorisation have not followed suit. For instance, design applications[74], patent applications, R&D expenditure in the business sector and 'sales impacts'[75] either decreased or only slightly increased over the past decade. This suggests that, while the environment is increasingly conducive for research and innovation, transferability into commercial applications has remained a challenge.

The four Convergence regions on which ERDF support for RTD was concentrated in **Italy** did not improve their performance but maintained their relative position. While improved research infrastructures were undoubtedly developed, and science-industry collaboration was generally strengthened in these regions, this did not immediately translate into significantly greater R&D competitiveness. The negative effects of the crisis certainly played a role in diluting the potential of the research projects to increase the competitive position of beneficiaries and the Convergence territories. As noted by many interviewees, however, the limited impact of the intervention in increasing the competitiveness of Convergence regions and industries also reflected more systemic problems. As described in the European Semester's Country Specific Recommendation, inefficiencies of public administration, reflected in the latter's weak capacity to administer funding, were a central issue. Italy's slow transition to a knowledge-based economy and its slow productivity growth also stems from weak investment in skills, the low quality and sustainability of the country's infrastructure, and a lack of improvement in the framework conditions for the business environment.

Overall, while ERDF support may have played a role in contributing to the modernisation of RTD systems by supporting the creation of more advanced and competitive research

[74] Number of individual designs applied for at EUIPO European Union Intellectual Property Office (EUIPO)

[75] Sales of new-to-market and new-to-firm innovations as percentage of turnover

systems, it also positively contributed to a catch-up process of the performance of some of the target regions on EU RTD standards. **It was, however, less effective in translating this increased research capacity into more competitive territories and regional economies**.

8. Conclusions and policy considerations

8.1. Main findings

The findings of this study indicate that the selected 2007-2013 ERDF programmes, and their associated strategies, were well justified overall and backed by a relatively solid rationale. Positive achievements were reported, in particular, by policy instruments targeting HEIs. The **main contribution was provided by infrastructure investments targeting the upgrade and modernisation of existing facilities** and the construction of new ones. This applied especially to those EU13 regions lagging behind in terms of scientific and technological capacities and standards. Support for R&D projects, both individual and collaborative, was important in developing know-how in new scientific fields or existing areas with great potential. As a result, there were **observable effects on scientific production and capacity**, as witnessed by some key RTD performance indicators: the increase in the volume of scientific publications, the increase in the number of people with a tertiary education employed in science and technology, and the growth rate in the number of R&D personnel and researchers.

The main drawback reported by the study relates to the **lack of observable long-term impacts, as far as the use of research results for technological development and innovation** are concerned. Evidence shows that the observed, improved scientific knowledge did not translate into technological development and innovation and ultimately did not increase regional competitiveness. Certainly, the economic crisis played a role in reducing the capacities of both public and private organisations to maintain long-term commitments to research and innovation strategies. Still, this was not the only reason. The analysis of the complex causal packages underpinning individual instruments' success and the full policy mixes shows that a combination of factors had to be guaranteed. The evidence shows, in particular, that synergies and complementarities with existing funding sources were not always well exploited. Moreover, administrative failures and legal constraints exposed implementations to delays, uncertainties, rejections and, for some beneficiaries, financial stress in a field where timing, long-term commitments and clear rules were crucial factors for the successful collaboration of engaged actors.

The following section provides answers to specific evaluation questions and an assessment for all evaluation criteria. Annex II indicates, for each question and criterion, the source of evidence, the level of analysis and where the extensive presentation of the evidence is discussed in the report.

8.2. Answers to the evaluation questions

8.2.1. RELEVANCE

The relevance criterion has to do with the relationship between the needs to be tackled and the objectives of the overall ERDF strategies and related policy instruments. More specifically, it touched on aspects of the design of the programmes and identified whether there was a mismatch between the ERDF mix of policy instruments for RTD and the barriers to research and technological development identified by the programmes.

EQ 1: What are the interventions supported by ERDF?

ERDF support in the field of RTD investments funded mainly infrastructure construction and modernisation, including ICT, to improve education and research activities. These investments took the lion's share of ERDF contributions. In total, excluding Spain, 55% of projects financed R&D projects, both individual and collaborative. Other types of interventions were internationalisation of research and capacity building for research, investments for science and dissemination, intellectual property rights instruments and operating subsidy.

EQ 2 How is ERDF support divided between the different types of intervention and forms of financing?

The largest share of ERDF expenditure, more than EUR 9 billion (72% of total), was concentrated on support for infrastructure investments, with infrastructure investments for research absorbing more than half of ERDF expenditure (57%). R&D projects, both individual and collaborative, represented the most common type of intervention in terms of the number of projects, but only 23% of the total ERDF expenditure. A smaller share of projects (6%) and expenditure (3%) was allocated to the implementation of other sorts of RTD activity, while a residual portion (3% of ERDF expenditure) funded activities that were not strictly related to RTD and should instead have been classified under different codes.

The selected 53 OPs supported more than 20,000 projects, almost half of which were in Spain. Almost all projects were funded through non-repayable grants.

The majority of beneficiaries were publicly owned organisations. A total of about 4,000 different institutions can be identified among the almost 24,000 lead beneficiaries (about 2,000 different institutions including almost 580 HEIs, more than 720 RTOs, nearly 470 enterprises, when excluding Spain).

EQ 3: What is the underlying rationale, also considering the role of ERDF support in the policy mix?

The rationale for public intervention in RTD stems from the need to tackle multiple investment needs. According to the literature, such needs refer to specific market mechanisms preventing long-term investments in RTD because of the indivisibility, inappropriability and uncertainty nature of research (market failures) as well as key deficiencies in the actors producing research and in overall systems (systemic failures).

According to the OP analysis, some systemic failures were the main rationale for RTD support. The need to tackle infrastructure gaps and failures and to facilitate improvements in science-industry collaboration comprised the logical foundation of the interventions of most of the programmes (87% and 79% respectively), despite the wide variety of territorial contexts and research systems. Differences were instead observed in the way the OPs translated their strategic approaches into policy mixes. Similar territorial contexts saw the adoption of different combinations of instruments.

Individual policy instruments differ in the rationales underpinning them:

- Infrastructure investments for research aimed at addressing the lack of sufficient or modern physical and technological infrastructure, an essential component in fostering knowledge creation.
- Infrastructure investments for education were geared more towards improving education facilities in universities than towards RTD laboratories.
- ICT-based infrastructures aimed at providing digital-based services and tools for data and computing-intensive research in virtual and collaborative environments.
- Collaborative projects had various aims, ranging from addressing industrially relevant or societal challenges to stimulating technological advancement in specific areas to boosting international cooperation by conducting internationally competitive high-quality R&D activities.
- Individual research projects had the objective to strengthen the scientific and technological capacity of the supported region.

EQ 4: Is ERDF support based on research demand (bottom-up), or does it focus on the availability of support services and infrastructure and gaps in these (top-down)?

In project selection, infrastructure investments largely followed a top-down approach guided by national road-mapping exercises. R&D projects, conversely, primarily followed a bottom-up approach within well-identified priority scientific or technological fields.

EQ 5: How was investment targeted in respect of geographical areas and sectors: to those with significant potential or comparative advantage or those in difficulty or lagging behind?

While broader territorial targeting strategies were driven by eligibility criteria targeting lagging territories, targeting strategies of specific OPs (especially nationally) or instruments did not include an explicit geographical component and were rather ‘territorially agnostic’. Overall, the funds were mainly addressed to strengthen existing territorial excellence, even in countries with strong regional disparities in RTD (such as Romania).

In many cases, ‘target priority’ sectors and technologies reflected regional specialisation and were identified by existing policy strategies and documents, either at national or regional levels.

In most cases, the target OPs funded beneficiaries with a competitive advantage, with a high concentration within individual beneficiary organisations leading institutions in their field.

EQ 6: Did the ERDF interventions match, or respond to, the policy challenges?

At programme level, despite differences in terms of policy challenges between Central and Eastern European countries on the one hand and Western EU countries on the other, the key strategic objectives pursued by the selected OPs and related PIs were to fill the infrastructure gap and to improve the systematic interaction among regional actors. This was in line with the main systemic failures identified by the different OPs.

ERDF support for RTD responded not only to the main policy challenges but also to external challenges, such as the economic crisis. It helped public research infrastructures and businesses to withstand the crisis by providing a significant source of funds, sometimes palliating a decrease in national public support. This holds true in particular in those countries and regions most severely affected by the crisis.

Individual policy instruments tackled different policy challenges:

- Infrastructure investments for research and education upgraded existing infrastructure and equipment and replaced obsolete or outdated instances in both Higher Education Institutions and RTD organisations.
- ICT-based infrastructures established or improved computing grids, data-storage centres, open-data infrastructures, ICT network systems and e-infrastructures.
- Collaborative projects consisted of projects between R&D institutions themselves and private-sector partners carrying out research activities mainly with technological and innovation potential.
- Individual research projects consisted of both early-stage (foundational) and exploratory research to generate new knowledge and further develop innovative skills in research institutions and projects with a predetermined commercial application.

Overall assessment on RELEVANCE

ERDF support for RTD was overall relevant. The combinations of policy instruments were designed to respond to a wide range of needs, mainly related to RTD capacities, identified in the programming documents and confirmed by the literature and the cluster analysis. More specifically, the ERDF supported massive investments to address infrastructural gaps and, to a lesser extent, tackled difficulties in the interactions of the innovation system actors. Overall, the ERDF support to RTD investments concentrated on interventions on the supply side, mainly focused on strengthening the RTD capacities than on improving the performance of the regional RTD systems as a whole.

The majority of RTD interventions were geared at supporting excellence objectives, targeting more advanced territories, stronger sectors and best performing institutions within eligible territories. Although this approach was justified by the need to ensure critical mass, fund absorption and knowledge externalities in more mature territories, the question of whether this approach may have contributed to increasing the territorial divide vis-à-vis lagging regions remains open.

8.2.2. EFFECTIVENESS

Effectiveness assesses the extent to which selected policy instruments have successfully achieved or progressed towards the stated objectives and delivered the expected outputs, outcomes, and impacts. Effectiveness assessed the extent to which:

- selected policy instruments have been successful, also in combination with other EU and national support for RTD, in achieving or progressing towards the stated objectives and delivered the expected results;
- the ERDF policy mix for RTD has been effective in improving RTD performances of funded regions.

The criterion also analysed the main factors influencing the effectiveness of RTD interventions.

EQ 7: Have research projects achieved their intended objectives?

Infrastructure investments for research and education contributed to the creation or modernisation of public R&D facilities (including universities), which increased the potential and capacity of the beneficiary institutions and created more 'respectable' research and education environments, thus attracting new students and researchers.

ICT-based infrastructures enabled the higher storage, computational and information capacities of R&D institutions, thus improving the availability of scientific information resources and keeping up with the always faster-progressing digitisation.

Collaborative projects generally boosted cooperation between science and industry actions, thus favouring a knowledge exchange process. Still, more limited evidence is available regarding the capacity of funded projects to generate economic benefits obtained from the commercial valorisation of R&D results.

Individual research projects helped develop high-level scientific activities and consolidate relevant knowledge in the scientific and technological system.

EQ 8: How effective were the different groups of ERDF interventions for RTD infrastructure and activities, and how they were combined with other RTD support?

Infrastructure investments targeting HEIs had a significant positive effect on the number of tertiary-educated persons and employment in science and technology, especially in those regions with more advanced industrial fabric and with higher R&D in the business sector and where continued public investment in science, technology and innovation in combination with ERDF support was ensured.

Collaborative R&D projects were less effective in improving the interactions between the different actors of the RTD system. While the level of collaboration has generally improved or remained stable, the role of industry actors in the uptake of RTD results has not significantly changed. This happened although collaborative R&D projects were combined with infrastructure investments which should improve the attractiveness of RTD institutions and lay the groundwork for science-industry collaborations.

EQ 9: Is there a specific impact associated with certain types of interventions?

Infrastructure investments and individual projects contributed to an increase in the number of R&D personnel and researchers at the regional level; infrastructure investments for education were also key for increasing the number of students and tertiary attainments. Those infrastructure investments targeting HEIs also contributed to an increase in scientific outputs. Specifically, ERDF infrastructure investments significantly contributed to the catching-up process of the EU13 regions in terms of scientific output. This was partially due to the magnitude of the investments in HEIs and certain other factors (national public expenditures in particular). Lagging regions performed better than more developed regions in terms of growth in the number of publications.

Collaborative R&D projects contributed to the increase of scientific and technological knowledge and competencies among beneficiaries. However, even when results were produced, they generally remained unfeasibly distant from an industrial application.

EQ 10: To what extent did the support generate additional innovation or output in the supported entities and growth and development in the regions?

Overall, while ERDF support played a role in contributing to the modernisation of RTD systems by supporting the creation of more advanced and competitive research systems, it was less effective in translating this increased research capacity into more competitive territories and regional economies. The cluster analysis highlighted that a decade after the launch of the 2007-2013 programming period, half of the supported regions had not changed their relative RTD performance. Performance improvements were concentrated in stronger regions, but some transition regions also saw a catch-up dynamic. In those regions where the economic crisis hit more profoundly, the ERDF support for RTD did not result in a leap in RTD performance; however, it played a countercyclical role, representing a 'safety belt' for many beneficiaries.

EQ 11: Which were the underlying factors for impacts generation?

A number of contextual factors played a crucial role (as pre-conditions, supporting factors or risks) in explaining what worked and how. Long-lasting strategic and financial commitment to investment priorities, both for private and public organisations, was key as it allowed for follow-up projects to take place. Clarity about the 'rules of the game', shared within the common RTD space by science and industry partners, was decisive for successful partnerships and effective implementation. Administrative and managerial capacities were crucial for effective public spending as they ensured the high scientific quality of selected projects and their timely selection and funding.

Overall assessment on EFFECTIVENESS

ERDF support for RTD effectively contributed to the consolidating and modernisation of existing RTD systems, also favouring a catch-up process of EU13 countries on EU RTD standards. It was less effective in facilitating the coordination and interactions between all the actors involved in the innovation ecosystem, thus addressing the system failures identified in the needs assessment. Ultimately, it did not succeed in transforming the knowledge base of regional economic systems and improving target territories' long-term competitiveness.

In less developed regions, the consequences of the economic crisis were more severe, and ERDF support has certainly played a countercyclical role. Its role was more prominent in those regions that maintained the commitment to investing in RTD investments in times of crisis instead of reprogramming funds to less risky types of investments.

Regarding the effectiveness of specific policy instruments, while infrastructure investments and individual R&D projects generally matched their intended objectives and intermediate results, collaborative projects were not always effective in consolidating the role of industrial partners in the RTD system and their uptake of research results. In this regard, the lack of continued public funding and administrative and managerial capacities issues have had a negative impact on effectiveness.

8.2.3. COHERENCE

Coherence was assessed from three perspectives:

- internal coherence, which focused on assessing whether different interventions under the same ERDF OP or across different ERDF OPs within the same region/country were coherent and complementary;
- external coherence, which focused on determining whether ERDF support to RTD infrastructures and activities were coherent and complementary to other EU and regional/national policies (including the EU Research Framework Programmes);
- influence of EU State Aid rules on the choice of interventions under ERDF.The criterion also analysed the main factors influencing the effectiveness of RTD interventions.

EQ 12: Did EU State Aid rules influence the choice of interventions?

The influence of State Aid was more evident in the implementation of policy instruments rather than in their design. Managing Authorities adapted their instruments to avoid any potential conflicts with, or infringement of, such rules, for instance, by limiting the involvement of the private sector or by selecting projects that could not produce factual findings that would result in a competitive advantage for certain companies. This limited the possibility of involving the private sector either as direct beneficiary or as users of funded infrastructures, with negative impacts on the uptake of research results and strengthening of science-industry partnerships.

The need to ensure coherence with State aid rules proved to be a challenge in some countries because of the unclear interpretation and changes in legislation over the period. The limited degree of alignment and even conflicts between competition and cohesion policy was the weakest aspect of coherence in the 2007-2013 programming period.

EQ 13: What was the role of the policy mix's links with the Research Framework Programmes (FP7 and Horizon2020)?

Despite a very high level of coherence in terms of overall policy goals, the level of synergy between ERDF RTD support for RTD investments and the European Research and Innovation framework programme was found to be limited. The two funds were conceived as being highly complementary, but they followed different rationales and operational arrangements that somehow hampered a systematic and intended combination of funds.

Despite there was no active strategy for combining the two sources of funds, matching data from the ERDF beneficiaries mapped by this study with FP7/H2020 beneficiaries from the CORDIS database shows that the proportion of ERDF beneficiaries that also benefited from FP7/H2020, at least in some countries, was rather significant.

EQ 14: What is the mix of RTD policy measures that MS implemented in the period (including regulatory incentives or national schemes if they play a role in the programmes)? What is the role of ERDF in this policy mix?

ERDF support for RTD was generally coherent with national strategies, both RTD and industrial competitiveness strategies. Strategic coherence in priority sectors and scientific fields was particularly strong. Still, there was a lack of long-term commitment regarding specific RTD strategies and the related political stability and predictability of national policies. In more operational terms, there was a general tacit division of goals between local and ERDF policies and instruments, with coordination mainly driven by co-financing obligations and a great effort towards avoiding overlapping.

There was a significant degree of coordination across interventions carried out in the framework of ERDF. This applied to coordination across different ERDF OPs (national and/or regional) and the different axes, measures, and instruments implemented in the framework of individual OPs.

There are also positive examples of the combination of ERDF and ESF funding. Synergies were particularly strong in the regions where the ERDF emphasised infrastructure investment in tertiary education, as in Poland, Estonia and Slovakia.

EQ 15: To what extent are interventions organised to maximise their combined effects, considering the different underlying goals?

Interventions funded with different EU and national/regional funds were mainly implemented in the light of the separation of objectives and approaches, with more attention to avoiding overlapping than building on relative strengths and maximising the combined effects.

While instruments supported by 01 and 02 ERDF categories of expenditure mainly targeted research providers to improve their capacities, the other expenditure codes primarily reflected the targeting of SMEs, with the principal aim of supporting innovation processes.

EU-level cooperation on research projects was undertaken mainly through the FP7/H2020 programme, while ERDF was essentially seen as a regional and national cooperation instrument.

RTD programmes supported by the ERDF were often closely linked to objectives of industrial competitiveness, as indicated by the strict links between the ERDF interventions for RTD and those of national and regional strategies for cluster development, business innovation and support. The ERDF was also instrumental in supporting national and regional strategies of economic conversion or transition from an industrial economy towards a diversified economy. Despite a high strategic alignment, however, there was often a tacit division of goals between local and ERDF policies and instruments in more operational terms.

Overall assessment on COHERENCE

Coherence of ERDF support with other funding instruments of the broader policy mix proved to be crucial in ensuring the success of ERDF interventions. ERDF support for RTD was strongly in line with other support policies, such as Framework Programmes and other ERDF and national/regional support. Therefore, the coherence of policy strategic objectives was relatively high with the FP7, ERDF support for business innovation, ESF support, and national RTD support. However, synergies and coordination between ERDF support for RTD and other types of RTD funding were not always ensured in practice. No active strategy for combining different sources of funds was generally implemented, except for ERDF and ESF OPs. Significant challenges were reported in terms of coherence between cohesion and competition policies. Uncertainties in the rules or risk-aversion interpretation of the legal framework limited the involvement of private businesses in implemented projects and hampered their capacity to use the services provided by funded research infrastructure.

8.2.4. EFFICIENCY

Efficiency did not address the wider aspect of value for money considerations but concentrated on two aspects. Firstly, it assessed the scale of funding and the use of financial resources under the angle of the concentration of ERDF funds to ensure critical mass. Second, it also explored the issue of administrative capacity and speed in funds absorption in selected case studies.

EQ 16.1: Was the funding sufficiently concentrated on making a perceptible difference to pursuing policy objectives (including when combined with other instruments or sources of support)?

There was a concentration pattern on stronger territories, sectors and leading institutions. ERDF support for RTD was overall sufficiently concentrated to lead to upgrades in both the quality of research infrastructure and research management capacities in most of the countries under investigation. Its role as ‘game-changer’ or ‘needle mover’ in terms of RTD performance in beneficiary countries and regions was strongly related to the importance of ERDF in the overall national and regional RTD policy mix. In cases where ERDF represented a limited share of the total national R&D spending but with a high regional concentration (e.g., in convergence regions), its role was crucial to develop critical mass in specific areas, sectors and types of beneficiary organisations.

EQ 16.2: Were there sources of inefficiencies in the way funds were managed and disbursed?

Delays in project selection and funds disbursements were reported, especially in Italy and Romania, which impacted funded projects' capacity to generate benefits. Some implementation issues, mainly related to limited administrative capacity or unclear legal framework, were reported especially for collaborative R&D. Uncertainties in the interpretation and application of rules, especially for what concerns State-aid rules, caused delays and generated confusion and adjustments during the implementation process.

Overall assessment on EFFICIENCY

ERDF support for RTD helped reach critical mass in most target territories, especially in convergence regions where it represented the main source of funding for RTD investments. It should also be highlighted that some inefficiencies in the implementation of ERDF interventions, especially in the management and disbursement of funds, impacted their effectiveness.

8.2.5. SUSTAINABILITY

Sustainability assessed the capacity of policy instruments to produce long-lasting effects (those which persist or last even after the provision of public support has ceased). In light of the types of instruments and operations funded as part of ERDF support to RTD during the period, sustainability assessed whether:

- the results of research projects, regardless of whether they are individual or collaborative, were relevant in the long term;
- research partnerships and collaborations lasted after project funding;
- funded research infrastructures, especially major infrastructure projects, proved to be financially sustainable in the long term.

EQ 17: To what extent are the effects likely to be sustained after the intervention ends? Is the sustainability of the interventions foreseen and ensured?

The long-term financial sustainability of RTD infrastructures was challenging in some cases. The limited use of infrastructure by the private sector and external users made them highly dependent on public funding for the operation and maintenance.

Research projects, especially collaborative ones, were not fully successful in ensuring the sustainability of the research results, as evidenced by the limited uptake of research results and the lack of a statistically significant relationship between ERDF support and the growth rate of technological outputs. The weaknesses mainly stem from the less intensive translation of research results into practical innovations.

Case studies showed that collaborative projects afforded an initial boost towards reinforcing existing partnerships, but their sustainability, in the long run, remains uncertain.

Overall assessment on SUSTAINABILITY

Long-term financial sustainability was problematic, especially for infrastructure investments. The same applies to the sustainability of research projects regarding uptake of research results and consolidation of long-term partnerships. On both aspects, the weak point was the unexploited use of supported infrastructure and poor market orientation of research activities.

8.2.6. EU ADDED VALUE

The EU added value criterion analysed the beneficial impacts attributed to EU intervention, over and above what could reasonably have been expected and achieved from the action of Member States at the national and/or regional level. Moreover, it provided evidence on the potential EU- wide effects of ERDF interventions in the field of RTD.

EQ 18: What additional value results from the EU intervention compared to what could have been achieved by MS at a national, regional and local level?

The main EU added value recognised by MAs was a scale effect produced by the access of a considerable quantity of financial resources, especially in the EU13, where ERDF 2007-2013 programmes represented the first systematic set of interventions addressed to the research field after years of underinvestment and limited political priority.

Another aspect highlighting the EU added value effect of ERDF support lies in the ambition of supporting research infrastructures of EU scientific and research relevance operating at EU level standards.

EQ 19: What was the impact of the interventions on cooperation between regions and Member States within the EU?

A missed opportunity was the lack of systematic interregional or international research collaborations as a potential EU added value. Partnerships of collaborative R&D projects were mainly regional or, albeit only in selected cases, multi-regional within the same country.

EQ 20: Did the interventions achieve any other EU-wide effects?

EU-wide effects were not among the directly intended effects of funded instruments. Thus, the contribution of ERDF support to them was more indirect, and it occurred through the development of EU-level research communities in specific fields, enabling the construction or upgrading of strategic infrastructures of pan-European relevance (as the later inclusion into the ESFRI roadmap confirms) and also supporting the internationalisation of research communities.

Overall assessment on EU ADDED VALUE

ERDF support for RTD produced a scale effect that would not have been achieved by national sources alone, especially in those countries and regions generally suffering from underinvestment in the field of RTD policy (all EU13 countries and convergence regions). Despite not specifically intended at producing EU-wide effects, ERDF support for RTD indirectly contributed to the development of EU-level research communities. It helped structure and consolidate a European Research Area by promoting the achievement of EU standards in RTD capacities and production. This can be claimed to have been the main EU added value of the ERDF support to RTD investments in the period 2007-2013.

8.3. Policy considerations and recent developments

This evaluation has highlighted several points that sought to be addressed in the subsequent programming period (2014–2020) through changes in the legislative framework and the refinement of policy priorities. As such, it is worthwhile to describe what significant changes took place in the 2014-2020 time period and offer a concise outlook on important considerations for the current programming period (2021-2027).

2014-2020

The 2014–2020 programming period brought forward a new legislative framework for the five ESI Funds. For instance, the **‘thematic concentration of funds’ and the delineation of 11 thematic objectives** represented a key element in the reform of the ESI Funds. This principle and the related regulatory requirements sought to align the ESI Funds with the Europe 2020 Strategy to integrate the ESI Funds with the broader policy framework of the EU. It also aimed to increase added value by concentrating the funds on fewer priorities across all Member States and regions. The first four of these thematic objectives[76] constituted key priorities for the ERDF and helped guide ERDF investments in research and innovation. A distinct emphasis was placed on promoting business investment in R&I and in developing linkages and synergies between enterprises, research and development centres and the higher education sector by promoting investments in product and service development as well as more effective processes of technology transfer.[77] As such, these priorities aimed at addressing some of the shortcomings outlined in this evaluation.

Furthermore, special provisions were developed to encourage Member States to pursue the complementary use of ESI Funds and other EU instruments, thereby emphasising synergies. These conditions ensured that the Member States pursued the strategic identification of priorities and made better use of the possibility to combine support from different instruments to finance individual operations. As such, Member States were tasked to develop '**smart specialisation strategies**' (S3) in entrepreneurial discovery processes so that ESI Funds could be used more efficiently and synergies between different EU, national and regional policies, as well as private and public investments, could be fostered. To this end, the implementation of S3 strategies encouraged greater stakeholder engagement, involving small, medium-sized and large firms and research centres and universities in developing, implementing and monitoring smart specialisation strategies, which would focus and prioritise economic development efforts and investments on each region's relative strengths.[78] A forthcoming study[79] confirms that such concentration and prioritisation efforts have largely been effective and are based on an objective data-driven identification process that involves key stakeholders from the private, public and research sectors.

As highlighted in this ex-post evaluation, **state aid regulations** in the context of RDI proved to be a source of difficulties in many settings across the EU. As such, the revised state aid rules in RDI[80] that came into effect in 2014 constituted an important change to the regulatory framework conditions. The new RDI state aid framework set out the more lenient conditions under which Member States could grant state aid to companies to carry out RDI activities without prior notification to the Commission and increased eligible financing levels. This provided the Member States with more flexibility and accelerated the process of implementing RDI investments. A recent evaluation of the changes in state aid rules[81] underscores that the revised rules are more adequate to promote RDI activities without unduly distorting competition. Key stakeholders confirm that clear improvements were observable after the revision of the rules.

[76] 1) Strengthening research, technological development, and innovation; 2) Enhancing access to, and use and quality of information and communication technologies (ICT); 3) Enhancing the competitiveness of small and medium-sized enterprises (SMEs); 4) Supporting the shift towards a low-carbon economy in all sectors

[77] Thematic Guidance Fiche: Research and Innovation (Thematic Objective 1 - Research and Innovation). European Commission: https://ec.europa.eu/regional_policy/sources/docgener/informat/2014/draft_thematic_guidance_fiche%20research_innovation_final.pdf

[78] National / Regional Innovation Strategies for Smart Specialisation – Cohesion Policy 2014 – 2020. Factsheet - European Commission: https://ec.europa.eu/regional_policy/sources/docgener/informat/2014/smart_specialisation_en.pdf

[79] Study on prioritisation in smart specialisation strategies in the EU (Prognos & CSIL on behalf of DG Regio – 2021)

[80] 1. dedicated Art. (25-29) in the General Block Exemption Regulation (GBER)14 and; 2. the Framework for State aid for research, development and innovation (RDI Framework).

[81] Retrospective evaluation of State aid rules for RDI and the provisions applicable to RDI State Aid of the FBER applicable in 2014–2020 (KPMG & Prognos on behalf of DG Competition – 2020)

Outlook on 2021-2027

Upon starting a new programming period (2021-2027), the outlook shifts towards the future and the priorities that will shape RDI investments under the ERDF. The 11 thematic objectives have been reduced to five policy objectives (PO) that seek to support growth in the upcoming programming period.[82] While investments towards all objectives will be supported, the ERDF will prioritise spending that promotes a more competitive and smarter Europe (PO1) and a greener, low-carbon economy (PO2). This will also guide RDI investments, which will support and foster innovation in small and medium-sized businesses and promote digitalisation and digital connectivity. Moreover, investments will focus on the transition to a net-zero carbon economy that is more resilient.[83]

8.4. A cookbook for policymakers

Based on a comprehensive analysis of achievements and their underlying factors (pre-conditions, supporting factors and risks), the study identifies a list of elements that should be considered when designing and implementing RTD policy. They should be considered in all phases of the long innovation journey, from design to implementation. In particular:

- The preparatory phase includes the needs assessment for the RTD landscape and the prioritisation process. It should be based on an in-depth understanding of the existing RTD actors (i.e., their capacities and expectations, their willingness and incentive to engage in know-how transfer, their territorial distribution) as well as the national institutional and legal framework (i.e., administrative capacities, legal constraints, policy framework). Specific points of attention should be the following:
    - Long-term commitment to public and private investments benefits from clarity regarding the legal framework. National authorities should guarantee that legislation regarding public procurement, state aid, and other important regulations is sufficiently clear and conducive to a smooth implementation of RTD investments. Clear and effective state-aid rules are important in ensuring that enterprises are eligible for public funding and encouraged to participate in collaborative R&D projects. Administrative burdens related to public procurement should be minimised, and rule changes should be avoided to reduce project delays. Legal constraints and other framework conditions that may prevent adequate pay for researchers are also important obstacles to consider.
    - Equally importantly, a clear policy strategy delineating a long-term commitment to public investment in R&D should be established, communicated and maintained over time, thereby reducing fluctuations, particularly in times of crisis. This should include a plan to coordinate the various support programmes in the field of RTD in the region and country to ensure an effective alignment and complementarity of all funding mechanisms. In this manner, the logic of supporting RTD investments in the long research-and-innovation journey with appropriate continuity, instead of a

[82] 1. a more competitive and smarter Europe; 2. a greener, low-carbon transitioning towards a net zero carbon economy; 3. a more connected Europe by enhancing mobility; 4. a more social and inclusive Europe; 5. Europe closer to citizens by fostering the sustainable and integrated development of all types of territories

[83] European Regional Development Fund – Funding Priorities. European Commission: https://ec.europa.eu/regional_policy/en/funding/erdf/#2

clear separation of competencies that may lead to fragmentation, can facilitate follow-up investments. A specific role for ERDF in the broader policy mix should be designed and acknowledged.

- Programme-management units within MAs should be appropriately staffed and trained. Implementing RTD investment supports is a demanding task that requires managerial and entrepreneurial capacity. When these are not already in place, especially in less developed regions benefiting from large financial envelopes, swift restructuring within responsible administrations should be carried out, with dedicated units equipped with the necessary staff and competencies.
- Investment prioritisation and targeting should be informed by an in-depth understanding of the system failures affecting the regional RTD ecosystem, looking particularly at the existing relationships between science-industry partners in the region and the drivers that can foster an environment enhancing their collaboration and better diffusion of R&D results. RTD supply-side investments should be combined with due consideration of demand-side absorption capacities and constraints. The absorption capacity of the local labour market or the business sector of trained researchers and advanced technological services offered as a result of the planned investments should be considered. Technology-transfer offices, or permanent collaboration platforms such as competence centres or clusters organisations, can be promoted in those cases where there are possible mismatches between the research supply and actual local demand. Demographic change can have an impact on the territorial absorption potential of RTD capacities. For example, the emigration of students and researchers due to unfavourable framework conditions can dilute the expected local impact of RTD investments and result in the so-called brain-drain phenomenon.
- In order to improve the sustainability of supported investments, in the design phase, there is the need to further focus R&I support on better use of the supported infrastructure and on market orientation of research activities to support smart economic transformation.
- Possible trade-offs between excellence and territorial inequality can emerge in the targeting strategy. In a place-based approach, such trade-offs should be addressed by better considering the local relevance of RTD investments to the territorial context, avoiding the promotion of investments motivated by the pursuit of scientific excellence but unrelated to the local business sector and technological capacities.

- During programme implementation, it is necessary to ensure a transparent and timely selection procedure and clear and prompt funds disbursement to prevent delays and ensure that high-quality projects are implemented and produce sustainable results. Positive conditions should be guaranteed and consistently and robustly maintained. To do so:
    - Instrumental support from advisory and support services may be useful in improving the engagement of stakeholders and ensuring that good-quality projects are prepared. This would also avoid that selection criteria promoting excellence concentrating the funds in a few leading institutions. MAs and implementing bodies are encouraged to guarantee a high level of commitment and willingness to assist in the application process. Capacity building is also essential in developing awareness of industry needs and providing the capacity to transfer knowledge. Communication channels can be activated to present and explain R&D results that may have commercial potential.

- Administrative procedures for fund disbursement should be kept as simple as possible to reduce the administrative burden on beneficiaries and the impact on timely beneficiary payments.
- In selecting infrastructure investments, due attention should be paid to ensure that sufficient, highly qualified R&D and ICT staff can be employed in the new infrastructure. For long-term financial sustainability, any beneficiary infrastructure must develop a business model specifying a balanced source of funds without relying unduly on an individual source. It is also essential to maximise the revenue-generating capacity arising from services offered to industrial partners.
- Private partners' lasting commitment and interest regarding research activities and collaboration with science partners should be promoted and maintained. Measures should be taken to prevent this commitment and interest from being undermined by external shocks or unfavourable contextual conditions.

9. Issues for further research and evaluation

The goals set at the beginning of the evaluation were very ambitious and required a far-reaching methodological design and extended data collection and analysis. Still, the work carried out could not provide fully concluding answers to some of the questions for limitations related to data or available resources. In addition, during the evaluation, other questions emerged as worth being addressed in future works.

This section discusses such still open questions, offering them as suggestions for further analysis and evaluations. It also discusses some methodological considerations emerging as lessons learned to improve the design of future evaluations.

9.1. Open questions

9.1.1. Investigating policy rationale of ERDF support to RTD investments

One of the key aspects of the evaluation was the presentation and the discussion of the rationales underpinning ERDF interventions, concerning both individual policy instruments and the whole RTD set of investments within a broader policy mix. This evaluation was descriptive on this point, reporting the different claimed justifications, usually based more on an ex-post reconstruction of interviewed programme managers. A more comprehensive and conclusive judgement about the most credible rationales of the different strategies cannot be provided.

The reason is double fold. By one side, by design, the evaluation dedicated less attention to the analysis of national and regional strategies than the assessment of individual policy instruments. The strategic design and rationale proved to be more or less effective could not be investigated solidly and comparatively. Future evaluations should better address the aspect of the appropriateness of the design of policy mix at the national and regional level, as well as the role of ERDF within the broader policy mix of RTD policies. On the other side, no clear-cut assessment criteria could be defined, lacking a broad and definitive consensus within scholars and practitioners about the most solid rationale that should have driven the design of RTD investments in Cohesion Policy during the 2007-2013 programming period. For example, no unique convincing solution was available about how to deal with the trade-off between excellence and cohesion objectives. The extent to which targeting more competitive territories, sectors and institutions may have contributed to increasing the territorial divide vis-à-vis lagging regions remains open. As highlighted by the literature review, while the justification of RTD investments with a place-based approach in an effective way was provided as a theoretical framework in the following programming period (with the Smart Specialisation approach), the actual implementation of this approach on the field is relatively new and the evaluation of its effectiveness beyond the scope of this evaluation. To this end, it would be particularly interesting to check to what extent the introduction of the Smart Specialisation approach in the 2014-2020 programming period may have provided a solid logic to assess the rationale of ERDF support to RTD investments. A longer-term analysis or a back-to-back approach of evaluations of different programming periods would better account for longer-term effects and policy development of cohesion policy.

9.1.2. A perspective on systems and their transformation

Somehow linked to the previous point, there is the need to reflect better a "system perspective" in evaluating RTD investments of cohesion policy. One of the main barriers for RTD investments recognised by the literature and indicated by MAs was system failures, particularly the sub-optimal interaction of the main actors of regional RTD systems. The study highlighted the importance of understanding the needs, capacities, motivations and interests belonging to the different actors of the system. In this sense, an analysis of the broader system involved and affected by RTD policies in the different regions is necessary to understand the impact or desirable impact of both individual instruments and overall investment strategies.

However, even if acknowledged to be important by the MA interviewed, this aspect was not specifically addressed in the programming documents. Strategies were conceived more as a menu of different policy instruments, each one tackling a specific barrier or targeting specific actors, but without a clear systemic RTD strategy.

This perspective may also reflect the approach of this study which, by design, started from the description of individual policy instruments and their specific rationale and barriers addressed.

Moreover, very limited evidence could be gathered by this evaluation about the capacity of the ERDF to transform the regional/national systems of actors structurally. The evaluation could instead conclude about a dominant scale effect of the policy, where existing systems performed better or maintained a stable performance but did not move towards a structural transformation in how knowledge is produced, disseminated and exploited. The problem may be due to the fact that systems needed different interventions or that there were not enough synergies between the ones designed.

The Smart Specialisation Strategy approach may have provided already an improvement on this point in the 2014-2020 programming period since it focused on bringing together different stakeholders and on the importance of a mapping of needs, on both the side of enterprises and research providers part of the RTD regional ecosystems, as a starting point in the formulation of the regional strategy.

Also, because of the smart specialisation approach, future evaluation should possibly take a more systemic point of view, first, by mapping regional systems and their investment needs and, second, by assessing the appropriateness of the trajectory of systemic change that the ERDF has contributed to or facilitated.

9.1.3. Better investigation of the links between the ERDF and European Framework Research Programmes

A relatively blind spot of this evaluation remained the relation between ERDF support and the European Framework Research Programmes' support to RTD investments. This evaluation described the existing alignment of policy objectives and implementation procedures, concluding on little synergies between the two funding streams. For data quality, however, information on beneficiaries collected by this evaluation could not be systematically matched with data on beneficiaries of the Framework Research Programmes. A more comprehensive assessment of the types of projects and beneficiaries funded by the two programmes may shed further light on the interlinkages and possible existing or potential synergies and complementarities. The more comprehensive dataset of operations and beneficiaries that will be available for the programming period 2014-2020 could be used to illustrate the long-term trajectories of funded beneficiaries tracking their performances under different angles. This analysis can be done in relation to individual beneficiary organisations and regional and local ecosystems (i.e., considering the mix of actors operating in the same territory and benefitting from EU funds).

9.1.4. Administrative capacity issues and role of ERDF

As highlighted in the conclusion section, implementation capacity remains a problem hampering the smooth and efficient delivery of public investment programmes, especially in countries such as Italy and Romania. This issue is particularly relevant when dealing with RTD investments where the efficient engagement of different actors and stakeholders of the regional ecosystems is a determinant success factor. Administrative capacity has been addressed for a long time as one of the main areas for improvement in the delivery of cohesion policy but will also deserve further attention in the 2021-2027 period. Future evaluations should dedicate enough attention to considerations on the extent to which there is noticeable long-term improvement in the administrative capacity of regions and the role that ERDF may have had to facilitate such improvements. In addition, evaluation should consider the extent to which the design of the regional/national strategies and individual policy instruments were taken into duly consideration and anticipated possible implementation failures due to administrative capacity issues.

9.1.5. Added value as unexpected achievement

The study illustrates how the added value of the cohesion policy in the RTD field, intended as the production of EU wide effects and catching-up phenomena of regional RTD performances to EU standards, comes as a sort of unexpected and unplanned effect of funded interventions. In particular, added value does not appear in the reconstructed ToCs as an explicitly intended effect. Despite this, it constitutes a relevant and visible effect of the policy that the MAs should be better recognised and pursued more deliberately since the beginning. MAs seem to have a better awareness of the financial scale effect of the contribution of EU funds to regional and national RTD investments rather than the more strategic effect, which has to do with setting standards of performance and promoting common approaches to RTD policies. It would be interesting to investigate to what extent, in the following programming period, the EU added value of RTD policies was an integral aspect of the logic of intervention of both individual policy instruments and the policy mix as a whole.

9.2. Methodological considerations

The approach to this ex-post evaluation is quite novel in the field of RTD support, mainly due to its scale, its cross-case analysis, and the strong emphasis on the role of contextual factors. The theory-based approach proved highly useful as a guide to evaluation activities and in structuring the analysis of individual policy instruments according to a consistent framework. The relation between theory-based and theory-informed approaches to gathering evidence and making conclusions seems to work quite well. It enables further advances in the integration of concepts and empirical methods. It was also found that the concept of theories of change can be especially valuable in the design phase of RTD policy instruments (i.e., in an ex-ante fashion) and when building on the lessons from such forms of evaluation to strengthen one's 'foresight' capacities.

At the same time, it was noted that further methodological advances were needed. In the light of the experience gained, some possible developments can come from the following aspects:

- The evaluation used a combination of methods and tools of analysis, mixing qualitative and quantitative evidence. While this was good for building a comprehensive picture, it remained a challenge when it came to the integration of findings from the different methods, especially qualitative and quantitative. Evidence can be contradictory or difficult to aggregate. The triangulation of evidence and constructing a solid and conclusive synthesis of results always require a certain discretionary exercise. Hence, at the beginning of the study, the evaluation design should be well-adjusted with a juxtaposing of tools and methods. At the end of the data collection and processing, guided stakeholder's consultation, the integration of experts' opinions and dedicated time and energy to open discussion and confrontation can help the final step of the evaluation.
- Linked to the above, there is the challenge of combining different levels and units of analysis, ensuring the width and depth of the evidence collected. The analysis of individual operations, regional or national strategies implemented in very specific contexts helped to understand contextual mechanisms at play and how different choices on the same policy challenges may have conditioned the success of implemented measures. However, attention to ecosystems and representative coverage of MS, OPs and context is also necessary to guarantee a broader validity of the results. The reconciliation of different units of analysis may not always be straightforward.
- Perceptions and opinions of programme managers and beneficiaries were an important ingredient of this evaluation. They are particularly important to gather a better understanding of motivations and incentives underpinning investment decisions. Although this was not possible in the context of this evaluation, future evaluation design can consider a more systematic use of direct surveys to beneficiaries. Evidence on behavioural effects and causal mechanisms can be collected by combining qualitative perceptions and quantitative evidence on organisations' performances. Comparing perceptions of different stakeholders in the same ecosystem can also shed light on the system's performance and functioning. However, a good combination of qualitative and quantitative evidence is always recommended to balance the respective limitations and provide more solid answers to the evaluation questions.
- The analysis and work performed in the context of this evaluation were affected by the quality of monitoring and evaluation on the ground. Experts in the field had to deal with missing or incomplete data and provide estimates or find other evidence when data was missing. Data collected at the central level from the different monitoring systems had to be harmonized and cleaned with demanding and often not conclusive cleaning activities. For future evaluation, it is important to highlight that the availability of quality data is the precondition for implementing certain types of methods and techniques. On one side, the evaluation design must reflect the potential of the available data, making use of innovative tools and techniques for data cleaning and harmonization, and, by the other, the collection of relevant data and information for evaluation purposes must be promoted by the EC at the national and regional level in a more effective way.

Annexes

ANNEX I. List of the sample of 53 operational programmes

The list of the 53 Operational Programmes covered by the study is presented in the Table below.

Table I.1 - List of 53 Operational Programmes

Country	CCI	Name of the OP
BE	2007BE161PO001	Programme opérationnel 'Convergence' Hainaut - FEDER
BE	2007BE162PO003	Programme opérationnel 'Compétitivité régionale et emploi' - Wallonie (hors Hainaut) - FEDER
CZ	2007CZ161PO004	OP Podnikání a inovace
CZ	2007CZ161PO012	OP Výzkum a vývoj pro inovace
CZ	2007CZ162PO001	OP Praha Konkurenceschopnost
DE	2007DE161PO001	Operationelles Programm EFRE Thüringen 2007 bis 2013
DE	2007DE161PO002	Operationelles Programm EFRE Brandenburg 2007-2013
DE	2007DE161PO003	Operationelles Programm EFRE 2007 - 2013 Mecklenburg-Vorpommern
DE	2007DE161PO004	Operationelles Programm EFRE Sachsen 2007-2013
DE	2007DE161PO007	Operationelles Programm EFRE Sachsen-Anhalt 2007-2013
DE	2007DE162PO001	Operationelles Programm EFRE Bayern 2007 - 2013
DE	2007DE162PO003	Operationelles Programm EFRE Schleswig-Holstein 2007-2013
DE	2007DE162PO004	Operationelles Programm EFRE Berlin 2007-2013
DE	2007DE162PO007	Operationelles Programm EFRE Nordrhein-Westfalen 2007-2013
EE	2007EE161PO001	Operational Programme for the Development of Economic Environment
ES	2007ES162PO002	Programa Operativo FEDER del País Vasco
ES	2007ES162PO004	Programa Operativo FEDER de Madrid
ES	2007ES162PO005	Programa Operativo FEDER de La Rioja
ES	2007ES162PO006	Programa Operativo FEDER de Cataluña
ES	2007ES162PO010	Programa Operativo FEDER de la Comunitat Valenciana
ES	2007ES16UPO001	Programa Operativo FEDER de Investigación, Desarrollo e innovación por y para el beneficio de las Empresas - Fondo Tecnológico
ES	2007ES16UPO003	Programa Operativo FEDER de Economía basada en el Conocimiento
FI	2007FI162PO001	Itä-Suomen EAKR-toimenpideohjelma 2007-2013
FR	2007FR162PO001	Programme opérationnel FEDER AQUITAINE
FR	2007FR162PO011	Programme opérationnel FEDER HAUTE-NORMANDIE
FR	2007FR162PO015	Programme opérationnel FEDER LORRAINE
FR	2007FR162PO016	Programme opérationnel FEDER PAYS DE LA LOIRE

Country	CCI	Name of the OP
FR	2007FR162PO017	Programme opérationnel FEDER NORD PAS-DE-CALAIS
FR	2007FR162PO020	Programme opérationnel FEDER PROVENCE ALPES COTE D´AZUR
FR	2007FR162PO021	Programme opérationnel FEDER MIDI-PYRENEES
HU	2007HU161PO001	Economic Development Operational Programme
IE	2007IE162PO002	Southern and Eastern Operational Programme
IT	2007IT161PO006	Pon Ricerca e competitivita' - Riprogrammazione - 30 ottobre 2014
IT	2007IT162PO002	Por Emilia Romagna FESR Versione approvata dal Comitato di Sorveglianza 2015
LT	2007LT161PO002	2007-2013 m. Ekonomikos augimo veiksmų programa
LV	2007LV161PO001	Entrepreneurship and Innovations
PL	2007PL161PO001	Program Operacyjny Innowacyjna Gospodarka, 2007-2013
PL	2007PL161PO002	Program Operacyjny Infrastruktura i Środowisko
PL	2007PL161PO003	Program Operacyjny Rozwój Polski Wschodniej 2007-2013
PL	2007PL161PO010	Małopolski Regionalny Program Operacyjny na lata 2007-2013
PL	2007PL161PO011	Regionalny Program Operacyjny Województwa Mazowieckiego
PL	2007PL161PO013	Regionalny Program Operacyjny Województwa Podkarpackiego
PT	2007PT161PO001	PO Factores de Competitividade 2007-2013
PT	2007PT161PO002	PO Regional do Norte 2007-2013
PT	2007PT161PO003	PO Regional do Centro 2007-2013
RO	2007RO161PO002	Sectoral Operational Programme Increase of Economic Competitiveness
SI	2007SI161PO001	Operativni program krepitve regionalnih razvojnih potencialov za obdobje 2007 - 2013
SK	2007SK16UPO001	OP Research and Development
UK	2007UK161PO002	West Wales and the Valleys ERDF Convergence programme
UK	2007UK161PO003	Cornwall and the Isles of Scilly ERDF Convergence programme
UK	2007UK162PO001	Lowlands and Uplands of Scotland ERDF Regional Competitiveness and Employment programme
UK	2007UK162PO008	Northwest England ERDF Regional Competitiveness and Employment Operational Programme
UK	2007UK162PO009	Yorkshire and Humberside England ERDF Regional Competitiveness and Employment programme

ANNEX II. Evaluation matrix

Table II.1 - Conclusions by evaluation criterion and question

RELEVANCE **The relevance criterion has to do with the relationship between the needs to be tackled and the objectives of the overall ERDF strategies and related policy instruments. More specifically, it touched on aspects of the design of the programmes and identified whether there was a mismatch between the ERDF mix of policy instruments for RTD and the barriers to research and technological development identified by the programmes.**			
Questions/sub-questions	**Conclusions**	**Source of evidence**	**Level of analysis**
EQ 1: What are the interventions supported by ERDF?	› ERDF support in RTD investments funded mainly infrastructure construction and modernisation, including ICT, to improve education and research activities. These investments took the lion's share of ERDF contributions. In total, excluding Spain, 55% of projects financed R&D projects, both individual and collaborative. Other interventions were internationalisation of research and capacity building for research, investments for science and dissemination, intellectual property rights instruments and operating subsidy (see Section 3.1).	› Mapping of projects and beneficiaries (Task 1)	› OP and MS level (46 OPs and 17 MS)
EQ 2 How is ERDF support divided between the different types of intervention and forms of financing?	› The largest share of ERDF expenditure, more than EUR 9 billion (72% of total), was concentrated on support for infrastructure investments, with infrastructure investments for research absorbing more than half of ERDF expenditure (57%). R&D projects, both individual and collaborative, represented the most common type of intervention in terms of the number of projects, but only 23% of the total ERDF expenditure. A smaller share of projects (6%) and expenditure (3%) was allocated to the implementation of other sorts of RTD activity, while a residual portion (3% of ERDF expenditure) funded activities that were not strictly related to RTD and should instead have been classified under different codes (see Section 3.1). › The selected 53 OPs supported more than 20,000 projects, almost half of which were in Spain. Almost all projects were funded through non-repayable grants (see Section 3.1). › The majority of beneficiaries were publicly owned organisations. About 4,000 different institutions can be identified among the almost 24,000 lead beneficiaries (about 2,000 different institutions including almost 580 HEIs, more than 720 RTOs, nearly 470 enterprises, when excluding Spain) (see Section 3.2).	› Mapping of projects and beneficiaries (Task 1) › OP analysis (Task 1)	› Project level (46 OPs) › OP level and MS (53 OPs and 18 MS)

RELEVANCE
The relevance criterion has to do with the relationship between the needs to be tackled and the objectives of the overall ERDF strategies and related policy instruments. More specifically, it touched on aspects of the design of the programmes and identified whether there was a mismatch between the ERDF mix of policy instruments for RTD and the barriers to research and technological development identified by the programmes.

Questions/sub-questions	Conclusions	Source of evidence	Level of analysis
EQ 3: What is the underlying rationale, also considering the role of ERDF support in the policy mix?	**Overall**: › The rationale for public intervention in RTD stems from the need to tackle multiple investment needs. According to the literature, such needs refer to specific market mechanisms preventing long-term investments in RTD because of the indivisible, inappropriable and uncertain nature of research (market failures) as well as key deficiencies in the actors producing research and in overall systems (systemic failures) (see Section 2.1). › According to the OP analysis, some systemic failures were the main rationale for RTD support. The need to tackle infrastructure gaps and failures and to facilitate improvements in science-industry collaboration comprised the logical foundation of the interventions of most of the programmes (87% and 79% respectively), despite the wide variety of territorial contexts and research systems. Differences were instead observed in the way the OPs translated their strategic approaches into policy mixes. Similar territorial contexts saw the adoption of different combinations of instruments (see Section 2.4). **By policy instrument**: › Infrastructure investments for research aimed at addressing the lack of sufficient or modern physical and technological infrastructure, an essential component in fostering knowledge creation (see Section 3.3.1). › Infrastructure investments for education were geared more towards improving university education facilities than towards RTD laboratories (see Section 3.3.2). › ICT-based infrastructures aimed at providing digital-based services and tools for data and computing-intensive research in virtual and collaborative environments (see Section 3.3.3). › Collaborative projects had various aims, ranging from addressing industrially relevant or societal challenges, stimulating technological advancement in specific areas, and boosting international cooperation by conducting internationally competitive high-quality R&D activities (see Section 3.4.1). › Individual research projects had the objective to strengthen the scientific and technological capacity of the supported region (see Section 3.4.2).	› Documentary and literature review (Task 2) › OP analysis (Task 1) › Case studies (Task 3)	› OP level and MS (53 OPs and 18 MS) › PI level (21 PIs)
EQ 4: Is ERDF support based on research demand (bottom-up), or does it focus on the availability of support services and infrastructure and gaps in these (top-down)?	› In project selection, infrastructure investments largely followed a top-down approach guided by national road-mapping exercises (see Section 3). R&D projects, conversely, primarily followed a bottom-up approach within well-identified priority scientific or technological fields (see Section 4).	› OP analysis (Task 1) › Case studies (Task 3)	› OP level and MS (53 OPs and 18 MS)
EQ 5: How was investment targeted in respect of geographical areas and sectors: to those with significant potential or comparative advantage or those in difficulty or lagging behind?	› While broader territorial targeting strategies were driven by eligibility criteria targeting lagging territories, targeting strategies of specific OPs (especially nationally) or instruments did not include an explicit geographical component and were rather 'territorially agnostic'. Overall, the funds were mainly addressed to strengthen existing territorial excellence, even in countries with strong regional disparities in RTD (such as Romania) (see Sections 3.7 and 5.2.1). › In many cases, 'target priority' sectors and technologies reflected regional specialisation and were identified by existing policy strategies and documents, either at national or regional levels (see Sections 3.7 and 5.2.1). › In most cases, the target OPs funded beneficiaries with a competitive advantage, with a high concentration within individual beneficiary organisations leading institutions in their field (see Sections 3.7 and 5.2.1).	› Mapping of projects and beneficiaries (Task 1) › Case studies (Task 3)	› OP level and MS (9 OPs and 7 MS)

<table>
<tr><th colspan="4">RELEVANCE
The relevance criterion has to do with the relationship between the needs to be tackled and the objectives of the overall ERDF strategies and related policy instruments. More specifically, it touched on aspects of the design of the programmes and identified whether there was a mismatch between the ERDF mix of policy instruments for RTD and the barriers to research and technological development identified by the programmes.</th></tr>
<tr><th>Questions/sub-questions</th><th>Conclusions</th><th>Source of evidence</th><th>Level of analysis</th></tr>
<tr><td>EQ 6: Did the ERDF interventions match, or respond to, the policy challenges?</td><td>Overall:
› Despite differences in terms of policy challenges between Central and Eastern European countries on the one hand and Western EU countries on the other, the key strategic objectives pursued by the selected OPs and related PIs were to fill the infrastructure gap and to improve the systematic interaction among regional actors. This was in line with the main systemic failures identified by the different OPs (see Section 3.6).
› ERDF support for RTD responded to the main policy challenges and external challenges, such as the economic crisis. It helped public research infrastructures and businesses to withstand the crisis by providing a significant source of funds, sometimes palliating a decrease in national public support. This holds true particularly in those countries and regions most severely affected by the crisis (see Section 5.1.1).
By policy instrument:
› Infrastructure investments for research and education upgraded existing infrastructure and equipment and replaced obsolete or outdated instances in Higher Education Institutions and RTD organisations (see Section 3.3.1 and Romania, Czechia, Estonia and Poland Case Study).
› ICT-based infrastructures established or improved computing grids, data-storage centres, open-data infrastructures, ICT network systems and e-infrastructures (see Section 3.3.1 and the Czechia and Germany Case Study).
› Collaborative projects consisted of projects between R&D institutions themselves and with private-sector partners carrying out research activities mainly with technological and innovation potential (see Section 3.4.1. and Romania, Poland and Italy Case Study).
› Individual research projects consisted of both early-stage (foundational) and exploratory research aimed to generate new knowledge and develop innovative skills in research institutions and projects with a predetermined commercial application (see Section 3.4.2 and the Portugal and Germany Case Study).</td><td>› Mapping of projects and beneficiaries (Task 1)
› OP analysis (Task 1)
› Case studies (Task 3)
› Cross-case studies analysis (Task 4)
› Seminar (Task 5)</td><td>› OP level and MS (53 OPs and 18 MS)
› PI level (21 PIs)</td></tr>
<tr><td>Overall assessment on RELEVANCE</td><td colspan="3">ERDF support for RTD was overall relevant. The combinations of policy instruments were designed to respond to a wide range of needs, mainly related to RTD capacities, identified in the programming documents and confirmed by the literature and the cluster analysis. More specifically, the ERDF supported massive investments to address infrastructural gaps and, to a lesser extent, tackled difficulties in the interactions of the innovation system actors.
The majority of RTD interventions were geared at supporting excellence objectives, targeting more advanced territories, stronger sectors and best performing institutions within eligible territories. Although this approach was justified by the need to ensure critical mass, fund absorption and knowledge externalities in more mature territories, the question of whether this approach may have contributed to increasing the territorial divide vis-à-vis lagging regions remains open.</td></tr>
</table>

EFFECTIVENESS

Effectiveness assesses the extent to which selected policy instruments have successfully achieved or progressed towards the stated objectives and delivered the expected outputs, outcomes, and impacts. Effectiveness assessed the extent to which:

- selected policy instruments have been successful, also in combination with other EU and national support for RTD, in achieving or progressing towards the stated objectives and delivered the expected results;
- the ERDF policy mix for RTD has been effective in improving RTD performances of funded regions.

The criterion also analysed the main factors influencing the effectiveness of RTD interventions.

Questions/sub-questions	Conclusions	Source of evidence	Level of analysis
EQ 7: Have research projects achieved their intended objectives?	› Infrastructure investments for research and education contributed to the creation or modernisation of public R&D facilities (including universities), which in turn increased the potential and capacity of the beneficiary institutions and created more 'respectable' research and education environments, thus attracting new students and researchers (see Section 4.2, 4.3 and the Czechia, Estonia, Poland and Romania Case Study). › ICT-based infrastructures enabled the higher storage, computational and information capacities of R&D institutions, thus improving the availability of scientific information resources and keeping up with the always faster progressing digitisation (see the Czechia and Germany Case Study). › Collaborative projects generally boosted cooperation between science and industry actions, thus favouring a knowledge exchange process, but more limited evidence is available regarding the capacity of funded projects to generate economic benefits obtained from the commercial valorisation of R&D results (see Section 4.5 and Romania, Poland and Italy Case Study). › Individual research projects helped develop high-level scientific activities and consolidate relevant knowledge in the scientific and technological system (see Section 4.4. and the Portugal and Germany Case Study).	› Mapping of projects and beneficiaries (Task 1) › Case studies (Task 3) › Cross-case studies analysis (Task 4) › Seminar (Task 5) › Econometric analysis (Task 6)	› PI level (21 PIs)
EQ 8: How effective were the different groups of ERDF interventions for RTD infrastructure and activities, and how they were combined with other RTD support?	› Infrastructure investments targeting HEIs had a significant positive effect on the number of tertiary-educated persons and employment in science and technology, especially in those regions with more advanced industrial fabric and with higher R&D in the business sector (see Section 4.2 and 4.3) and where continued public investment in science, technology and innovation in combination with ERDF support was ensured (see the Estonia and Portugal Case Study). While the level of collaboration has generally improved or remained stable, the role of industry actors in the uptake of RTD results has not significantly changed. › Collaborative R&D projects were less effective in improving the interactions between the different actors of the RTD system. This happened although collaborative R&D projects were combined with infrastructure investments which should improve the attractiveness of RTD institutions and lay the groundwork for science-industry collaborations (see Section 4.4 and Italy, Romania and Poland Case Study).	› Mapping of projects and beneficiaries (Task 1) › Case studies (Task 3) › Cross-case studies analysis (Task 4) › Seminar (Task 5) › Econometric analysis (Task 6)	› PI level (21 PIs)
EQ 9: Is there a specific impact associated with certain types of interventions?	› Infrastructure investments and individual projects contributed to an increase in the number of R&D personnel and researchers at the regional level; infrastructure investments for education were also key to increasing the number of students and tertiary attainments. Those infrastructure investments targeting HEIs also contributed to an increase in scientific outputs. Specifically, ERDF infrastructure investments significantly contributed to the catching-up process of the EU13 regions in terms of scientific output. This was partially due to the magnitude of the investments in HEIs and certain other factors (national public expenditures in particular). Lagging regions performed better than more developed regions in terms of growth in publications (see Section 4.3). › Collaborative R&D projects contributed to the increase of scientific and technological knowledge and competencies among beneficiaries. However, even when results were produced, they generally remained unfeasibly distant from an industrial application (see Section 4.4).	› Mapping of projects and beneficiaries (Task 1) › Case studies (Task 3) › Cross-case studies analysis (Task 4) › Seminar (Task 5) › Econometric analysis (Task 6)	› PI level (21 PIs)
EQ 10: To what extent did the support	› Overall, while ERDF support played a role in the modernisation of RTD systems by supporting the creation of	› Cluster analysis (Task 1)	› OP level and MS

EFFECTIVENESS

Effectiveness assesses the extent to which selected policy instruments have successfully achieved or progressed towards the stated objectives and delivered the expected outputs, outcomes, and impacts. Effectiveness assessed the extent to which:

- selected policy instruments have been successful, also in combination with other EU and national support for RTD, in achieving or progressing towards the stated objectives and delivered the expected results;
- the ERDF policy mix for RTD has been effective in improving RTD performances of funded regions.

The criterion also analysed the main factors influencing the effectiveness of RTD interventions.

Questions/sub-questions	Conclusions	Source of evidence	Level of analysis
generate additional innovation or output in the supported entities and growth and development in the regions?	more advanced and competitive research systems, it was less effective in translating this increased research capacity into more competitive territories and regional economies. The cluster analysis highlighted that a decade after the launch of the 2007-2013 programming period, half of supported regions had not changed their relative RTD performance. Performance improvements were concentrated in stronger regions, but some transition regions also saw a catch-up dynamic. In those regions where the economic crisis hit more profoundly, the ERDF support for RTD did not result in a leap in RTD performance; however, it played a countercyclical role, representing a 'safety belt' for many beneficiaries (see Section 7.3).	› Case studies (Task 3) › Cross-case studies analysis (Task 4) › Seminar (Task 5)	(53 OPs and 18 MS)
EQ 11: Which were the underlying factors for impacts generation?	› A number of contextual factors played a crucial role (as pre-conditions, supporting factors or risks) in explaining what worked and how. Long-lasting strategic and financial commitment to investment priorities, both for private and public organisations, was key as it allowed for follow-up projects to take place. Clarity about the 'rules of the game', shared within the common RTD space by science and industry partners, was decisive for successful partnerships and effective implementation. Administrative and managerial capacities were crucial for effective public spending as they ensured the high scientific quality of selected projects and their timely selection and funding (see Section 5).	› Case studies (Task 3) › Cross-case studies analysis (Task 4) › Seminar (Task 5)	› OP level and MS (9 OPs and 7 MS)
Overall assessment on EFFECTIVENESS	ERDF support for RTD effectively contributed to the consolidating and modernisation of existing RTD systems, also favouring a catch-up process of EU13 countries on EU RTD standards. It was less effective in transforming the knowledge base of regional economic systems and ultimately improving target territories' long-term competitiveness. In less developed regions, the consequences of the economic crisis were more severe, and ERDF support has certainly played a countercyclical role. Regarding the effectiveness of specific policy instruments, while infrastructure investments and individual R&D projects generally matched their intended objectives and intermediate results, collaborative projects were not always effective in consolidating the role of industrial partners in the RTD system and their uptake of research results. In this regard, the lack of continued public funding and administrative and managerial capacities issues have had a negative impact on effectiveness.		

COHERENCE

Coherence was assessed from three perspectives:

- internal coherence, which focused on assessing whether different interventions under the same ERDF OP or across different ERDF OPs within the same region/country were coherent and complementary;
- external coherence, which focused on determining whether ERDF support to RTD infrastructures and activities were coherent and complementary with respect to other EU and regional/national policies (including the EU Research Framework Programmes);
- influence of EU State Aid rules on the choice of interventions under ERDF.

Sub-questions	Conclusions	Source of evidence	Level of analysis
EQ 12: Did EU State Aid rules influence the choice of interventions?	› The influence of State Aid was more evident in the implementation of policy instruments rather than in their design. Managing Authorities adapted their instruments to avoid any potential conflicts with, or infringement of, such rules, for instance, by limiting the involvement of the private sector or by selecting projects that could not produce factual findings that would result in a competitive advantage for certain companies. This limited the possibility of involving the private sector either as a direct beneficiary or as users of funded infrastructures, with negative impacts on the uptake of research results and strengthening of science-industry partnerships (see Section 5.2.2). › The need to ensure coherence with State aid rules proved to be a challenge in some countries because of the unclear interpretation and changes in legislation over the period. The limited degree of alignment and even conflicts between competition and cohesion policy was the weakest aspect of coherence in the 2007-2013 programming period (see Section 5.2.2).	› Documentary and literature review (Task 2) › Case studies (Task 3)	› OP level and MS (9 OPs and 7 MS)
EQ 13: What was the role of the policy mix's links with the Research Framework Programmes (FP7 and Horizon2020)?	› Despite a very high level of coherence in terms of overall policy goals, the level of synergy between ERDF RTD support for RTD investments and the European Research and Innovation framework programme was found to be limited. The two funds were conceived as being highly complementary, but they followed different rationales and operational arrangements that somehow hampered a systematic and intended combination of funds (see Section 5.1.4). › Despite there was no active strategy for combining the two sources of funds, matching data from the ERDF beneficiaries mapped by this study with FP7/H2020 beneficiaries from the CORDIS database shows that the proportion of ERDF beneficiaries that also benefited from FP7/H2020, at least in some countries, was rather significant (see Section 5.1.4).	› OP analysis (Task 1) › Documentary and literature review (Task 2) › Case studies (Task 3)	› OP level and MS (53 OPs and 18 MS)
EQ 14: What is the mix of RTD policy measures that MS implemented in the period (including regulatory incentives or national schemes if they play a role in the programmes)? What is the role of ERDF in this policy mix?	› ERDF support for RTD was generally coherent with national strategies, both RTD and industrial competitiveness strategies. Strategic coherence in priority sectors and scientific fields was particularly strong, but there was a lack of long-term commitment regarding specific RTD strategies and the related political stability and predictability of national policies. In more operational terms, there was a general tacit division of goals between local and ERDF policies and instruments, with coordination mainly driven by co-financing obligations and a great effort towards avoiding overlapping (see Section 5.1.2). › There was a significant degree of coordination across interventions carried out in the framework of ERDF. This applied to coordination across different ERDF OPs (national and/or regional) and the different axes, measures, and instruments implemented in the framework of individual OPs (see Section 5.1.3). › There are also positive examples of the combination of ERDF and ESF funding. Synergies were particularly strong in the regions where the ERDF emphasised infrastructure investment in tertiary education, as in Poland, Estonia and Slovakia (see Section 5.1.5).	› Documentary and literature review (Task 2) › Case studies (Task 3) › Cross-case studies analysis (Task 4)	› OP level and MS (9 OPs and 7 MS)

COHERENCE

Coherence was assessed from three perspectives:

- internal coherence, which focused on assessing whether different interventions under the same ERDF OP or across different ERDF OPs within the same region/country were coherent and complementary;
- external coherence, which focused on determining whether ERDF support to RTD infrastructures and activities were coherent and complementary with respect to other EU and regional/national policies (including the EU Research Framework Programmes);
- influence of EU State Aid rules on the choice of interventions under ERDF.

Sub-questions	Conclusions	Source of evidence	Level of analysis
EQ 15: To what extent are interventions organised to maximise their combined effects, considering the different underlying goals?	› Interventions funded with different EU and national/regional funds were mainly implemented in light of a separation of objectives and approaches, with more attention to avoiding overlapping than building on relative strengths and maximising the joint effects. › While instruments supported by 01 and 02 ERDF categories of expenditure mainly targeted research providers to improve their capacities, the other expenditure codes primarily reflected the targeting of SMEs, with the principal aim of supporting innovation processes (see Section 5.1.3). › EU-level cooperation on research projects was undertaken mainly through the FP7/H2020 programme, while ERDF was essentially seen as an instrument for regional and national cooperation (see Section 5.1.4). › RTD programmes supported by the ERDF were often closely linked to objectives of industrial competitiveness, as indicated by the strict links between the ERDF interventions for RTD and those of national and regional strategies for cluster development, business innovation, support. The ERDF was also instrumental in supporting national and regional strategies of economic conversion or transition from an industrial economy towards a diversified economy. Despite a high strategic alignment, however, there was often an implicit division of goals between local and ERDF policies and instruments (see Section 5.1.2).	› Documentary and literature review (Task 2) › Case studies (Task 3)	› OP level and MS (9 OPs and 7 MS)
Overall assessment on COHERENCE	ERDF support for RTD was strongly in line with other support policies, such as Framework Programmes and other ERDF and national/regional support. Therefore, the coherence of policy strategic objectives was relatively high with the FP7, ERDF support for business innovation, ESF support, and national RTD support. However, synergies and coordination between ERDF support for RTD and other types of RTD funding were not always ensured in practice. No active strategy for combining different sources of funds was generally implemented, except for ERDF and ESF OPs. Significant challenges were reported in terms of coherence between cohesion and competition policies. Uncertainties in the rules or risk-aversion interpretation of the legal framework limited the involvement of private businesses in implemented projects and hampered their capacity to use the services provided by funded research infrastructure.		

EFFICIENCY Efficiency did not address the wider aspect of value for money considerations but concentrated on two aspects. Firstly, it assessed the scale of funding and the use of financial resources under the angle of the concentration of ERDF funds to ensure critical mass. Second, it also explored the issue of administrative capacity and speed in funds absorption in selected case studies.			
Questions/sub-questions	Conclusions	Source of evidence	Level of analysis
EQ 16.1: Was the funding sufficiently concentrated on making a perceptible difference to pursuing policy objectives (including when combined with other instruments or sources of support)?	› There was a concentration pattern on stronger territories, sectors and leading institutions (see Section 5.2.1). › ERDF support for RTD was overall sufficiently concentrated to lead to upgrades in both the quality of research infrastructure and research management capacities in most of the countries under investigation. Its role as "game-changer" or "needle mover" in terms of RTD performance in beneficiary countries and regions was strongly related to the importance of ERDF in the overall national and regional RTD policy mix. In cases where ERDF represented a limited share of the total national R&D spending, but where there was a high regional concentration of this spending (e.g., in convergence regions), its role was crucial to develop critical mass in specific areas, sectors and types of beneficiary organisations (see Section 5.2.1 and the Czechia, Romania, Poland, Italy Case Study).	› Case studies (Task 3) › Cross-case studies analysis (Task 4)	› OP level and MS (9 OPs and 7 MS)
EQ 16.2: Were there sources of inefficiencies in the way funds were managed and disbursed?	Some implementation issues, mainly related to limited administrative capacity or unclear legal framework, were reported especially for collaborative R&D. Delays in project selection and funds disbursements, especially in Italy and Romania, which impacted the capacity of funded projects to generate benefits. Uncertainties in the interpretation and application of rules, especially regarding State-aid rules, caused delays and generated confusion and adjustments during the implementation process.	› Case studies (Task 3) › Cross-case studies analysis (Task 4)	› OP level and PI level (9 OPs and 21PIs)
Overall assessment on EFFICIENCY	ERDF support for RTD helped reach critical mass in most of the target territories, especially in convergence regions where it represented the main funding source of RTD investments. It should also be highlighted that some inefficiencies in the implementation of ERDF interventions impacted their effectiveness.		

SUSTAINABILITY

Sustainability assessed the capacity of policy instruments to produce long-lasting effects (those which persist or last even after the provision of public support has ceased). In light of the types of instruments and operations funded as part of ERDF support to RTD during the period, sustainability assessed whether:

- the results of research projects, regardless of whether they are individual or collaborative, were relevant in the long term;
- research partnerships and collaborations lasted after project funding;
- funded research infrastructures, especially major infrastructure projects, proved to be financially sustainable in the long term.

Sub-questions	Conclusions	Source of evidence	Level of analysis
EQ 17: To what extent are the effects likely to be sustained after the intervention ends? Is the sustainability of the interventions foreseen and ensured?	› Long-term financial sustainability of RTD infrastructures was challenging in some cases. The limited use of infrastructure by the private sector and external users made them highly dependent on public funding for the operation and maintenance (see Section 6.1.3). › Research projects, especially collaborative ones, were not fully successful in ensuring the sustainability of the research results, as evidenced by the limited uptake of research results and the lack of a statistically significant relationship between ERDF support and the growth rate of technological outputs. The weaknesses mainly stem from the less intensive translation of research results into practical innovations (see Section 6.1.1). › Case studies showed that collaborative projects afforded an initial boost towards reinforcing existing partnerships, but their sustainability remains uncertain in the long run (see Section 6.1.2).	› Mapping of projects and beneficiaries (Task 1) › Documentary and literature review (Task 2) › Case studies (Task 3)	› PI level (21 PIs)
Overall assessment on SUSTAINABILITY	Long-term financial sustainability remains problematic, especially for infrastructure investments. The same applies to the sustainability of research projects regarding uptake of research results and consolidation of long-term partnerships.		

EU ADDED VALUE The EU added value criterion analysed the beneficial impacts attributed to EU intervention, over and above what could reasonably have been expected and achieved from the action of Member States at the national and/or regional level. Moreover, it provided evidence on the potential EU- wide effects of ERDF interventions in the field of RTD.			
Sub-questions	Conclusions	Source of evidence	Level of analysis
EQ 18: What additional value results from the EU intervention compared to what could have been achieved by MS at a national, regional and local level?	› The main EU added value recognised by MAs was a scale effect produced by the access of a considerable quantity of financial resources, especially in the EU13, where ERDF 2007-2013 programmes represented the first systematic set of interventions addressed to the research field after years of underinvestment and limited political priority (see Section 7.1). › Another aspect highlighting the EU added value effect of ERDF support lies in the ambition of supporting research infrastructures of EU scientific and research relevance operating at EU level standards (see Section 7.2).	› OP analysis (Task 1) › Case studies (Task 3) › Seminar (Task 5)	› OP level and MS (53 OPs and 18 MS)
EQ 19: What was the impact of the interventions on cooperation between regions and Member States within the EU?	› A missed opportunity was the lack of the systematic promotion of interregional or international research collaborations as a potential EU added value. Partnerships of collaborative R&D projects were mainly regional or, albeit only in selected cases, multi-regional within the same country (see Section 7.2).	› Case studies (Task 3) › Seminar (Task 5)	› OP level and MS (53 OPs and 18 MS)
EQ 20: Did the interventions achieve any other EU-wide effects?	› EU-wide effects were not among the directly intended effects of funded instruments. Thus, the contribution of ERDF support to them was more indirect, and it occurred through the development of EU-level research communities in specific fields, enabling the construction or upgrading of strategic infrastructures of pan-European relevance (as the later inclusion into the ESFRI roadmap confirms) and also supporting the internationalisation of research communities (see Section 7.2).	› Case studies (Task 3) › Seminar (Task 5)	› OP level and MS (53 OPs and 18 MS)
Overall assessment on EU ADDED VALUE	ERDF support for RTD produced a scale effect that would not have been achieved by national sources alone, especially in those countries and regions generally suffering from underinvestment in the field of RTD policy (all EU13 countries and convergence regions). Despite not specifically intended at producing EU-wide effects, ERDF support for RTD indirectly contributed to the development of EU-level research communities. It helped structure and consolidate a European Research Area by promoting EU standards in RTD capacities and production. This can be claimed to have been the main EU added value of the ERDF support to RTD investments in the period 2007-2013.		

ANNEX III. Number of observations for each method used

As described in Section **Error! Reference source not found.**, the evaluation approach relied on several tasks and a combination of different methods and sources of evidence. This annex briefly presents the number of observations and stakeholders engaged for each task and related method(s) in the table below.

Table III.1 - The number of each task and method

Task	Method	Key numbers
Task 1 - Mapping	Mapping of ERDF projects and beneficiaries	› More than 20,000 projects (9,793 excluding Spain) › A total of 4,000 institutions benefitting from ERDF support for RTD (2,000 excluding Spain)
	OP analysis	› 53 Operational Programmes analysed › 98 stakeholders interviewed (mainly Managing Authorities and Intermediate Bodies)
	Cluster analysis	› 53 Operational Programmes › 134 EU regions (NUTS2)
Task 2 – Literature review	Analysis of the literature	› 148 articles, papers and evaluation studies reviewed
Task 3 – Case Studies	Case studies at MS level	› 7 Member States covered › In-depth analysis of 9 OPs › Contribution analysis of 21 policy instruments › In-depth interviews with 200 stakeholders (43 Managing Authorities, 135 direct and final beneficiaries, 14 EU/national/regional authorities involved in the oversight of ERDF funds and 8 other relevant stakeholders, such as business associations, etc.)
Task 4 – Cross-case studies analysis	Cross-case studies	› Overarching contribution analysis of 4 policy interventions
Task 5 – Seminar	Virtual validation seminar	› 65 participants, including EC officers, representatives of Managing Authorities and direct/final beneficiaries
Task 6 – Final report	Econometric analysis	› 46 Operational Programmes (Spain was excluded) › 104 EU regions (NUTS2)

ANNEX IV. Methodology and results of the econometric analysis

We employed multivariate regression analysis to support the findings in the main report. The multivariate analysis permits one “to isolate” the contribution of the ERDF types of instruments in the scope of the study to specific regional outcomes from the other potential factors (e.g., regional socio-economic conditions, other R&D policies beyond the ERDF instruments, etc.) influencing those outcomes (see box below).

The regression equation we estimated is as follows:

$$Y_i=\alpha+\beta X_i+\gamma Z_i+\varepsilon_i$$

Where:

- Y_i indicates the outcome (dependent) variable we want to explain in the NUTS2 region i (for instance, the growth rate in the number of scientific publications);
- X_i is the ERDF type of instrument (policy variable) we are interested in;
- Z_i is a vector of controls, i.e. variables that can influence the outcome variable beyond the ERDF instrument (for instance, the GERD expenditure in the region);
- ε_i is an i.i.d error term.
- α,β, and γ represent the parameters (coefficients) of the model to be estimated and measure the correlation between the regressors (X_i,Z_i) and the outcome variable. If the ERDF policy variable had an impact on the outcome variable, then the coefficient β in the equation above is expected to be positive and statistically significant. α is the constant of the model.

Specifically, **we tested a set of hypotheses about the contribution of three ERDF types of instruments** implemented in the 2007-2013 programming period **to a set of regional outcomes**.

The ERDF types of instruments this annex focuses on are (see the main report for the rationale behind their selection):

- ERDF expenditure in infrastructures for research and individual R&D projects in universities / Higher Education Institutions (HEIs);
- ERDF expenditure in infrastructures and investments for education;
- ERDF expenditure in infrastructures for research and in private-public collaborative R&D projects that involve enterprises. This instrument is targeted to Research and Technology Organisations (RTOs), Enterprises, Clusters; Science Parks, Consortia, Competence and/or excellence centres.

As explained in detail in the main report, each ERDF type of instrument had its specific instrument logic, its policy objectives and targeted different beneficiaries. Accordingly, depending on the instrument and related hypotheses, we run several regression analyses with different dependent (outcome) and control (context) variables.

Building on the findings of the case studies, the following **hypotheses were selected for testing**:

- **HP1:** Regions, especially lagging ones, improved their basic research capacities by supporting universities' infrastructure investments and research projects. This contributed to an increase in the R&D personnel in the region and an improvement in scientific production. This process has been further supported by an increase in public expenditures in R&D but did not immediately improve scientific excellence.
- **HP2:** Lagging regions investing in infrastructure for education attracted more students and improved the tertiary attainment in the region. This contributed to an increase in employees in science and technology, but only in those regions with an already advanced industrial fabric.
- **HP3:** Regions investing a larger share of funds in RTO, science-industry collaborations or centres of excellence (either infrastructures or activities) experienced an increase in the level of patent applications and/or other IPRs and public-private co-publications. This holds true in those regions with a high concentration of funds among beneficiaries and regions with a more mature R&I system.

We assembled a database at the regional NUTS2 level from several sources, including Eurostat, Patstat, Web of Science to test the hypotheses. The sample includes **104 EU regions (NUTS2)** covered by selected Operational Programmes (OPs) in the scope of the evaluation: 46 OPs with the highest ERDF expenditure in the Cohesion Policy themes of expenditures 01 and 02.[84]

Hypotheses are verified employing regression analysis. The main variables entering the models vary according to the specific hypothesis and type of instrument under scrutiny[85].

This Annex is organised into three main sections, each one devoted to the analysis of one hypothesis. Tables with related statistics and econometric results are reported, and, at the end of each section, the main findings are summarised.

Hypothesis 1

The first hypothesis we tested states that:

Regions, especially lagging ones, improved their basic research capacities by supporting universities' infrastructure investments and research projects. This contributed to an increase in the R&D personnel in the region and an improvement in scientific production. This process has been further supported by an increase in public expenditures in R&D but did not lead immediately to an improvement in scientific excellence.

In practice, three different regression models, each one with a different outcome variable, were employed to verify such a hypothesis. The selected outcome variables are (see Table IV.1 -):

1. the growth rate in the number of R&D personnel and researchers in 2007 – 2017

[84] Depending on the way how the regional and national expenditure monitoring systems are organised, project-level data were not available for all the OPs. In some cases, they had to be derived from processing the list of beneficiaries or data on individual tranches of payments. Significant efforts were devoted to this activity, and it was eventually possible to build a consistent database of projects for 46 out of 53 OPs. In the specific case of Spain, the peculiarities of the monitoring systems and particularly the lack of any project-level identification code (see Annex II), prevented from aggregating all expenditure data at the level of projects. In the report, approximate data and information on the Spanish programmes are provided. Still, they are not considered when producing aggregate project-level statistics to preserve the accuracy and reliability of the rest of the data.

[85] In the analysis, our variable of interest – i.e., the ERDF instrument- is labelled as "ERDF policy variable".

2. the growth rate in the number of scientific publications in 2007-2017 as a proxy of scientific production in the region;

3. the growth rate in the number of regional scientific publications in the top25% of most cited publications worldwide. It is a proxy of scientific excellence.

We were interested in whether the ERDF type of instrument "expenditure in infrastructures for research and individual R&D projects in universities / Higher Education Institutes (HEIs)" contributed to the growth of the above outcomes. To such an end, we employed the ERDF policy variable into two different measures:

- in Million EUR
- in natural logarithm – ln (of Million EUR)[86]

All the models presented in this Annex were also run by using a third standardised transformation of the ERDF policy variable, i.e. *std* $X_i = X_i / Max\,(X_i)$ where X_i is the ERDF expenditure in million EUR. In that way, a "dose-response function" was created ranging from 0 (no expenditure in that instrument was implemented in the region) to 1 (maximum expenditure in our sample of regions was implemented)[87]. While not straightforward to interpret, this standardised variable returns similar econometric results to the case when the variable in M euro is employed; accordingly, the results with the standardised variable are not visualised in the following tables.

In order to investigate the influence of the regional context on outcomes, we employed a set of six context variables (controls) listed in the last column of Table IV.1 - . The rationale behind their selection is explained andTable IV.2 - reports the descriptive statistics of all the variables used to examine hypothesis 1.

[86] Logarithmic transformation is a convenient means of transforming a highly skewed variable into a more normalized dataset. Using the logarithm of one or more variables improves the fit of the model by transforming the distribution of the features to a more normally-shaped bell curve.

[87] See European Commission (2021). EVALUATION HELPDESK 2014-2020. Cross-Regional Sequential Difference in Difference (CR-SEQDD): An Empirical Approach for Evaluating EU Thematic-Objective Instruments with Regional Data Aggregated at the National Level. Technical note by Bondonio D. (2021).

Table IV.1 - Hypothesis 1: Variables entering the model

	Dependent variable – outcome (label in the regression model)		ERDF Policy variable - input (label in the regression model)		Context variables - Controls (label in the regression model)
1	**Growth rate in the number of R&D personnel and researchers in 2007 – 2017** (GR_N_RDpersonnel_2007_2017)	**1**	**ERDF expenditure in infrastructure for research and individual R&D projects in Higher Education Institutes – HEIs - in the period 2007-2013.** We employ the ERDF policy variable in two different measures: • Million Euro • log (of Million EUR)	**1**	• **Initial number of R&D personnel and researchers in 2007 in log** (ln_TotRD_personnel_FTE_2007) • **Initial number of scientific publications in 2007 in log** (lnN_publications_2007) • **Initial regional publications share (over the total) in the Top25 publications by citations worldwide in 2007** (ShareTop25_public_2007)
2	**Growth rate in the number of scientific publications in 2007-2017.** It is a measure of scientific production in the region (GR_N_public_2007_2017)			**2**	• **Initial level of the GERD in the region in the government and higher education sector in 2007 as % of GDP** (GERD_GOVandHIEDU_GDP_2007)
3	**Growth rate in the number of regional scientific publications in the top25% of most cited publications worldwide**. It is a proxy of scientific excellence (GR_N_toppublic25_2007_2017)			**3**	**Variation of the Gross R&D Expenditure (GERD) in the region in the government and higher education sector between 2007 and 2017.** it is measured as % of the regional GDP (VAR_GERDGOV_HIEDU_GDP_2007_2017).
				4	**EU13**. It is a binary variable, which equals 1 if the region is in EU13 and 0 otherwise. It is used as a proxy of lagging region (EU13)
				5	**Convergence region.** It is a binary variable, which equals 1 if the region was under the Cohesion Policy objective “Convergence” in the 2007-2013 programming period. It is an alternative proxy of lagging regions (Convergence_region_20072013)
				6	**Type of Territory.** They are a set of 6 binary variables identifying the R&D&I cluster the region belongs to (see the project First Intermediate Report). The clusters are (i) Leader; (ii) Strong; (iii) Moderate +; (iv) moderate -; (v) Modest +; (vi) Modest -. This variable is used to capture regional R&D&I fixed effects or to characterise further “lagging regions”. When employed in regressions, the omitted dummy is the “Modest –” dummy.

Table IV.2 - Hypothesis 1: summary statistics

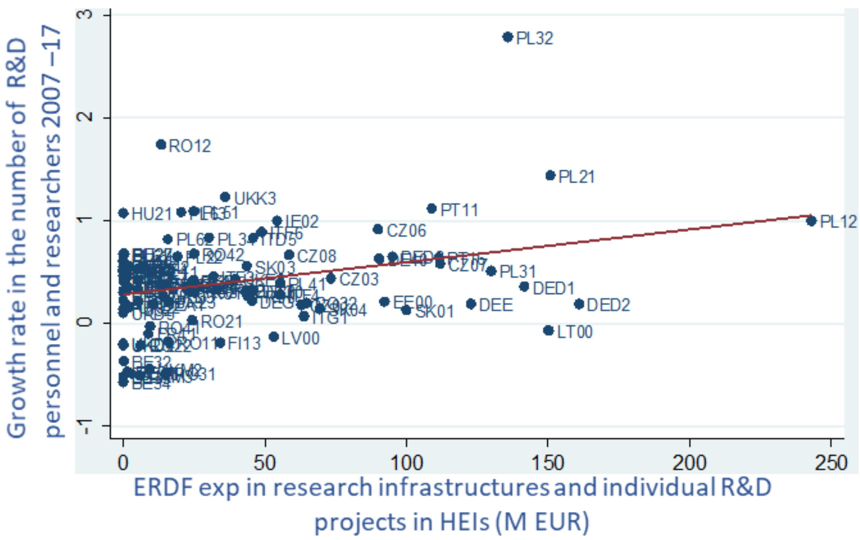
	VARIABLE	N of OBS	MEAN	STD. DEV.	MIN	MAX
	DEPENDENT VARIABLE – OUTCOME					
1	*Growth rate in the number of R&D personnel and researchers in 2007 – 2017*	104	0.394	0.483	-0.570	2.79
2	*Growth rate in the number of scientific publications in 2007-2017*	104	1.737	1.545	0.250	10.049
3	*Variation of the share of regional scientific publications in the top25% of most cited publications worldwide in 2007 - 2017*	104	3.262	3.525	0.269	30.000
	ERDF POLICY VARIABLE – INPUT					
	ERDF expenditure in infrastructure for research and individual R&D projects in Higher Education Institutes – HEIs in the period 2007-13					
	… in Million EUR	104	35.315	46.214	0	243.045
	… in natural log (Ln)	84	2.921	1.713	-2.877	5.493
	… standardised	104	0.145	0.190	0	1
	CONTEXT VARIABLE – CONTROLS					
1	*Initial level of the number of R&D personnel and researchers in 2007 in log*	104	8.444	1.015	5.493	11.007
	Initial N of scientific publications in 2007 in log	104	6.913	1.478	2.079	9.317
	Initial regional publications share (over the total) in the Top25 publications by citations worldwide in 2007	104	0.301	0.097	0.06	0.46
2	*Initial level of the GERD in the region in the government and higher education sector in 2007 as % of GDP*	97	0.004	0.004	0.0001	0.018
3	*Variation of the Gross R&D Expenditure (GERD) in the region in the government and higher education sector between 2007 and 2017*	92	0.0006	0.002	-0.003	0.006

	VARIABLE	N of OBS	MEAN	STD. DEV.	MIN	MAX
4	*EU13*	104	0.451	0.500	0	1
5	*Convergence region*	104	0.558	0.500	0	1
6	*Type of Territory…*					
	… Leader	104	0.038	0.193	0	1
	… Strong	104	0.135	0.343	0	1
	…Moderate +	104	0.269	0.446	0	1
	…Moderate -	104	0.144	0.353	0	1
	…Modest +	104	0.278	0.451	0	1
	… Modest -	104	0.135	0.343	0	1

The analysis starts with the set of regressions having the "***growth rate in the number of R&D personnel and researchers in 2007 – 2017*"** as a dependent (outcome) variable. Figure IV.1 points to a positive relationship between the growth rate in the number of R&D personnel and researchers and the ERDF expenditure in research infrastructures and individual R&D projects in HEIs (Panel A). Between 2007 and 2017, the average growth rate in the number of R&D personnel and researchers in our sample of 104 NUTS2 regions was 40%, ranging from -60% in the Belgian region "BE34 - Prov. Luxembourg (BE)" to a maximum of 280% in the Polish region of Podkarpackie (PL32). The average ERDF expenditure in the instrument under analysis was about EUR 35 million. The Polish region of Mazowieckie (PL12) invested close to EUR 250 million, an amount very high compared to the other regions. In order to detect whether the positive association between the outcome variable and the ERDF instrument was not driven by outliers, Figure IV.1, Panel B shows the relationship without considering the Polish regions of Podkarpackie (PL32) and Mazowieckie (PL12), suggesting that the positive link also held true when outliers are excluded.

Figure IV.1 Hypothesis 1: Two-way relationship between the "Growth rate in the number of R&D personnel and researchers in 2007 – 2017" and the ERDF intervention "Expenditure in infrastructure for research and individual R&D projects in HEIs"

Panel A: all sample (n = 104)



Panel B: restricted sample, no outliers (n = 102)

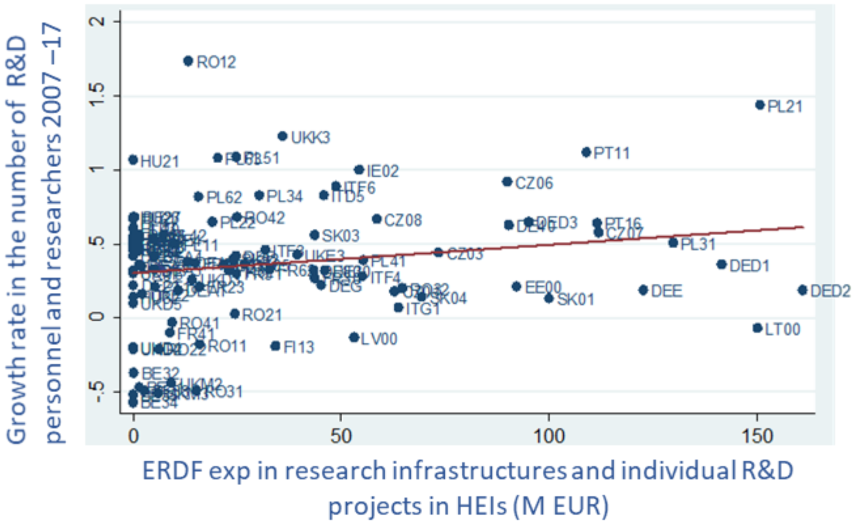


Table IV.3 - reports the OLS regressions. The ERDF policy variable is measured in M EUR (Columns 1-8) and logarithm (Columns 9-13). Different model specifications are reported for each measure, including only the ERDF policy variable as a regressor (Columns 1 and 9) to more complete specifications with additional controls. Columns 8 and 13 reports regressions without outliers. **Overall, the ERDF instrument (policy variable) coefficient is positive and statistically significant,** corroborating the hypothesis **that, on average, ERDF investments in research infrastructures and individual R&D projects in HEIs contributed to the increase in the number of R&D personnel and researchers at the regional level.** Such a relationship was valid on average, i.e., without any statistically significant differences in lagging regions compared to the other regions.[88]

[88] In order to test whether the ERDF policy variable was more effective in lagging regions, we test a set of interaction terms between the dummy variable "EU13" and the ERDF policy variable (not reported in the Table), between the dummy variable "Convergence region "and the ERDF policy variable (not reported in the Table) and between the Type of Territory dummy variables and the ERDF policy variable (not reported in the Table). Interaction terms were never statistically significant.

Table IV.3 - Hypothesis 1: OLS regressions. The dependent variable is the "Growth rate in the number of R&D personnel and researchers in 2007 – 2017."

	The ERDF policy variable is in Million EUR							The ERDF policy variable is in logarithm				
	(1)	(2)	(3)	(4)	(6)	(7)	No outliers (8)	(9)	(10)	(11)	(12)	No outliers (13)
ERDF Policy variable	**0.003** (0.001)**	**0.004* (0.002)**	**0.002** (0.001)**	**0.002** (0.001)**	**0.002** (0.001)**	**0.002* (0.001)**	**0.002** (0.0009)**	**0.068** (0.028)**	**0.041* (0.023)**	0.034 (0.022)	**0.046* (0.027)**	**0.041* (0.023)**
ERDF Policy variable (squared)		0.000 (0.000)										
Initial N of R&D personnel and researchers in 2007 (in log)			-0.064 (0.054)	-0.058 (0.054)	-0.059 (0.059)	-0.061 (0.061)	-0.040 (0.049)		-0.067 (0.055)	-0.052 (0.058)	-0.065 (0.062)	-0.067 (0.055)
Initial level of the GERD in the region in the government and higher education sector in 2007 as % of GDP			-17.05 (12.15)	-15.99 (12.24)	-16.55 (12.13)	-10.37 (12.06)	-16.48 (12.18)		-13.10 (12.04)	-10.67 (12.22)	-7.033 (11.63)	-13.10 (12.04)
GERD variation in the government and higher education sector between 2007 and 2017			16.79 (23.26)	18.63 (24.15)	17.41 (24.31)	8.74 (27.45)	19.54 (23.04)		19.58 (25.20)	23.95 (25.48)	11.24 (28.35)	19.58 (25.20)
EU13				0.028 (0.089)						0.068 (0.093)		
Convergence region					0.018 (0.097)							
Constant	0.283 (0.05)***	0.275 (0.06)***	0.934** (0.432)	0.869* (0.441)	0.885* (0.497)	0.754 (0.534)	0.714 (0.387)	0.228* (0.072)	0.920 (0.447)	0.764 (0.486)	0.703 (0.544)	0.920 (0.447)

	The ERDF policy variable is in Million EUR							The ERDF policy variable is in logarithm				
	(1)	(2)	(3)	(4)	(6)	(7)	No outliers (8)	(9)	(10)	(11)	(12)	No outliers (13)
Type of territory fixed effects	NO	NO	NO	NO	NO	YES	NO	NO	NO	NO	YES	NO
N of Observations	104	104	92	92	92	92	91	104	92	92	92	92
R-squared	0.09	0.09	0.11	0.11	0.11	0.20	0.11	0.06	0.07	0.07	0.188	0.07
P-value F-test	0.02	0.06	0.02	0.03	0.03	0.003	0.02	0.016	0.113	0.192	0.002	0.113

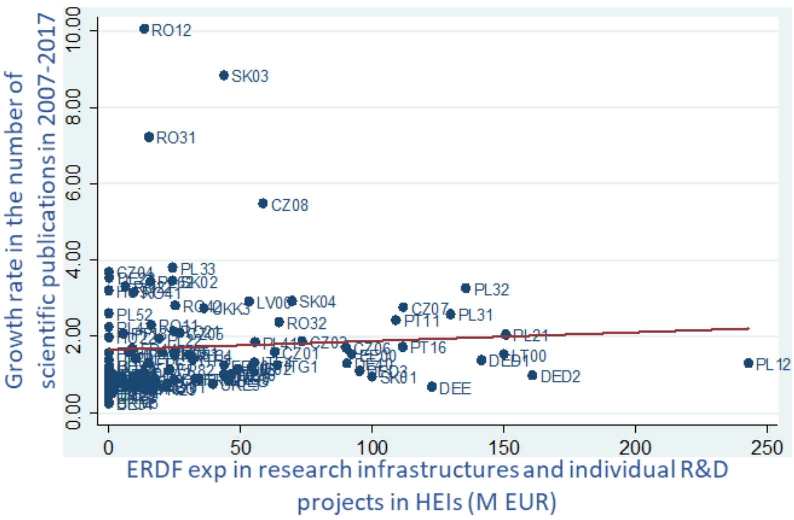
This table reports the regression results by using the Growth rate in the number of R&D personnel and researchers in 2007 – 2017 as a dependent variable and the ERDF expenditure in infrastructure for research and individual R&D projects in HEIs in the period 2007-2013 as a policy variable. When the ERDF policy variable is measured in logarithm, not to lose observations, the zero value was retained for those regions with EUR 0 of expenditures (actually, the log of 0 does not exist). Moreover, negative logarithm values (i.e., ERDF expenditure less than EUR 1 M) were treated as zeros and did not alter the policy variable's distribution too much. Indeed, the log goes to -infinity for values less than EUR 1, increasing the original distance between those regions investing just above EUR 1 Million and those investing just below that threshold. Columns 8 and 13 report specifications without considering outliers, i.e. the NUTS2 regions PL12 and PL32. Robust standard errors in parenthesis; *p<0.10, ** p<0.05,***p<0.01.

Source: Authors.

In addition to R&D personnel and researchers, hypothesis 1 also states that regions that invested in research infrastructure and HEIs also increased their scientific production. This statement was tested using the "***growth rate in the number of scientific publications in the period 2007-2017***" as a dependent (outcome) variable. Figure IV.2 points to a positive relationship between the growth rate in the number of scientific publications in 2007-2017 and the ERDF expenditure in research infrastructures and individual R&D projects in HEIs (Panel A). Between 2007 and 2017, the average growth rate in the number of scientific publications in our sample of 104 NUTS2 was 174%. EU13 regions showed higher growth rates (145% on average) than EU15 regions (96% on average).[89] In particular, some regions located in Romania, Slovakia, and Czechia experienced values higher than 400%.[90] We perform regression analysis with and without such outlier NUTS2 regions (Figure IV.2, Panel B).

Figure IV.2 Hypothesis 1: Two-way relationship between the "Growth rate in the number of scientific publications in 2007-2017" and the ERDF intervention "Expenditure in infrastructure for research and individual R&D projects in HEIs"

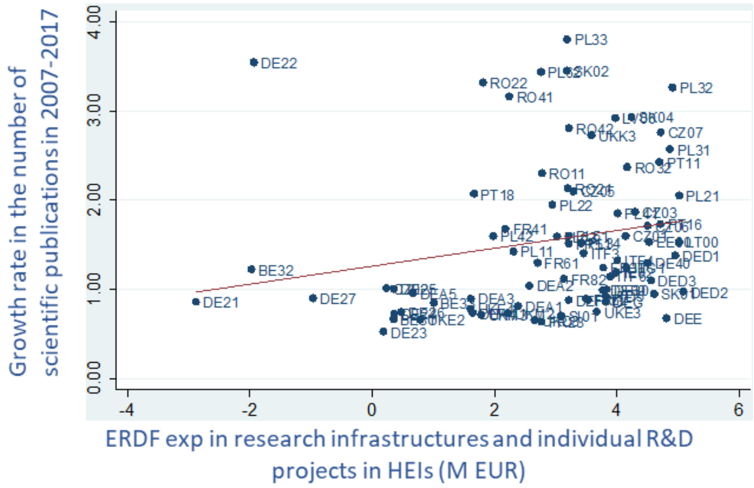
Panel A: all sample (n = 104)



[89] The t-test (unreported) suggests that the mean difference is statistically significant at 1% level.

[90] In our sample, there are four NUTS2 regions with an extremely high rate of growth in the number of scientific publications. They are: RO12 – Centru (growth rate=1,005%); SK03 - Stredné Slovensko (883%); RO31 - Sud – Muntenia (723%); and CZ08 – Moravskoslezsko (549%).

Panel B: restricted sample, no outliers (n = 99)



As indicated by the positive sign and the statistical significance on the coefficient associated with the ERDF policy variable in Table IV.4 - , **regressions confirm that having invested ERDF funds in research infrastructures and HEIs contributed to an increase in the scientific production:** the higher the ERDF expenditure, the higher the growth rate in the number of scientific publications in the period 2007-2017 was.[91]

As already mentioned above, the positive and statistical significance of the coefficient on the EU13 or the “Convergence region” variables suggests that lagging regions performed better than more developed regions (i.e., EU15 regions or non-convergence regions) in terms of the number of publications growth, but this happened regardless the ERDF investments in the type of instrument under scrutiny.[92] The higher growth rate recorded by EU13 (or convergence-) regions was mainly explained by their worse starting conditions with respect to more developed regions. For instance, the Romanian region of *Centru* recorded a number of scientific publications equal to 101 in 2007 and 1,116 in 2017, with an extraordinary growth rate of 1,005% in this ten-year period. Indeed, the regression analysis shows a negative and statistical significance of the coefficient associated with the “initial number of scientific publications in 2007”, pointing to a sort of “diminishing returns to scale” on the evolution of the number of publications over time.

[91] Columns from 2 to 5 in Table IV.4 - would indicate the presence of non-linearities as suggested by the statistical significance of the coefficient on the squared ERDF policy variable. However, non-linearities disappear when excluding outlier regions from the analysis.

[92] In order to test whether the ERDF policy variable was more effective in lagging regions, we test a set of interaction terms between the dummy variable “EU13” and the ERDF policy variable (not reported in Table IV.4 -), between the dummy variable “Convergence region “and the ERDF policy variable (not reported in the Table) and between the Type of Territory dummy variables and the ERDF policy variable (not reported in the Table). Interaction terms were never statistically significant.

Table IV.4 - Hypothesis 1: OLS regressions. The dependent variable is the "Growth rate in the number of scientific publications in 2007 – 2017."

	The ERDF policy variable is in Million EUR								The ERDF policy variable is in logarithm			
	(1)	(2)	(3)	(4)	(5)	(6)	No outliers (7)	No outliers (8)	(9)	(10)	(11)	No outliers (12)
ERDF Policy variable	0.002 (0.002)	**0.013**** **(0.006)**	**0.016***** **(0.006)**	**0.015***** **(0.006)**	**0.012***** **(0.006)**	**0.013***** **(0.007)**	**0.016***** **(0.004)**	**0.014***** **(0.004)**	**0.170***** **(0.060)**	**0.601**** **(0.306)**	**0.275***** **(0.075)**	**0.160***** **(0.040)**
ERDF Policy variable (squared)		**-0.0001**** **(0.00003)**	**-0.0001**** **(0.00003)**	**-0.0001**** **(0.00003)**	**-0.0001*** **(0.00003)**	-0.0001 (0.0004)	-0.0001 (0.0005)	-0.0001 (0.0005)		-0.095 (0.063)		
Initial N of scientific publication in 2007 (in log)			-0.679*** (0.164)	-0.607*** (0.168)	-0.621*** (0.162)	-0.620*** (0.156)	-0.397*** (0.076)	-0.332*** (0.089)			-0.674*** (0.177)	-0.352*** (0.087)
Initial level of the GERD in the region in the government and higher education sector in 2007 as % of GDP			-42.61 (39.21)	-29.77 (41.58)	-20.69 (34.36)	-28.52 (36.66)	-35.82 (23.14)	-25.07 (24.34)			-41.84 (41.13)	-28.29 (22.66)
GERD variation in the government and higher education sector between 2007 and 2017			-17.35 (59.61)	13.20 (55.61)	11.34 (58.13)	52.28 (67.40)	-35.82 (23.14)	10.34 (29.81)			0.722 (58.82)	0.077 (27.93)
EU13				0.431* (0.244)				0.378** (0.194)			0.221 (0.239)	0.329*** (0.185)
Convergence region					0.542** (0.234)							
Constant	1.657*** (0.188)	1.508*** (0.190)	6.392*** (1.181)	5.666*** (1.244)	5.679*** (1.216)	6.799*** (1.287)	4.197*** (0.528)	3.554*** (0.688)	1.322*** (0.174)	1.140*** (0.181)	5.917*** (1.248)	3.611*** (0.684)
Type of territory fixed effects	NO	NO	NO	NO	NO	YES	NO	NO	NO	NO	NO	NO
N of Observations	104	104	92	92	92	92	87	87	104	104	92	87
R-squared	0.004	0.02	0.43	0.44	0.44	0.48	0.52	0.55	0.04	0.06	0.48	0.57
P-value F-test	0.294	0.089	0.0001	0.0000	0.0000	0.0004	0.0000	0.0000	0.005	0.014	0.0000	0.0000

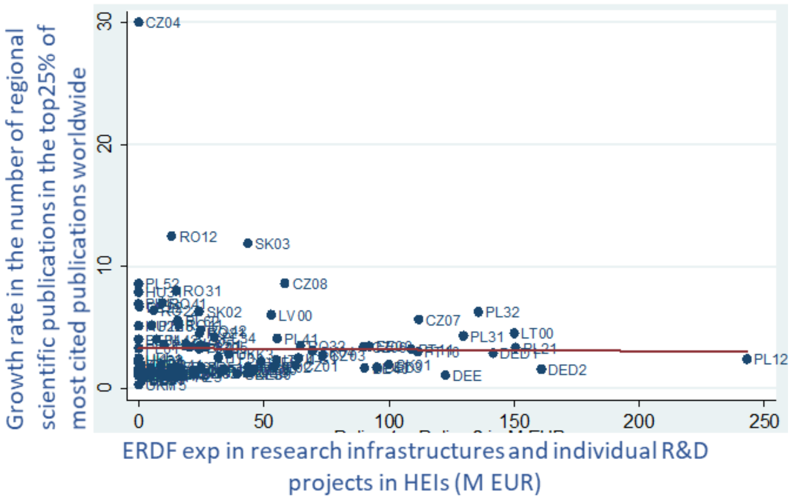
This table reports the regression results by using the Growth rate in the number of scientific publications in 2007 – 2017 as a dependent variable and the ERDF expenditure in infrastructure for research and individual R&D projects in HEIs in the period 2007-2013 as a policy variable. When the ERDF policy variable is measured in logarithm, not to lose *observations, the zero value was retained for those regions with EUR 0 of expenditures (actually, the log of 0 does not exist). Moreover, negative logarithm values (i.e., ERDF expenditure less than EUR 1 M) were treated as zeros and did not alter the policy variable's distribution too much. Indeed, the log goes to -infinity for values less than EUR 1, increasing the original distance between those regions investing just above EUR 1 Million and those investing just below that threshold. Columns 7, 8, and 12 report specifications without considering outliers, i.e., the NUTS2 regions RO12, SK03, RO31, CZ08, and PL12. Robust standard errors in parenthesis; *p<0.10, ** p<0.05,***p<0.01.*

Source: Authors.

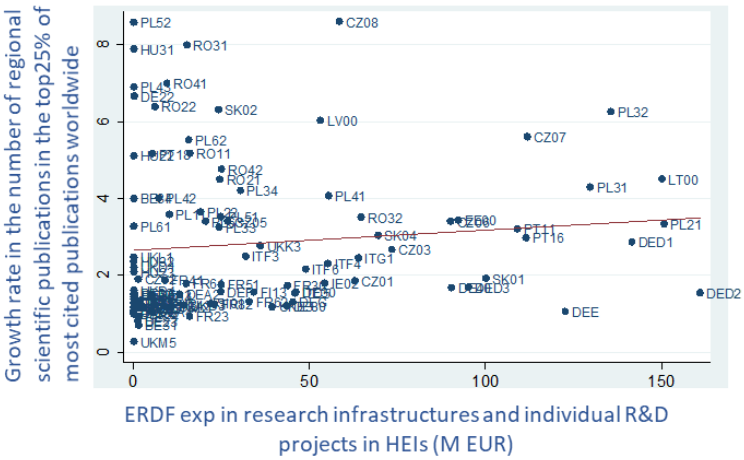
The next issue investigated was whether there was any relationship between the ERDF expenditure in research infrastructures and individual R&D projects in HEIs and the scientific excellence in the region proxied by the growth rate in the number of regional scientific publications in the top25% of most cited publications worldwide. From a preliminary examination in Figure IV.3, it seems that no statistical correlation existed between the ERDF policy variable and scientific excellence. Regression analysis (not reported here) confirmed this evidence. Therefore, **it is likely that the ERDF policy variable did not contribute to improving scientific excellence in the region.** In contrast, the analysis suggested that scientific excellence was mainly driven by the level of R&D development in the region in the initial year (2007); this evaluation refers to as measured by the level of regional GERD in that year and long-term investments in R&D in the following decade.

Figure IV.3 Hypothesis 1: Two-way relationship between the "Growth rate in the number of scientific publications in 2007-2017" and the ERDF intervention "Expenditure in infrastructure for research and individual R&D projects in HEIs"

Panel A: all sample (n = 104)



Panel B: restricted sample, no outliers (n = 100)



The Box below summarises the main findings related to Hypothesis 1.

1. There is evidence that the ERDF instrument "Expenditure in infrastructure for research and individual R&D projects in HEIs" in the period 2007-13 **contributed to an increase in the growth rate of the number of R&D personnel and researchers** in the period 2007-2017. This holds true on average regardless of

whether the region was a lagging one [i.e., belonging to EU13 (vs EU15), or being under the Cohesion Policy objective "Convergence", or the type of R&D territory the region is characterised].

2. As far as the **scientific production** in the period 2007-2017 is concerned and conditional to our sample, the regression analysis indicates that a **positive and statistically significant relationship between the ERDF** "Expenditure in infrastructure for research and individual R&D projects in HEIs" and **the growth rate in the number of scientific publications existed**.

Specifically, in the ten-year period 2007-2017, **EU13 regions experienced a higher growth rate in the number of scientific publications than regions in EU15**. The average growth rate was 96% in EU15 and 145% in EU13. If, on the one hand, the regression analysis indicates that the better performance of EU13 regions was likely due to reasons beyond the ERDF investments (e.g., worse starting R&D conditions or lower research capacity in 2007 as compared to EU15); on the other hand, EU13 regions implemented, on average, higher ERDF investments in HEIs (EUR 43 million) as compared to EU15 regions (EUR 29 million) in the period 2007-13. This may suggest that the ERDF was likely to play a role in this catching-up process, at least from the scientific production viewpoint.

3. Differently from the above finding, **there was no relationship between the ERDF** "Expenditure in infrastructure for research and individual R&D projects IN HEIs" **and scientific excellence in the period under analysis.** This result holds true both when the scientific excellence is measured by the 2007-2017 rate of growth in the share of regional publications in the top25% publications by citations worldwide and also when considering the number of scientific publications in the top10% (it was used as an alternative proxy of regional scientific excellence). Scientific excellence is mainly driven by (long-term) investments in public R&D, i.e., especially in the government and in the HEIs sector.

Hypothesis 2

The second hypothesis we tested states that:

Lagging regions investing in infrastructure for education attracted more students and improved the tertiary attainment in the region. This contributed to an increase in employees in science and technology, but only in those regions with an already advanced industrial fabric.

Two different regression models with different outcome variables were employed to verify such a hypothesis. The outcome variables we focussed on are (Table IV.5 -):

1. the growth rate in the share of tertiary educated people (as % of POP 25-64) in the period 2007 and 2017;
2. the growth rate in the number of tertiary educated people and employed in science and technology (S&T) in the period 2007 – 2017;

According to hypothesis 2, we were interested in whether the ERDF type of instrument "*expenditure in infrastructures and investments for education in the period 2007-2013*" has contributed to the growth of the above outcomes. As for hypothesis 1, we employed the ERDF policy variable into two different measures:

- in Million EUR
- in natural logarithm – ln (of Million EUR)[93]

To investigate the influence of the regional context on outcomes, we employed six context variables (controls) listed in the last column of Table III.5, where the rationale behind their selection is explained. Table IV.6 - reports the descriptive statistics of all the variables used for testing hypothesis 2.

[93] The standardised measure of the ERDF expenditure was employed as well. Results did not change with respect to case when the ERDF expenditure is measured in million euro.

Table IV.5 - Hypothesis 2: Variables entering the model

	Dependent variable – outcome (label in the regression model)		ERDF Policy variable - input (label in the regression model)		Context variables - Controls (label in the regression model)
1	**Growth rate in the share of tertiary educated people (as % of POP 25-64) in the period 2007 and 2017** (VAR_TEREDU_POP_2007_2017)	1	ERDF expenditure in infrastructures and investments for education in the period 2007-2013	1	• **Initial share of POP with tertiary education in 2007 (denominator is POP 25-64)** (Tertiary_Edu_atta_2007) • **Initial number of tertiary educated people and employed in S&T in 2007 in log** (ln_TotTerEduST_Persons_2007)
2	**Growth rate in the number of tertiary educated people and employed in science and technology (S&T) in the period 2007 – 2017** (GR_N_TerEduSTpersons_2007_2017)		We employ the ERDF policy variable in two different measures: • Million Euro • log (of Million EUR)	2	• **Initial level the GERD in the region in the government and higher education sector in 2007 as % of GDP** (GERD_GOVandHIEDU_GDP_2007) • **Variation of the Gross R&D Expenditure (GERD) in the region as % of GDP in the government and higher education sector between 2007 and 2017.** (VAR_GERDGOV_HIEDU_GDP_2007_2017)
				3	• **Initial level of the GERD in the region in the business sector in 2007 as % of GDP** (GERD_Business_GDP_2007) • **Variation of the regional GERD in the business sector as % of GDP in the period 2007 -2014** (VAR_GERDBusiness_GDP_2007_2017) These variables are used to capture the R&I maturity of the regional system
				4	**EU13**. It is a binary variable, which equals 1 if the region is in EU13 and 0 otherwise. It is used as a proxy of lagging region (EU13)
				5	**Convergence region.** It is a binary variable, which equals 1 if the region was under the Cohesion Policy objective “Convergence” in the 2007-2013 programming period. It is an alternative proxy of lagging regions (Convergence_region_20072013)
				6	**Type of Territory.** They are a set of 6 binary variables identifying the R&D&I cluster the region belongs to (see the project First Intermediate Report). The clusters are (i) Leader; (ii) Strong; (iii) Moderate +; (iv) moderate -; (v) Modest +; (vi) Modest -. This variable is used to capture regional R&D&I fixed effects or to characterise further “lagging regions”. When employed in regressions, the omitted dummy is the “Modest –” dummy.

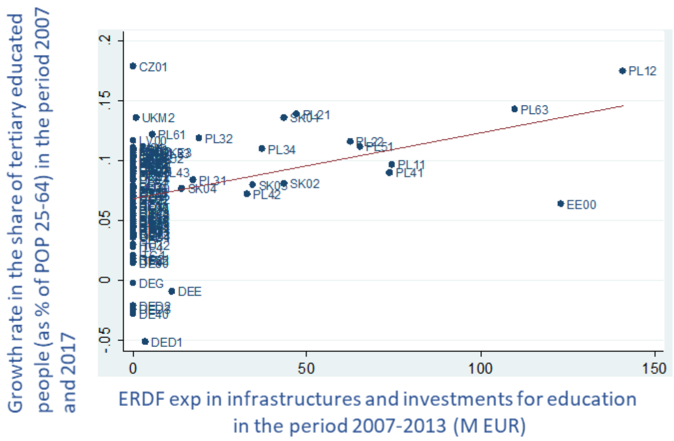
Table IV.6 - Hypothesis 2: summary statistics

	VARIABLE	N of OBS	MEAN	STD. DEV.	MIN	MAX
	DEPENDENT VARIABLE – OUTCOME					
1	*Growth rate in the share of tertiary educated people (as % of POP 25-64) in the period 2007 and 2017*	103	0.073	0.040	-0.051	0.179
2	*Growth rate in the number of tertiary educated people and employed in science and technology (S&T) in the period 2007 – 2017*	104	0.427	0.254	-0.16	1.40
	ERDF POLICY VARIABLE – INPUT					
	ERDF expenditure in infrastructures and investments for education in the period 2007-2013.					
	… in Million EUR	104	9.480	25.62	0	140.85
	… in natural log (Ln)	29	2.254	2.301	-3.097	4.948
	CONTEXT VARIABLE – CONTROLS					
1	*Initial share of POP with a tertiary education in 2007 (denominator is POP 25-64)*	103	0.211	0.084	0.073	0.476
	Initial N of tertiary educated people and employed in S&T in 2007 in log	104	11.632	0.648	10.07	13.056
2	*Initial level of the GERD in the region in the government and higher education sector in 2007 as % of GDP*	97	0.004	0.004	0.0001	0.018
	Variation of the Gross R&D Expenditure (GERD) as % of GDP in the region in the government and higher education sector between 2007 and 2017	92	0.0006	0.002	-0.003	0.006
3	*Initial level of the GERD in the region in the business sector in 2007 as % of GDP*	99	0.006	0.007	0.0001	0.0409
	Variation of the regional GERD in the business sector as % of GDP in the period 2007 -2014	99	0.002	0.004	-0.0191	0.0145
4	*EU13*	104	0.451	0.500	0	1
5	*Convergence region*	104	0.558	0.500	0	1
6	*Type of Territory…*					
	… Leader	104	0.038	0.193	0	1
	… Strong	104	0.135	0.343	0	1
	…Moderate +	104	0.269	0.446	0	1
	…Moderate -	104	0.144	0.353	0	1
	…Modest +	104	0.278	0.451	0	1
	… Modest -	104	0.135	0.343	0	1

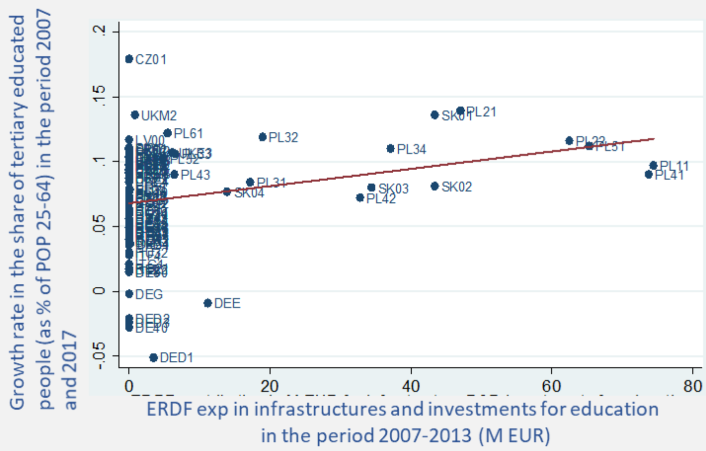
In our sample of NUTS2 regions, only 29 of them (out of 104) invested in R&D infrastructure for education. 21 of them were in EU13, and, in particular, the Polish regions of Mazowieckie (PL12) and Pomorskie (PL63), and Estonia (EE00) allocated more than EUR 100 million in that instrument. As far the outcome variable "growth rate in the share of tertiary educated people", it was, on average, 7% ranging from a minimum of -5% in the German region of Chemnitz (DED1) to a maximum of 18% in the region of Praha (CZ01). Figure IV.4 points to a positive relationship between the ERDF investments in infrastructures for education and the growth rate of tertiary educated people (as % of the population) (Panel A); the positive link also remains when the three regions that invested more than EUR 100 million were excluded from the analysis (Figure IV.4, Panel B).

Figure IV.4 Hypothesis 2: Two-way relationship between the "Growth rate in the share of tertiary educated people (as % of POP 25-64) in the period 2007 and 2017" and the ERDF intervention "Expenditure in infrastructures and investments for education in the period 2007-2013"

Panel A: all sample (n = 104)



Panel B: restricted sample, no outliers (n = 101)



Following the same logic as in the case of hypothesis 1, Table IV.7 - reports the regression results where the outcome variable is the "***growth rate in the share of tertiary educated people (as % of POP 25-64) in the period 2007 and 2017***". On average, regressions indicate **a positive and significant correlation between the growth rate in the share of tertiary educated people in that period and ERDF investments in infrastructures for education.** Indeed, the coefficient on the policy variable is always statistically significant both when the policy variable is measured in million euro (Columns 1-7) and in logarithm (Column 8-10). In addition, the significance of the correlation between the two variables also remained when excluding the three regions investing more than EUR 100 Million in that ERDF instrument (Column 7).

Table IV.7 - Hypothesis 2: OLS regressions. The dependent variable is the "Growth rate in the share of tertiary educated people (as % of POP 25-64) in the period 2007 and 2017."

	The ERDF policy variable is in Million EUR							The ERDF policy variable is in logarithm		
	(1)	(2)	(3)	(4)	(5)	(6)	No outliers (7)	(8)	(9)	(10)
ERDF Policy variable	**0.0005*** (0.0001)**	**0.0005*** (0.0001)**	**0.0003* (0.0002)**	**0.0006*** (0.0001)**	**0.0005*** (0.0002)**	**0.0005*** (0.0001)**	**0.0003** (0.0002)**	**0.0095*** (0.002)**	**0.0088*** (0.002)**	**0.010*** (0.002)**
Initial share of POP with tertiary education in 2007 (denominator is POP 25-64)		0.084 (0.064)	0.161** (0.069)	-0.001 (0.097)	-0.047 (0.120)	0.012 (0.066)	0.202*** (0.066)		0.091 (0.063)	-0.017 (0.065)
Initial level of the GERD in the region in the government and higher education sector in 2007 as % of GDP		-1.747 (1.835)	-1.496 (1.772)	-1.378 (1.839)	-1.641 (1.806)		-1.968 (1.786)		-1.626 (1.833)	
GERD variation in the government and higher education sector between 2007 and 2017		-5.025 (3.032)	-3.632 (2.991)	-5.522* (3.008)	-7.849** (3.384)		-2.794 (2.991)		-5.650* (3.110)	
Initial level of the GERD in the region in the business sector in 2007 as % of GDP						0.491* (0.266)				0.719** (0.277)
GERD variation in the business sector between 2007 and 2017						1.793* (1.004)				1.950** (0.990)
EU13			0.026** (0.011)							
Convergence region				-0.0199 (0.013)						
Constant	0.068*** (0.004)	0.061*** (0.011)	0.033* (0.017)	0.087*** (0.022)	0.055*** (0.013)	0.058*** (0.010)	0.025 (0.017)	0.067*** (0.004)	0.058*** (0.010)	0.053*** (0.010)
Type of territory fixed effects	NO	NO	NO	NO	YES	NO	NO	NO	NO	NO
N of Observations	103	91	91	91	91	98	88	103	91	98
R-squared	0.12	0.18	0.23	0.21	0.33	0.15	0.21	0.12	0.18	0.16
P-value F-test	0.0004	0.0044	0.003	0.002	0.0000	0.001	0.0000	0.001	0.0023	0.0002

This table reports the regression results by using the Growth rate in the share of tertiary educated people (as % of POP 25-64) in the period 2007 and 2017 as a dependent variable and the ERDF expenditure in infrastructures and investments for education in the period 2007-2013 as a policy variable. When the ERDF policy variable is measured in logarithm, not to lose observations, the zero value was retained for those regions with EUR 0 of expenditures (actually, the log of 0 does not exist). Moreover, negative logarithm values (i.e., ERDF expenditure less than EUR 1 M) were treated as zeros and did not alter the policy variable's distribution too much. Indeed, the log goes to -infinity for values less than EUR 1, increasing the original distance between those regions investing just above EUR 1 Million and those investing just below that threshold. Columns 7 reports specifications without considering outliers, i.e. the NUTS2 regions PL12, PL63, and EE00. Robust standard errors in parenthesis; *p<0.10, ** p<0.05,***p<0.01.

Source: Authors.

The same results (not reported here) held true when the "*growth rate in the number of tertiary educated persons employed in science and technology*" was employed as an alternative outcome variable.[94] Apart from the ERDF instrument, the other context variables that positively and significantly contributed to the growth in the number of tertiary educated persons (and employment in science and technology) are the initial level (in 2007) and the growth rate (2007-17) of the R&D in the business sector. Regions with more advanced industrial fabric and investing in R&D in the business sector experienced higher growth rates in the number of tertiary educated people employed in S&T, probably because of higher levels of skill demand by firms.[95]

III.1 Hypothesis 3

The third hypothesis we tested states that:

Regions investing a larger share of funds in RTO, science-industry collaborations or centre of excellence (either infrastructures or activities) experienced an increase in the level of patent applications and/or other IPRs and public-private co-publications. This holds true in particular in those regions with a high concentration of funds among beneficiaries and in regions with a more mature R&I system.

In line with the statement, three different regression models, each one with a different outcome variable, were performed to verify such a hypothesis. The outcome variables we examined were (Table IV.8 -):[96]

1. the growth rate in the number of patents in the period 2008 – 2016;
2. the growth rate in the number of European Union Trademark (EUTM) applications in the period 2007 - 2015;[97]
3. the growth rate in the number of regional public-private co-publications in the period 2008-2015.

The ERDF policy variable the hypothesis focuses on is the "*ERDF regional expenditure in infrastructures for research and in private-public collaborative R&D projects involving firms in the period 2007- 2013*. Specifically, we considered the ERDF expenditure in the following beneficiaries: (i) Research and Technology Organisations (RTO); (ii) Enterprises; (iii) Clusters; (iv) Science Parks; (v) Consortia; (vi) Competence and/or excellence centres. As before, the amount of ERDF expenditure in the regression analysis was treated both in million euro and in logarithm.

The influence of the regional context on the outcome variables was captured through six context variables (controls) listed in the last column of Table IV.8 - , where the rationale behind their selection is explained. Table IV.9 - reports the descriptive statistics of all the variables used to test hypothesis 3.

[94] The correlation coefficient between the two dependent variables. i.e., the Growth rate in the share of tertiary educated people (as % of POP 25-64) and the Growth rate in the number of tertiary educated persons employed in science and technology was 0.74, which was statistically significant at 1% level.

[95] As an additional proxy of the regional R&I system/industrial fabric, we also employed the per-capita GDP in PPS and its growth rate. The GDP was never statistically significant.

[96] Data on patents are from Patstat and, at the time of writing, data are only available up to 2016. Data on EUTM and Private-public co-publication are from Eurostat and, at the time of writing, they are fully available up to 2015.

[97] Data on EUTM are from Eurostat and, at the time of writing, data are only available up to 2015

Table IV.8 - Hypothesis 3: Variables entering the model

Dependent variable – outcome (label in the regression model)		ERDF Policy variable - input (label in the regression model)		Context variables - Controls (label in the regression model)	
1	**Growth rate in the number of patents in the period 2008 – 2016** (GR_N_patents_2008_2016)	1	ERDF regional expenditure in infrastructures for research and private-public collaborative R&D projects in selected beneficiaries in 2007- 2013. Specifically, we considered the ERDF expenditure in the following beneficiaries: • Research and Technology Organisations (RTO); • Enterprises; • Clusters; • Science Parks; • Consortia; • Competence and/or excellence centres.	1	• **Initial number of patent applications in 2008 in log** (ln_N_patents_2008) • **Initial number of EUTM in 2007 in log** (ln_N_EUtrademarks_2007) • **Initial number of private-public co-publications in 2008 in log** (ln_N_pubpri_copublica_2008**)**
				2	• **Initial level of the total GERD in the region (all sectors) in 2007 as % of GDP** (GERD_all_sectors_GDP_2007) • **Initial level of the GERD in the region in the business sector in 2007 as % of GDP** (GERD_Business_GDP_2007)
2	**Growth rate in the number of European Union Trademark (EUTM) applications in the period 2007 - 2015** (GR_N_EUtrademarks_2007_2015)		We employ the ERDF policy variable in three different measures: • Million Euro • log (of Million EUR)	3	• **Variation of the total regional GERD (all sectors) as % of GDP in 2007-2014** (VAR_GERDAllSectors_GDP_2007_2014). • **Variation of the regional GERD in the business sector as % of GDP in 2007 -2014** (VAR_GERDBusiness_GDP_2007_2017). *Note: these variables are used to capture the R&I maturity of the regional system*
3	**Growth rate in the number of public-private co-publications in the period 2008 - 2015** (GR_N_pubpri_copublica_2008_2015) *Note: Private-public co-publication data are fully available up to 2015.*			4	• **Average ERDF expenditure in infrastructures for research and private-public collaborative R&D projects per beneficiary in log (ERDF/ N of beneficiaries** (ln_AvgERDF_21_12_selec_ben_EUR) *Note: it captures the ERDF concentration of funds in this policy instrument*
				5	• **ERDF expenditure in other cohesion policy themes of expenditures targeted to enterprises (i.e., in themes 03,04,07, and 09) in log** (ln_ERDFexp_OP_cod03_04_07_09)

Table IV.9 - Hypothesis 3: summary statistics

	VARIABLE	N of OBS	MEAN	STD. DEV.	MIN	MAX
	DEPENDENT VARIABLE – OUTCOME					
1	*Growth rate in the number of patents in the period 2008 – 2016*	104	0.479	1.862	-0.63	11.87
2	*Growth rate in the number of European Union trademark (EUTM) applications in the period 2007 - 2015*	104	1.366	1.534	-0.21	10.5
3	*Growth rate in the number of public - private co-publications in the period 2008 - 2015*	79	0.045	0.416	-0.67	2.1
	ERDF POLICY VARIABLE – INPUT					
	ERDF regional expenditure in infrastructures for research and private-public collaborative R&D projects in selected beneficiaries					
	… in Million EUR	104	36.50	60.03	60.027	285.1107
	… in natural log (Ln)	80	2.828	1.690	-1.449	5.653
	CONTEXT VARIABLE – CONTROLS					
1	*Initial number of patent applications in 2008 (in log)*	104	3.793	1.784	0	7.764
	Initial number of EUTM in 2007 (in log)	104	4.183	1.364	1.386	7.471
	Initial number of private-public co-publications in 2008 (in log)	79	3.987	1.380	1.099	6.922
2	*Initial level of the total GERD in the region (all sectors) in 2007 as % of GDP*	104	0.011	0.010	0.0009	0.067
	Initial level of the GERD in the region in the business sector in 2007 as % of GDP	99	0.006	0.007	0.0001	0.0409
3	*Variation of the total regional GERD (all sectors) as % of GDP in the period 2007-2014*	104	0.0024	0.0037	-0.0192	0.015

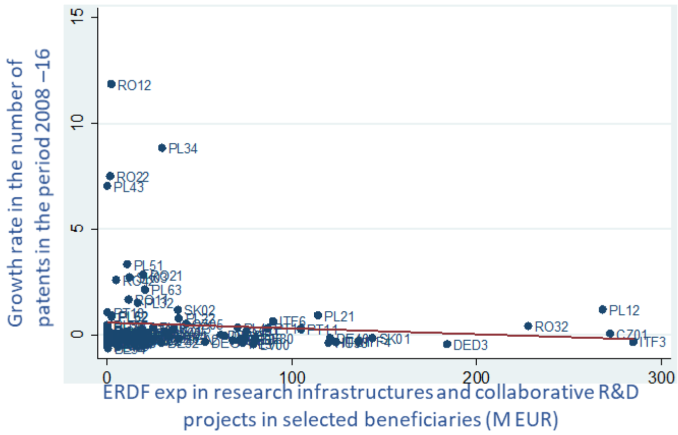
	VARIABLE	N of OBS	MEAN	STD. DEV.	MIN	MAX
	Variation of the regional GERD in the business sector as % of GDP in the period 2007 -2014	99	0.002	0.004	-0.0191	0.0145
4	*Average ERDF expenditure in infrastructures for research and in private-public collaborative R&D projects per beneficiary (in log)*	80	14.15	1.258	10.98	17.21
5	*ERDF expenditure in other cohesion policy themes of expenditures targeted to enterprises (i.e., in themes 03,04,07, and 09) (in log)*	103	19.54	1.746	16.08	22.16
6	*Type of Territory…*					
	… Leader	104	0.038	0.193	0	1
	… Strong	104	0.135	0.343	0	1
	…Moderate +	104	0.269	0.446	0	1
	…Moderate -	104	0.144	0.353	0	1
	…Modest +	104	0.278	0.451	0	1
	… Modest -	104	0.135	0.343	0	1

The analysis of hypothesis 3 started with the regression models having the ***"growth rate in the number of patents in the period 2008 –16***" as a dependent variable. The average value of this variable in our sample was 48%: four regions experienced an increase in the number of patents higher than 500% [RO12 – Centru (1,200%); PL34 – Podlaskie (880%); RO22 – Sud-est (750%); PL43 – Lubuskie (700%)];[98] in contrast, there are a set of regions located in mainly in Germany, Italy, UK, Czechia, and Belgium that recorded negative growth rates (Figure IV.5, Panel A).

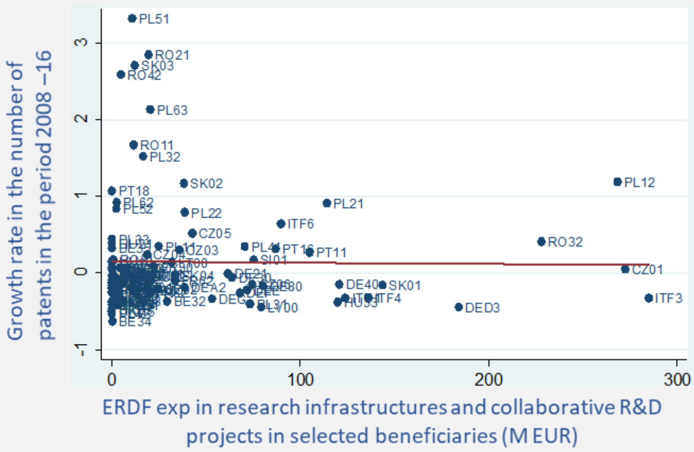
Figure IV.5 offers a preliminary inspection of the **relationship between the growth rate in the number of patents and the regional ERDF expenditure in infrastructures for research and private-public collaborative R&D projects**. It suggests that **there was no association between these two variables**.

Figure IV.5 Hypothesis 3: Two-way relationship between the "Growth rate in the number of patents in the period 2008 –2016" and the ERDF intervention "ERDF expenditure in infrastructures for research and in private-public collaborative R&D projects in selected beneficiaries in the period 2007-2013"

Panel A: all sample (n = 104)



Panel B: restricted sample, no outliers (n = 100)



The regression analysis further corroborates this finding in the following: the regression coefficient associated with this type of ERDF instrument is never statistically significant. Therefore, there is no evidence that ERDF investments in research and private-public

[98] For instance, the Romanian region of Centru (RO12) had a number of patents equal to 1 in 2008 and 17 in 2016.

collaborative R&D projects contributed to the production of patents in that period.[99] **The main driver of patents' growth were the R&D investments carried out by firms and the maturity of the R&I industry system** in the region as proxied by the initial level (in 2008) of regional R&D investments in the business sector (Table IV.10 - , columns 4-8 and columns 12-13). The concentration of funds among beneficiaries played no role in the growth of patents (Column 5).[100]

[99] As additional and alternative dependent variable, we also used the growth rate in the share of patents per million inhabitants in the same period 2008-2016 instead of the pure growth rate in the number of patents. Results did not change. Indeed, the correlation coefficient between these two dependent variables was 0.99 (p-value < 0.01).

[100] For the sake of completeness, we also tested whether our ERDF policy instrument had an indirect link with the rate of growth in the number of patents via the R&D expenditure in the business sector. Our hypothesis was that the ERDF policy instrument positively influenced the R&D expenditure variation in the business sector and, through this channel, had an indirect impact on patents. The regression analysis rejected any statistically significant link between our ERDF policy instrument and the increase of business R&D expenditure at the NUTS2 level during the decade 2007-2017

Table IV.10 - Hypothesis 3: OLS regression. The dependent variable is the "Growth rate in the number of patents in the period 2008 –2016."

	The ERDF policy variable is in Million EUR								The ERDF policy variable is in logarithm			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	No outliers (8)	(10)	(11)	(12)	No outliers (13)
ERDF Policy variable	-0.003 (0.002)	-0.007 (0.005)	-0.002 (0.0015)	-0.002 (0.0014)	-0.0018 (0.0018)	-0.0017 (0.0017)	-0.0007 (0.0023)	-0.0007 (0.0010)	-0.060 (0.087)	-0.065 (0.076)	-0.051 (0.078)	0.035 (0.047)
ERDF Policy variable (squared)		0.00002 (0.00002)										
Initial number of patent applications in 2008 (in log)			- 0.611*** (0.188)	- 0.658*** (0.200)	- 0.730*** (0.262)	- 0.679*** (0.244)	- 0.863*** (0.327)	-0.210*** (0.064)		-0.612*** (0.190)	- 0.662*** (0.200)	-0.248** (0.103)
Initial level of the total GERD in the region (all sectors) in 2007 as % of GDP			16.50 (12.99)							15.96 (13.12)		
Variation of the total regional GERD (all sectors) as % of GDP in the period 2007-2014			26.81 (25.01)							30.08 (24.65)		
Initial level of the GERD in the region in the business sector in 2007 as % of GDP				41.40* (22.93)	47.28 (31.96)	41.34** (22.47)	37.61* (20.63)	12.04 (8.090)			42.43* (23.13)	15.70** (7.563)
Variation of the regional GERD in the business sector as % of GDP in the period 2007 -2014				48.53** (23.18)	58.42 (46.77)	50.58** (24.73)	64.87** (30.65)	26.71** (11.34)			49.40* (23.18)	31.46** (12.33)
Average ERDF exp in infrastructures for research and collaborative R&D projects per beneficiary (in log)					-0.252 (0.346)							
ERDF expenditure in other cohesion policy themes of						-0.037	0.052	0.060				0.009

	The ERDF policy variable is in Million EUR								The ERDF policy variable is in logarithm			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	No outliers (8)	(10)	(11)	(12)	No outliers (13)
expenditures targeted to enterprises (codes 03,04,07,09)						(0.145)	(0.116)	(0.060)				(0.063)
Constant	0.581** (0.234)	0.647** (0.273)	2.635*** (0.785)	2.701*** (0.801)	6.604 (5.437)	3.483 (3.504)	2.498 (2.804)	-0.311 (1.340)	0.613* (0.329)	2.685*** (0.845)	2.747*** (0.864)	0.837 (1.406)
Type of territory fixed effects	NO	NO	NO	NO	NO	NO	YES	NO	NO	NO	NO	YES
N of Observations	104	104	104	99	76	98	98	94	104	104	99	94
R-squared	0.008	0.01	0.29	0.30	0.33	0.30	0.36	0.24	0.004	0.29	0.30	0.29
P-value F-test	0.13	0.28	0.016	0.014	0.08	0.02	0.04	0.000	0.49	0.01	0.01	0.002

*This table reports the regression results by using the Growth rate in the number of patents in the period 2008 –2016 as a dependent variable and the ERDF regional expenditure in infrastructures for research and private-public collaborative R&D projects in selected beneficiaries in the period 2007- 2013 as a policy variable. When the ERDF policy variable is measured in logarithm, not to lose observations, the zero value was retained for those regions with EUR 0 of expenditures (actually, the log of 0 does not exist). Moreover, negative logarithm values (i.e., ERDF expenditure less than EUR 1 M) were treated as zeros and not to alter the distribution of the policy variable too much. Indeed, the log goes to -infinity for values less than EUR 1, increasing the original distance between those regions investing just above EUR 1 Million and those investing just below that threshold. Columns 8 reports specifications without considering outliers, i.e., the NUTS2 regions PL43, PL34. RO12; RO22. Robust standard errors in parenthesis; *p<0.10, ** p<0.05,***p<0.01.*

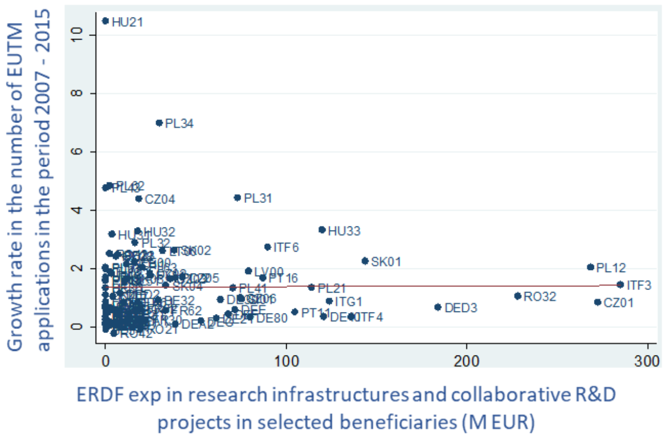
Source: Authors.

Differently from patents, there is evidence that the above **ERDF policy instrument positively and significantly correlated with other types of innovation outcomes such as the growth rate in the number of European Union trademark (EUTM) applications in the period 2007 – 2015.** Figure IV.6 visualises the relations between the two variables, while Table IV.11 - reports the full regression analysis. Beyond the ERDF expenditure in infrastructures for research and in private-public collaborative R&D projects, the other determinants of the EUTM evolution over time were the total regional expenditure in R&D (GERD), including the R&D expenditure in the business sector and other ERDF business support measures recorded in other Cohesion policy themes targeted to enterprises (i.e., in codes 03, 04, 07, and 09).

In addition, we also performed a regression analysis using the **growth rate in the number of public-private co-publications in the period 2008 – 2015** as an outcome variable. The analysis (not reported here) suggested that there was no effect of the regional ERDF expenditure in infrastructures for research and private-public collaborative R&D projects on that outcome variable.

Figure IV.6 Hypothesis 3: Two-way relationship between the "Growth rate in the number of European Union Trademark (EUTM) applications in the period 2007 - 2015" and the ERDF intervention "ERDF expenditure in infrastructures for research and in private-public collaborative R&D projects in selected beneficiaries in the period 2007-2013"

Panel A: all sample (n = 104)



Panel B: restricted sample, no outliers (n = 98)

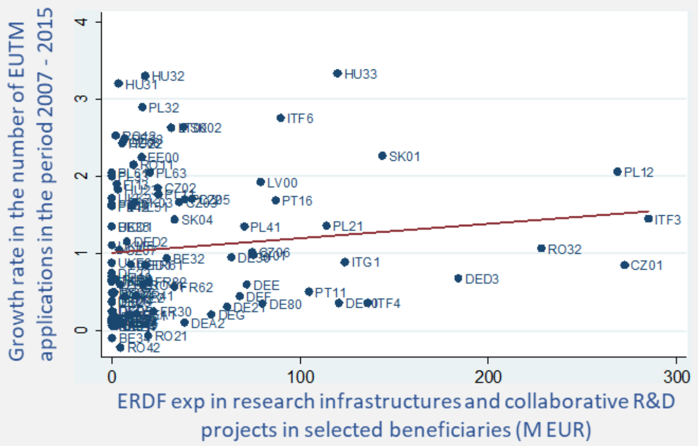


Table IV.11 - Hypothesis 3: OLS regression. The dependent variable is the "Growth rate in the number of European Union Trademark (EUTM) applications in the period 2007 - 2015."

	(1)	(2)	(3)	No outliers (4)	No outliers (5)	No outliers (6)	No outliers (7)	No outliers (8)	(9)	(10)	(11)	(12)	No outliers (13)	No outliers (14)
ERDF Policy variable	**0.002**** **(0.0012)**	**0.003**** **(0.0012)**	**0.003**** **(0.0013)**	**0.003***** **(0.001)**	**0.003***** **(0.001)**	**0.002*** **(0.0013)**	**0.0018*** **(0.0010)**	**0.0025**** **(0.0010)**	**0.179***** **(0.059)**	**0.163***** **(0.061)**	0.049 (0.085)	**0.182*** **(0.106)**	**0.097**** **(0.052)**	**0.098*** **(0.056)**
Initial number of EUTM applications in 2007 (in log)	-0.679*** (0.149)	-0.747*** (0.161)	-0.677*** (0.174)	-0.387*** (0.061)	-0.436*** (0.061)	-0.430*** (0.073)	-0.400*** (0.065)	-0.364*** (0.064)	-0.585*** (0.105)	-0.620*** (0.108)	-0.521*** (0.083)	-0.574*** (0.104)	-0.40*** (0.072)	-0.367*** (0.079)
Initial level of the total GERD in the region (all sectors) in 2007 as % of GDP	-3.863 (8.883)			-5.897 (5.969)					-3.045 (6.525)					
Variation of the total regional GERD (all sectors) as % of GDP in the period 2007-2014	64.13* (33.55)			41.40** (17.41)					54.50 (38.86)					
Initial level of the GERD in the region in the business sector in 2007 as % of GDP		11.55 (18.18)	18.39 (18.32)		4.020 (10.58)	9.116 (15.12)	13.89 (11.00)	9.169 (10.51)		8.445 (14.99)	7.912 (13.75)	57.87** (28.98)	22.32 (14.48)	21.86** (11.18)
Variation of the regional GERD in the business sector as % of		63.79 (42.91)	45.23 (41.98)		39.59** (19.98)	46.52 (40.28)	37.02** (18.32)	19.41 (18.29)		32.42 (36.97)	-7.375 (46.11)	27.74 (33.67)	41.75 (34.51)	13.65 (30.89)

	(1)	(2)	(3)	No outliers (4)	No outliers (5)	No outliers (6)	No outliers (7)	No outliers (8)	(9)	(10)	(11)	(12)	No outliers (13)	No outliers (14)
GDP in the period 2007 - 2014														
Initial level of the GERD in the region in the business sector in 2007 as % of GDP ***ERDF Policy variable**												-12.17 (9.82)		
Average ERDF exp in infrastructures for research and collaborative R&D projects per beneficiary (in log)						0.070 (0.102)					0.307* (0.182)			
ERDF expenditure in other cohesion policy themes of expenditures targeted to enterprises (codes 03,04,07,09)							0.161*** (0.043)	-0.004 (0.054)				0.193** (0.094)	0.164*** (0.049)	0.026 (0.057)
Constant	4.007 (0.659)	4.274*** (0.692)	3.366*** (0.681)	2.619*** (0.303)	2.789*** (0.290)	1.757 (1.525)	-0.577 (1.000)	2.227** (1.122)	3.156*** (0.540)	3.404*** (0.557)	-0.997 (2.423)	-.0766 (1.948)	-0.843 (1.090)	1.467 (1.213)
Type of territory fixed effects	NO	NO	YES	NO	NO	NO	NO	YES	NO	NO	NO	NO	NO	YES
N of Observations	104	99	99	98	93	72	92	92	80	76	76	76	72	72

	(1)	(2)	(3)	No outliers (4)	No outliers (5)	No outliers (6)	No outliers (7)	No outliers (8)	(9)	(10)	(11)	(12)	No outliers (13)	No outliers (14)
R-squared	0.40	0.41	0.54	0.40	0.42	0.40	0.48	0.62	0.43	0.43	0.48	0.48	0.47	0.59
P-value F-test	0.0000	0.000	0.000	0.0000	0.000	0.000	0.0000	0.0000	0.000	0.000	0.000	0.000	0.000	0.000

*This table reports the regression results by using the Growth rate in the number of European Union Trademark (EUTM) applications in the period 2007 - 2015 as a dependent variable and the ERDF regional expenditure in infrastructures for research and private-public collaborative R&D projects in selected beneficiaries in the period 2007- 2013 as a policy variable. Columns 4-8 and 13-14 report specifications without considering outliers, i.e., the NUTS2 with a growth rate in EUTM application higher than 400%: HU21; PL31, PL34, PL62. Robust standard errors in parenthesis; *p<0.10, ** p<0.05,***p<0.01.*

Source: Authors.

The Box below summarises the main findings related to Hypothesis 3.

As regards the dependent (outcome) variables, we tested the impact of the ERDF instrument “expenditure in infrastructures for research and private-public collaborative R&D projects involving enterprises” on two sets of variables:

- “hard” innovation outcomes proxied by (i) the growth rate in the number of patents between 2008 and 2016; (ii) the growth rate in the number of patents between 2008 and 2016 per million inhabitants; (iii) the growth rate in the number of public-private co-publications in the period 2008 – 2015;
- “soft” innovation outcomes proxied by the growth rate in the number of EUTMs applications between 2007 and 2015.

As far as the “hard” innovation outcomes are concerned and conditional to our sample, the econometric analysis suggests the following results:

1. **There was no significant relationship between the ERDF instrument and the growth rate in the number of patent applications in the period under scrutiny**. This holds true when:

- Considering different model specifications with different context variables and controlling for the average ERDF investment in that policy instrument (e.g. amount of ERDF expenditure/N of beneficiaries);
- Removing group of countries (e.g., with or without regions with 0 EUR invested in the ERDF policy instrument) and/or outliers;
- Considering ERDF investments in infrastructure for research and in private-public collaborative R&D projects as two separate policy instruments (not reported in the previous tables);
- Considering as alternative outcome variables “the growth rate in the number of patents per million inhabitants in the period 2008-2016” or the “growth rate in the number of public-private co-publications” during the period 2008 – 2015.

2. **The growth rate in the number of patents was mainly driven by regional investments in expenditure for R&D in the business sector** (as % of GDP).

As far as the “soft” innovation outcomes are concerned and conditional to our sample, the econometric analysis points to the following results:

3. Differently from patents**, there is evidence that ERDF expenditure in infrastructures for research and in private-public collaborative R&D projects involving enterprises positively and significantly correlated with the growth rate in the number of EUTMs** applications in the period 2007 – 2015;

4. In addition to the ERDF instrument above, the **additional regional drivers of the growth rate in the number of EUTMs were**:

- the level of the ERDF expenditure targeted to enterprises, specifically in the expenditure codes 03,04,07, and 09;
- the investments in expenditure for R&D in the business sector (as % of GDP);

5. **Other context variables** such as the type of R&D territory (based on the cluster analysis) or being based in EU13/EU15 **played no role in shaping the relationship** between the ERDF instrument and the growth rate in the number of EUTMs applications

ANNEX V. Overview of core and common indicators on RTD

In the framework of the past 2007-2013 Cohesion Policy, monitoring and evaluation activities were asked to be performed by regulation 1083/2006 (Art 37.c). The relevance of the indicators is “to make it possible to measure the progress of each Priority Axis of the Operational Programme in relation to the baseline situation and the achievement of the targets”. For each result and output indicator, the baseline and target values were required to be established by the Managing Authorities. The progress towards achieving targets established for each indicator has to be reported by the Member States in the Annual Implementation Report (as required by Art 29 of the EC Reg. 1083/2006) and the financial execution tables.

While result and output indicators were mandatory, impact indicators were strongly encouraged but not formally required. Member States were free to identify and use the most appropriate indicators according to Programme objectives and the programming period's strategic focus. While providing the Member States with this responsibility, the European Commission also strongly encouraged them to use a limited number of “core indicators” (output and result), aggregated and compared at the EU level.[101] Out of the full list of 56 core indicators indicated by the European Commission, three are directly and explicitly referred to research and technological development (RTD), i.e.:

- ‘number of RTD projects (4)’
- ‘number of cooperation projects enterprises – research institutions (5)’
- ‘research jobs created (preferably 5 years after projects start) (6)’.

Additionally, during the 2014-2020 programming period, the Commission recommended using an additional 46 common indicators, some of which had already been used by many OPs in the previous programming period. The common indicators relevant to the RTD investments are:

- ‘number of new researchers in supported entities (24)’,
- ‘number of researchers working in improved research infrastructure facilities (25)’,
- ‘number of enterprises cooperating with research institutions (26)’
- ‘private investments matching public support in innovation or R&D projects (27)’.

In addition to these, each OP included various programme-specific indicators selected by the Managing Authorities to keep track of the achievements concerning the specific objectives set in the programme.

Previous evaluation studies have stressed that the achievement indicators of the regional monitoring systems have some limitations: they are generally not available at the level of individual projects or policy instruments and could refer to projects funded under other

[101] The concept of core indicators was first used in the EC Working Document No. 2, providing guidelines on the setting up of indicator systems for monitoring and evaluation. European Commission (2006), Working Document No. 2: Indicative guidelines on evaluation methods: monitoring and evaluation indicators, DG Regio, Brussels.

categories of expenditure than 01 and 02; 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; being focused on the programme outputs and results (and not on the impact), the achievement indicators are not sufficient for a complete evaluation of effectiveness.

Despite this, these indicators are a source of evidence (even the only one for some OPs) to have some signs of what has been reported as having been achieved by the OPs. The following table provides a few quantitative indicators (core and common) for the 53 OPs covered by the evaluation and related to the outputs and results reported on the ERDF investments in the RTD field.

Table V.1 - Achievement indicators and degree of achievement of the target (in %, between parenthesis) of RTD core and common indicators

	CORE INDICATORS			COMMON INDICATORS			
	Number of RTD projects	Number of cooperation project enterprises-research institutions	Research jobs created	Number of new researchers in supported entities	Number of researchers working in improved research infrastructure facilities	Number of enterprises cooperating with research institutions	Private investment matching public support in innovation or R&D projects
2007BE161PO001	96 (53.3%)	2 (20%)	229 (127%)	-	-	-	-
2007BE162PO003	91 (65.4%)	13 (130%)	138 (138%)	-	-	-	-
2007CZ161PO004	1,031 (49%)	66 (47%)	-	-	-	-	-
2007CZ161PO012	7 (14.5%)	437 (336%)	2,689 (107%)	-	192 (7.6%)	-	-
2007CZ162PO001	-	11 (73.3%)	41 (49%)	-	-	-	-
2007DE161PO001	519 (94%)	156 (78%)	-	-	-	-	220,000,000 (104%)
2007DE161PO002	527 (target=0)	435 (target =0)	784 (target=0)	-	-	-	-
2007DE161PO003	339 (target=0)	156 (104%)	1,201 (target=0)	-	-	-	-
2007DE161PO004	1,746 (99%)	172 (target=0)	664 (87.3%)	-	-	-	-
2007DE161PO007	2,685 (76%)	36 (211%)	11 (1.8%)	-	-	-	-
2007DE162PO001	15 (21.7%)	91 (target=0)	-	-	-	-	264,258 (2.5%)
2007DE162PO003	5 (125%)	10 (90%)	809 (157%)	-	-	19 (105%)	-
2007DE162PO004	236 (43%)	94 (target=0)	772 (target=0)	-	-	-	-
2007DE162PO007	-	-	-	-	-	-	-
2007EE161PO001	1,664 (target=0)	-	-	-	-	398 (663%)	83 (215%)
2007ES162PO002	6,431 (98%)	1,753 (151%)	-	-	-	-	-
2007ES162PO004	1,445 (35%)	-	-	-	-	-	-
2007ES162PO005	234 (124%)	34 (178%)	-	-	-	-	-
2007ES162PO006	761	0	-	-	-	-	-

	CORE INDICATORS			COMMON INDICATORS			
	Number of RTD projects	Number of cooperation project enterprises-research institutions	Research jobs created	Number of new researchers in supported entities	Number of researchers working in improved research infrastructure facilities	Number of enterprises cooperating with research institutions	Private investment matching public support in innovation or R&D projects
	(69.2%)	(target=0)					
2007ES162PO010	1,781 (109%)	420 (98%)	-	-	-	-	-
2007ES16UPO001	13,612 (47.4%)	1,746 (57%)	-	-	-	-	-
2007ES16UPO003	7,687 (103%)	0 (target=0)	-	-	-	-	-
2007FI162PO001	0.25 (71%)	0 (target=0)	639 (80%)	-	-	-	-
2007FR162PO001	146 (112%)	3,810 (2,721%)	15 (5%)	-	-	-	-
2007FR162PO011	244 (122%)	101 (101%)	72 (90%)	-	-	-	-
2007FR162PO015	-	-	-	-	-	-	-
2007FR162PO016	238 (119%)	13 (100%)	1,020 (114%)	-	-	-	-
2007FR162PO017	500 (104%)	64 (30.4%)	48 (4.8%)	-	-	-	-
2007FR162PO020	42 (116%)	128 (1,600%)	-	-	-	-	-
2007FR162PO021	93 (132%)	78 (108%)	73 (91%)	-	-	-	-
2007HU161PO001	3,028 (target=0)	544 (target=0)	4,556 (target=0)	4,583.66 (206%)	-	-	-
2007IE162PO002	-	-	819,5 (96.7%)	-	-	-	-
2007IT161PO006	1,000 (125%)	246 (106%)	623 (37.8%)	-	-	-	-
2007IT162PO002	228 (109%)	144 (99.3%)	853 (100.4%)	-	-	-	-
2007LT161PO002	1,530 (588%)	32 (target=0)	299 (target=0)	-	-	-	-
2007LV161PO001	120 (60%)	46 (92%)	203 (406%)	-	-	-	-
2007PL161PO001	555 (33%)	439 (48.7%)	1,585 (32.3%)	-	-	-	-
2007PL161PO002	-	-	-	-	-	-	-
2007PL161PO003	25 (38.4%)	4 (25%)	53 (47.3%)	-	-	-	-
2007PL161PO010	77 (51.3%)	0 (target=0)	63.73 (106%)	-	-	-	-

	CORE INDICATORS			COMMON INDICATORS			
	Number of RTD projects	Number of cooperation project enterprises-research institutions	Research jobs created	Number of new researchers in supported entities	Number of researchers working in improved research infrastructure facilities	Number of enterprises cooperating with research institutions	Private investment matching public support in innovation or R&D projects
2007PL161PO011	81 (32.4%)	1 (0.5%)	0 (target=0)	-	-	-	-
2007PL161PO013	1 (10%)	0 (target=0)	4 (8%)	-	-	-	-
2007PT161PO001	27 (target=0)	0 (target=0)	0 (target=0)	-	-	-	-
2007PT161PO002	47 (9%)	0 (target=0)	0 (target=0)	-	-	-	-
2007PT161PO003	23 (8.5%)	0 (target=0)	13 (6.5%)	-	-	-	-
2007RO161PO002	531 (88.5%)	44 (22%)	1,042 (208%)	45 (150%)	-	-	193.89 (114%)
2007SI161PO001	655 (284%)	-	-	5,195.94 (546%)	-	-	-
2007SK16UPO001	396 (25.7%)	260 (23%)	25 (5.2%)	-	16,307 (99.1%)	-	-
2007UK161PO002	19 (target=0)	974 (189%)	961 (target=0)	-	-	-	-
2007UK161PO003	10 (target=0)	-	140 (target=0)	-	-	427 (87%)	-
2007UK162PO001	-	2,628 (438%)	-	-	-	-	-
2007UK162PO008	33 (target=0)	29 (target=0)	-	-	-	1,266 (84.4%)	-
2007UK162PO009	713 (57.5%)	-	29 (target=0)	-	-	599 (74.7%)	-
All 53 OPs (average degree of achievement)	51,274.24 (75.6%)	15,217.15 (149%)	20,475.5 (116%)	9,824.6 (307%)	16,499 (87%)	2,709 (94%)	220,264,534.39 (99.4%)

Note: the percentage of achievement of the target has been calculated as the ratio between the actual achievement at the end of the programming period and the target value of each core and common indicator. This means that if the percentage between parenthesis is lower than 100%, the target has not been reached; if it is equal to 100%, the target has been achieved if it is higher than 100%, the target has been exceeded.

Source: Authors' elaboration based on DG Regio "Ex post evaluation of Cohesion Policy programmes 2007-2013, focusing on the European Regional Development Fund (ERDF) and Cohesion Fund (CF) – Work Package Zero: Data collection and quality assessment."

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KN-01-21-530-EN-N

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