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

Case study report

Portugal

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LIST OF ABBREVIATIONS

ANI	National Innovation Agency
BERD	Business enterprise expenditure on R&D
CA	Contribution analysis
CCDR(s)	Regional Coordination and Development Commission(s)
CERN	European Organisation for Nuclear Research
CMU	Carnegie Mellon University
COMPETE	Operational Programme for Competitiveness Factors
CSF III	Community Support Framework III (2000-2006)
CSIL	Centro Studi Industria Leggera (Centre for Industrial Studies)
DGEEC	Directorate General of Education and Science Statistics of the Ministry of Education and Science
EC	European Commission
ERA	European Research Area
ERC	European Research Council
ERDF	European Regional Development Fund
ESF	European Social Fund
ESIF	European Structural and Investment Funds
EU	European Union
FCT	Foundation for Science and Technology
FP	Framework Programmes
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 Technologies
IPCTN	Survey on National Scientific and Technological Potential
MA	Managing Authority

MIT	Massachusetts Institute of Technology
MS	Member State(s)
NRSF	National Reference Strategic Framework
NSTS	National Scientific and Technological System
OECD	Organisation for Economic Co-operation and Development
OP	Operational Programme
p.p.	Percentage point(s)
POPH	Human Potential Operational Programme
R&D	Research and Development
RTD	Research and Technological Development
RTO(s)	Research and Technology Organisation(s)
S3	Smart Specialisation Strategy(ies)
SAESCTN	Support to Entities of the National Scientific and Technological System
SI Innovation	Innovation Incentive System
SI RTD	Support System to Research and Technological Development
SI SME Qualification	SME Qualification and Internationalisation Incentive System
SIAC	Incentive System for Collective Actions
SMEs	Small and Medium Enterprises
STI	Science, Technology and Innovation
ToC(s)	Theory(ies) of Change(s)
TRL	Technology Readiness Level
UT Austin	University of Texas at Austin

EXECUTIVE SUMMARY

BACKGROUND AND GOAL OF THE CASE STUDY

This document is one of seven case studies included in the ex-post evaluation of investments in Research and Technological Development (RTD) activities and infrastructures supported by the European Regional Development Fund (ERDF) in the 2007-2013 period. It focuses on Portugal and, in particular, on the national Operational Programme for Competitiveness Factors (COMPETE OP), providing an in-depth analysis of three specific policy instruments implemented under this OP:

- Research and Technological Development (RTD) projects in all scientific fields led by entities of the national scientific and technological system (individual projects).
- Research and Technological Development (RTD) strategic projects developed in public interest areas led by entities of the national scientific and technological system (individual projects).
- International cooperation RTD projects (individual projects).

This case study investigates whether the ERDF policy mix for RTD achieved its intended objectives and matched or responded to the country's policy challenges. It also looks at whether the selected interventions for RTD activities were effective and according to which mechanisms.

The methodology used is a Contribution Analysis (CA), which builds on the reconstruction of the underlying Theories of Changes (ToCs) of selected policy instruments, testing their validity based on evidence collected. This approach implies disentangling the complex causal relationships between different stages of implementation and the production of results.

The evidence basis includes hard data and information from strategic and programming documents, OP implementation reporting, statistical data, indicators from the monitoring system and other literature, complemented by interviews with representatives of programme managers, beneficiaries and other stakeholders.

The analysis was carried out during the period of September-November 2020. It builds on the evidence available from a previous task, including a comprehensive mapping and classification of projects and beneficiaries funded in 53 operational programmes in 18 Member States under the codes of expenditures #01 and #02 (research activities and infrastructure; please see the First Intermediate Report for more details).

OVERVIEW OF KEY FINDINGS AND CONCLUSIONS

Analysis of the policy context at the national level

Although Portugal was still a follower country in the innovation scoreboard, the period before the 2007-2013 programming stage was a turning point in Science and Innovation policy. The previous decade was characterised by a strong push in scientific policy, with research and human capital becoming two pillars of the convergence and economic development agenda. These policies contributed to significant production and accumulation of human capital and growth of R&D institutions, which was reflected in progress observed in scientific publications, PhD graduates and R&D expenditure. However, from 2004 onwards, an economic crisis exposed the importance of not only reinforcing research capabilities but using them to fuel innovation. Hence, the policy instruments used to fund science were relocated under COMPETE OP. A policy shift repositioned the support framework to focus the science-policy on three pillars - researchers, R&D institutions and internationalisation, and stimulate collaboration and

business investment in RTD. Hence, the Technology Plan launched in 2005 gained importance and led to a change in innovation policy to accommodate both a science-push effort with a demand-pull traction effect.

By 2007, the Portuguese GERD/GDP level represented 1.12% in 2007 and 1.45% in 2008, compared to 0.7% in 2000, placing Portugal as the fastest catching-up country in terms of innovation indicators. Notwithstanding this progress registered from 2007-2010, those were soon put in jeopardy. By 2011, the international financial crisis had exposed the fragilities of the Portuguese public finances. With a budget deficit, a relatively high public debt and soaring interest rates, Portugal underwent a financial assistance programme led by the International Monetary Fund, which imposed a significant reduction on public expenditure, including public investment. This significantly constrained research organisations and jeopardized the important achievements obtained until then. ERDF and ESF funded programmes became even more important to withstand the progress made and played a major role in smoothing the negative impact on RTD organisations. Specifically, national and regional policy instruments (COMPETE OP and regional OPs) were combined to fund RTD activities and RTD organisations, sustaining and creating existing and novel capabilities in line with the RTD strategy's goals to strengthen the innovation system on three levels: researchers, R&D institutions, and internationalisation. The spectre of instruments mobilised within the policy mix framework had a clear additionality effect, which is illustrated by the level of scientific and technological outputs associated with funded projects and the clear positive impact in the level of Portuguese participation in FP7 and later on H2020.

Achievement of intended effects of the analysed policy instruments (i.e. effectiveness)

The COMPETE operational programme 2007-2013 represented a total investment of around €6.7 billion with an EU contribution through the European Regional Development Fund (ERDF) of about €3.3 billion. The OP played a crucial role in mitigating the effects of the global financial crisis 2007-2008, allowing for continued investment in RTD and innovation activities in the country which otherwise would not have been possible.

The Support to Entities of the National Scientific and Technological System (SAESCTN), allocated under the OP Axis 1, can be seen as the OP most relevant instrument to support Science and Technology policy in the mainland convergence regions. It was the main national source of funding for RTD activities promoted by Higher Education Institutions (HEIs) and Research and Technology Organisations (RTOs) based on the target regions. Under SAESCTN, about 2,600 projects were funded (EUR 335 m of eligible investment, EUR 303 m ERDF contribution).

The three selected policy instruments for an in-depth analysis under the case study have contributed in a relevant way to strengthen and enlarge the national scientific and technological system through the investment in three crucial dimensions: researchers, RTD organisations and internationalisation.

The first policy instrument analysed - **RTD projects led by entities of the scientific and technological system in all scientific fields** – funded on a competitive basis around 1,400 projects (all individual projects and classified as ERDF expenditure category #01 – "R&TD activities in research centres"). It was an important source of funding for many HEIs and RTOs based in the convergence regions to develop high-level scientific activities and create new knowledge. The instrument had an overall positive impact on the scientific production in the target regions (particularly in Norte and Centro), contributing to the development of scientific skills and accumulation of relevant knowledge in the scientific and technological system. The instrument was an important contribution for funded research groups to embrace more ambitious RTD activities

afterwards, and in many cases, to increase their international visibility, although with rather limited results in terms of knowledge transfer to the economy and society at large.

RTD strategic projects developed in areas of public interest led by entities of the scientific and technological system involved the best-performing R&D organisations in Convergence regions to strengthen their capacity and make them competitive on a global scale. The projects supported by this instrument were institutional, structuring the activities of the respective research groups around strategic research plans and aiming at guaranteeing certain basic funding that could leverage the work carried out by the RTD centres. By concentrating resources in a restricted number of research groups, this measure generated results that were considered superior to the average of other OP measures, especially with regards to upgraded scientific skills, increased scientific and technological capacities of the involved actors, internationalisation, growth of the scientific system and (to a lesser extent) enhancement of the innovation systems in the target regions.

The **international cooperation RTD projects** instrument supported 49 projects (classified as ERDF priority theme #01 – "R&TD activities in research centres") involving a national RTD centre and one of the five world reference institutions with which the Portuguese government established cooperation agreements (i.e. the European Organisation for Nuclear Research (CERN), Massachusetts Institute of Technology (MIT), Harvard Medical School, Carnegie Mellon University, and the University of Texas at Austin). Such partnerships allowed national RTD actors to have access to cutting-edge knowledge worldwide, with outstanding opportunities to develop scientific and technological capabilities. They provided an excellent basis for learning processes on how those international reference entities operated and managed science and technology. Overall, the measure demonstrated a strong additionality effect to the ERDF support, funding projects that would otherwise not be pursued, and contributed to a cultural transformation that impacted the Portuguese participation in FP7 and H2020.

Drivers and barriers to success

An array of drivers at various levels can be indicated as having been relevant to the policy instruments' overall good performance under assessment. First, the existence of HEIs and RTOs with good scientific quality, some of which appeared in world rankings, and a significant number of R&D entities that were classified as "excellent" by international peer-review panels. The continuous expansion of the scientific and technological system had already started before the NSRF 2007-2013. This allowed a sustained growth of the national scientific production in all scientific areas and enabled a converging path with the EU average in terms of research and innovation performance during the period considered.

The continuous growth in the human resources allocated to R&D, namely researchers, and the significant investment in R&D infrastructures (particularly in convergence regions) were also structural improvements that favoured the study's measures and projects. It was also a period in which national research actors showed growing capabilities to compete internationally in research projects and integrate scientific consortia and networks.

From an operational point of view, the tradition of competitive allocation of resources through international evaluations of projects and institutions reinforced the investments' selectivity. The capacity and experience demonstrated in general by the applicant entities helped the overall good performance of the projects.

On the other hand, it must be taken into account that despite the progress achieved in this period, R&D expenditure (public and private) was below the European average and that national scientific production continued to have a rather limited global impact. The

financial and economic crisis negatively impacted the assessment measures, mainly in the early years of the NSRF 2007-2013. The difficulties faced by public finances, as well as by public and non-profit entities that were direct beneficiaries of the OP, made it more difficult to ensure the necessary investment to cover the percentage not funded by the ERDF.

Although the measure was strongly oriented towards scientific knowledge production, better overall performance could be expected about the economic and social valorisation of project results. This limitation was due to a number of reasons: restricted production of technological outcomes (e.g. prototypes, pilot plants, patents); weak links between the supported entities and the business community; incipient mechanisms for technology transfer; mismatches between research outcomes and firms' needs, also taking into account the existence of economies in the convergence regions specialised in areas of low or medium-low technological intensity; and overall regulation that did not encourage the exploitation of intellectual property and knowledge transfer.

In particular, the number of patents generated by the scientific system continued to be quite low compared to the EU average (although high-technology patents represented a significant proportion of all patent applications), especially concerning international patents (PCT).

Relevance

The COMPETE OP provided the framework for deploying a comprehensive set of instruments intended to promote the development of the Portuguese national innovation system. The necessary balance between demand-pull dynamics and science push dynamics was achieved to some extent through the combination of instruments dedicated to strengthening capacity building both on firms and research units, but also through the introduction of cooperation inducing instruments to close the gap and mitigate the divide between science and economy.

The various typologies of projects supported under the OP Axis 1 – Knowledge and Technological Development contributed to addressing the main needs identified in the RTD field regarding both activities led by entities of the scientific system (SAESCTN support instrument) and businesses (SI RTD instrument). In particular, the funding of these projects eventually had positive medium- and long-term outcomes on key aspects such as strengthening the skills of scientific institutions and their ability to better cooperate with economic actors; significantly increasing the number of company-led RTD projects (including consortia projects); increasing the number of collective research projects; the expansion of demonstration actions and technology transfer; the creation of RTD centres in companies; a slight increase in activities and number of stakeholders involved in industrial property protection; and higher participation of Portuguese organisations in the European Framework Programme for Research (particularly in the last years of the OP).

The study findings suggest that the instruments deployed were in line with the objectives, being relevant to respond to the scientific and technological system's effective needs. The ERDF played a major role in sustaining and enlarging this system, having had a key intervention amidst the financial crisis in sustaining the results of previous investments and allowing to continue to finance research and technological development activities.

Efficiency

The evidence collected under the study, as well as the conclusions drawn in other assessment exercises, show that the investment of ERDF funding in activities of COMPETE OP Axis 1, and in particular in the support mechanism for entities of the

scientific and technological system (SAESCTN), was most efficient and overall followed international good practices regarding the forms of available support.

The outputs, outcomes and impacts identified in the study show that the ERDF support to the measures under assessment was sufficient to strengthen and enlarge the national scientific and R&D base, suggesting that the instruments mobilised by the OP induced the production of results with efficient use of resources.

Other evaluations of the OP had already concluded that in terms of scientific production (e.g. scientific papers, pilot installations, patents), SAESCTN's projects, including the three instruments assessed in the study - performed better in the number of deliverables per million euros of funding.

Even considering that there were cases of projects approved without financial execution (mainly during the first years of the OP implementation) and that a budget reduction in the SAESCTN took place during the first OP reprogramming action, the financial execution was roughly achieved according to what was initially estimated, allowing the use of the planned contribution from the ERDF.

Sustainability and replicability

The policy instruments included in this analysis are all directed to support scientific organisations. The first two instruments dealt with building and expanding internal competences for research, whereas the third one intended to promote international collaboration and induce a more proactive stance to collaboration. Intended effects occurred to some extent and seemed to be sustainable. Scientific and technological capacity building, development of new key competences, and organisational changes to better support project management and professionally addressing bridge-building with international partners have endured.

Lesser sustainability concerning effective knowledge transfer to the economy and consolidation of international partnerships was also identified. Regarding the former, linking to the economy and establishing dense cooperation patterns to fuel enterprise innovation produced feeble outcomes. About the latter, the discontinuity in terms of funding schemes and the lack of sequential projects hampered the sustainability of effects.

In terms of replicability, these instruments have been replicated over time and also in the context of the current programming period. In particular, the model to foster international partnerships was replicated to new international collaborations (e.g. European Space Agency) and new models (e.g. Atlantic International Research Centre). In general, the three instruments' funding mechanisms can easily be transferred to different regions or countries. Nevertheless, concerning RTD advanced strategies and international collaborative R&D, policy coherence and consistency are required and the presence of advanced research centres and knowledge-based businesses and entrepreneurial culture. It is most likely that only the more advanced regions will have the capacity to launch and sustain a policy instrument such as the RTD international cooperation projects in the long term.

Coherence

The quantitative measurement of the results and the visible effects on the target beneficiaries supports the conclusion that COMPETE ensured coherence in addressing the issues identified ex-ante in fundamental research, applied research, business R&D, technological services, and technology transfer, and high-tech entrepreneurship. The set of instruments selected were also consistent with the objectives supporting the interventions, addressing failures and shortcomings within the national scientific and

innovation systems, and creating the support mechanisms to induce change and transformation.

The territorial scope of the COMPETE operational programme was limited to mainland Portugal's convergence regions (i.e. NUTS II regions of Norte, Centro and Alentejo). In order to ensure the necessary articulation between the national and the regional operational programmes, all these operational programmes (i.e. OPs COMPETE, Norte, Centro and Alentejo) adopted a thematic structure which, although different from one programme to another, allowing the implementation of common support instruments and main typologies of projects in the RTD and innovation fields.

The sharing of competences between COMPETE and regional programmes was established on the following main principles: actions that benefited from management closer to the beneficiaries or were to be implemented under a regional or local intervention logic were supported by regional OPs; actions that required critical thresholds, implied some kind of coordination or resulted from national strategies were funded by COMPETE. Furthermore, bearing in mind the need for coordination that had to be established between the national OP and the OPs of those three regions, particularly as regards the definition of responsibilities and tasks of each programme, a number of criteria were taken into account (non-exhaustive enumeration):

- national COMPETE OP funded, under Axis 1, RTD projects led by entities of the scientific and technological system (SAESCTN), RTD projects led by large and medium-sized companies (SI RTD), and actions to support the Portuguese participation in FP7 (in fact, later funded under the OP Axis 5);
- regional OPs funded scientific and technological infrastructures, including business hosting infrastructures, as well as RTD projects led by small and micro companies;
- funding for business investment incentive systems under Axis 2 (SI Innovation and SI SME Qualification) was provided according to company size: medium and large companies' projects were supported by the national OP, while projects carried out by micro and small companies were funded by regional OPs.

There were synergies with other European objectives and strategies, for example, between the European Social Fund (ESF) and the national OP for Human Potential (POPH, as well as with Cohesion Policy (regional OPs). The application of complementarity between ESIF funds allowed the financing of advanced training (e.g. PhD), reinforcing the internal capabilities of scientific organisations and also human capital accumulation.

There were also elements of connection with the European framework programmes for research, despite the lack of specific coordination mechanisms. ERDF investments were in principle meant to enable the subsequent participation in FP actions, which has been confirmed by recent data on ERDF recipients' participation in research projects at the European level after the end of the 2007-2013 programming period.

EU added value

Overall, cohesion policy funds allocated to Portugal between 2007 and 2013 amounted to about €21.5b (€11.9b from ERDF), 24% of which for RTD, innovation and business support activities.[1] The OP implementation took place in an extremely unfavourable context for the national economy caused by the international economic crisis and the need to consolidate public finances. The OP, together with several regional operational programmes, was the main public instrument to enhance the competitiveness of the

[1] European Commission, 2009. "European Cohesion Policy in Portugal".

Portuguese economy by funding strategic dimensions such as research and technological development, innovation, internationalisation and entrepreneurship.

The OP supported more than 8,000 companies and 600 different organisations, highlighting the role that ERDF funding had in encouraging competitive investment in the country while minimising the negative impacts of the adverse economic situation.

There is clear additionality resulting from the ERDF funding, and the scale and pace of effects would have been produced at a much lower level and slower rhythm without ERDF funding. The ERDF played a fundamental role in funding the capacity building of scientific organisations and firms, laying the foundations for the consolidation of national scientific and innovation systems. In parallel, the synergies with regional OPs reinforced convergence regions' scientific and technological systems, particularly in Norte and Centro.

The projects funded under the three policy instruments taken into account in the study and those carried out under international cooperation agreements established with renowned knowledge centres contributed to the prestige of the Portuguese institutions with relevant impact on the international collaboration patterns and intensity. On an EU-wide level, the strengthening of the Portuguese innovative capabilities had an impact by increasing the participation in EU projects, firstly by scientific actors, and later also by firms, enriching the European innovation ecosystem.

1. INTRODUCTION

This case study has been carried out in the framework of the 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's main objective was to identify the effectiveness of RTD activities and infrastructures, their coherence with other policies, their efficiency, relevance, and EU added value. The evaluation encompassed 53 Operational Programmes (OPs) selected by the European Commission, covering a substantial amount of the RTD funding (EUR 14.64 billion, or about 85% of the EU total for the relevant themes) during this programming period.

The case study has been conducted based on a Contribution Analysis (CA) approach and the underlying development of Theories of Change (ToC) for selected policy instruments. This involved disentangling the complex causal relationships between different stages of implementation and the production of these policy instruments' results to identify the contributions made by the ERDF to improving RTD in specific regions and Member States (MS). This approach aimed to build a detailed narrative of the ToC 'at work' in a particular region/MS and context by addressing the specific conditions influencing the policy rationale (further explored in the cross-case analysis), the interplay of different stakeholders, as well as their expectations, and the observed effects resulting from the policy instruments.

The selected policy instruments for an in-depth analysis under the Portuguese case study were all implemented under the national Operational Programme for Competitiveness Factors (henceforth COMPETE OP) and include:

- Research and Technological Development (RTD) projects led by entities of the national scientific and technological system in all scientific fields (individual projects).
- Research and Technological Development (RTD) strategic projects developed in public interest areas led by entities of the national scientific and technological system (individual projects).
- International cooperation RTD projects (individual projects).

The case study provides an assessment of the implementation of the ERDF in RTD under the COMPETE OP. The latter concentrated funds on the three mainland convergence regions eligible under the 2007-2013 programming period: Alentejo, Centro and Norte.

Upon the selection of policy instruments, the case study was developed based on the following methodological approach:

- Step 1: Carry out background research on the selected OP and policy instruments;
- Step 2: Screening of key stakeholders;
- Step 3: Developing an initial Theory of Change (ToC) for each of the selected instruments and identifying performance metrics;
- Step 4: Establishing initial contact with key case study stakeholders, including interviews with the managing authority and programme managers;
- Step 5: Interviews;
- Step 6: Completing the contribution analysis assessment framework for the selected instruments and major project ToCs;
- Step 7: Drafting the case study report.

The following chapters provide, against the description of the national and regional economic and innovative background, an overview of the RTD policies and ERDF policy

mix implemented in the country both at the national and regional levels. A specific chapter is devoted to an analysis of the COMPETE OP.

The case study was developed based on hard data and information from strategic and programming documents, OP implementation reporting, statistical data, indicators from the monitoring system and other literature, complemented by interviews with representatives of programme managers, beneficiaries and other stakeholders. The analysis was carried out during the period of September-November 2020. It builds on the evidence available from a previous task, including a comprehensive mapping and classification of projects and beneficiaries funded in 53 Operational Programmes in 18 Member States under the codes of expenditures #01 and #02 (research activities and infrastructure; please see the First Intermediate Report for more details) and cluster analysis of European regions according to their R&D performance.

About 35 stakeholders were consulted in the preparation of this report, including representatives of the managing and implementing authorities and direct beneficiaries. The stakeholders' consultation was done through phone/video conferencing interviews and carried out by the evaluation team from October to mid of November 2020.

The COMPETE OP Managing Authority provided good collaboration and the Foundation for Science and Technology (FCT) as the OP Intermediate Body regarding the provision of data on the instruments under assessment and qualitative information on their implementation and influential contexts. As was somehow expected, it was not always possible to find monitoring data provided by the programme managers broken down into the individual support measures considered in the study.

Direct beneficiaries were, in general, able to provide relevant data and information at the project level.

When available, evaluation reports carried out in the context of the OP evaluation plan were also used to strengthen the case study's analytical reliability further.

2. ANALYSIS OF THE POLICY CONTEXT AT THE NATIONAL LEVEL

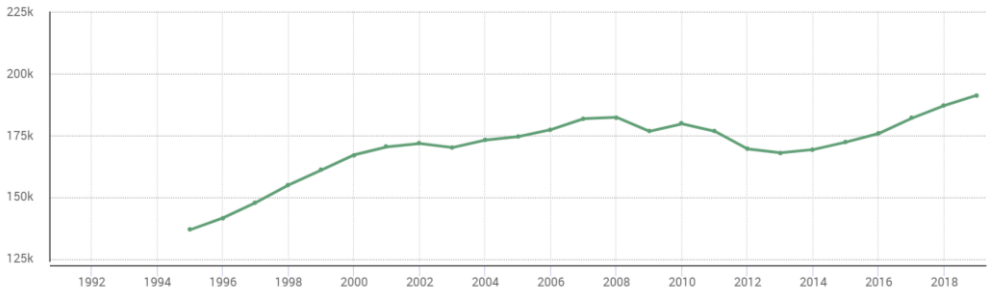
This chapter presents the policy context in which ERDF support was provided during the 2007-2013 programming period in the field of RTD. Section 2.1 provides an analysis of the national context and the main RTD needs and strategies. Section 2.2 is devoted to the description of the role of ERDF concerning national and regional RTD strategies as well as other European RTD policies and analyses how intended articulations were meant to act as drivers of effectiveness. Finally, Section 2.3 describes the institutional structure for ESIF programming and management at the country level, as well as the total OPs implemented in the country, with an overview of RTD expenditure across all OPs in order to present the ERDF RTD policy mix.

2.1. National RTD objectives and strategies

2.1.1. National RTD context

Portugal entered the European Economic Community in 1986, and the following years were characterised by a significant expansion. From an economic standpoint, this period was marked by a strong growth performance. The facilitated access to the European market, the foreign direct investment attracted, and the support of structural funds to the country's modernisation contributed to a steady growth path of convergence.

Figure 1. GDP (chain-linked volumes, base year 2010)



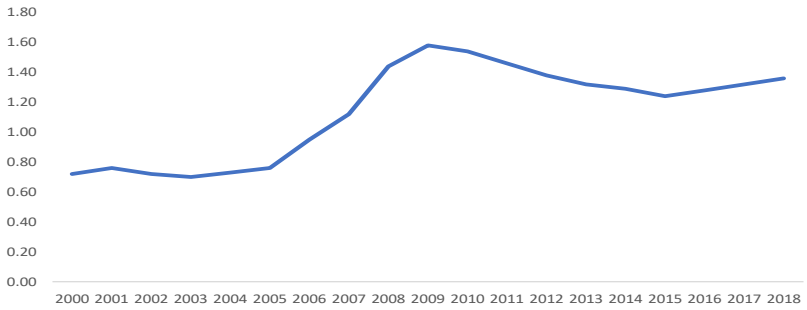
Source: Eurostat.

However, at the turn of the century, the Portuguese economy initiated a painful structural change process. Following years of economic growth until 2000, the consequences of the Marrakesh Agreement and the Uruguay Round led to the opening of European markets to massive Chinese imports, exposing the Portuguese industry's fragilities. Despite the positive growth dynamics, the competitiveness of the Portuguese manufacturing industry had relied on relatively lower labour costs. The reduction or elimination of trade barriers affected the regions with greater export intensity and greater share of manufacturing industries in gross value added (namely in Norte and Centro).

From 2005, stemming from the Lisbon Agenda (2000) and the awareness of the urgency of a structural change towards the knowledge economy, a new shift in science policy paradigm occurred with scientific knowledge understood as instrumental for economic and social development. Hence, RTD policies laid on three pillars: researchers, R&D institutions and internationalisation. From 2007 onwards, the deployment of several programmes aimed at improving national capabilities on those three pillars was observed. For example, the "Science" programme (2007 and 2008) created a mechanism for institutions to hire researchers and expand internal capabilities. On R&D institutions, emphasis was placed on critical mass, with many policy instruments, including the ones under analysis in this study, being deployed to build capacity and increase the scale of

R&D institutions, improving their ability to integrate international networks. Regarding the latter, the Programme Welcome II is an example of this commitment to internationalisation, funding the recruiting of leading European scientists by Portuguese R&D units.

Figure 2. R&D intensity as a percentage of GDP invested in R&D activities

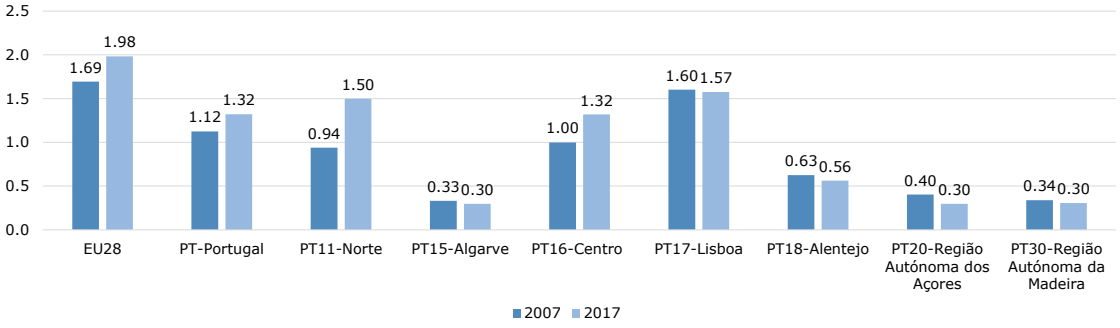


Source: DGEEC, IPCTN

The science push of public policy at the turn of the century is noticeable from 2005, with a strong increase in the investment in R&D, reducing the gap to the EU average. In 2007, the national Gross Expenditure on R&D (GERD) in the percentage of the GDP was 1.12% in comparison to 1.69% of EU28. Even though still lagging from the EU28 average, the progress registered was quite impressive considering that in 2000 GERD in the percentage of GDP was approximate 0.7%. Figure 2 demonstrates the level effect of the change in policies with the policy-mix deployed in 2007.

Nonetheless, in terms of BERD, the evolution was slower. Within the context of a consolidating innovation system, R&D institutions and universities tend to be more sensitive to policy changes and faster in the adjustment.

Figure 3. Government Expenditure in Research and Development

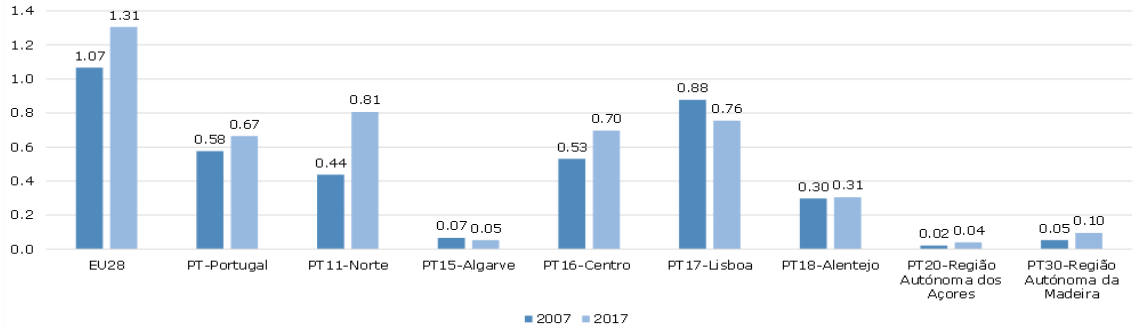


Source: CSIL elaboration based on EUROSTAT data.

Concerning regional disparities, the above figure highlights the differences in terms of RTD, with convergence regions Norte and Centro showing significant progress, which was not registered for Alentejo, Madeira or Azores.

Still, with regard to BERD, a positive trend was already being observed, starting in 2005. By 2007, the BERD accounted for roughly 50% of total R&D expenditure, with a similar pattern in terms of regional distribution.

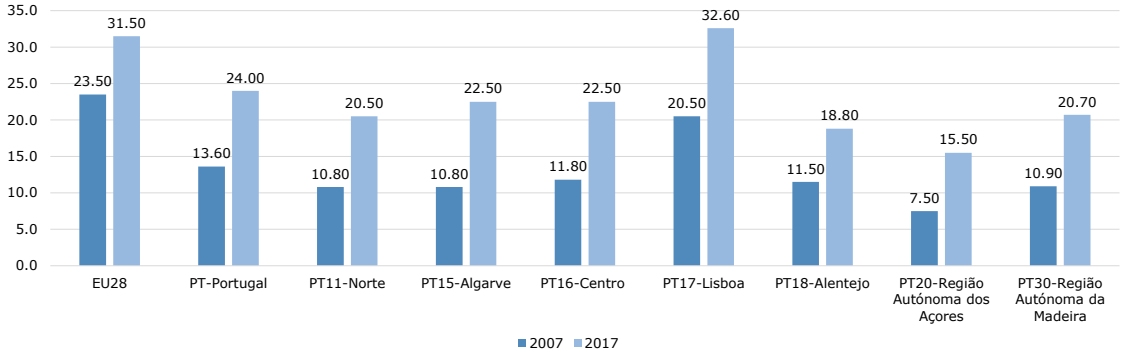
Figure 4. Business Expenditure on Research and Development



Source: CSIL elaboration based on EUROSTAT data.

As mentioned above, in the last decades, public policy targeted human capital and R&D institutions as fundamental elements for a successful innovation strategy. Hence, policies were implemented to reinforcing these inputs. From the human capital perspective, an observable continuous increase in the percentage of the population with tertiary education and an effective catching-up process to EU average, unlike in R&D inputs, was common to all seven Portuguese NUTS 2 regions.

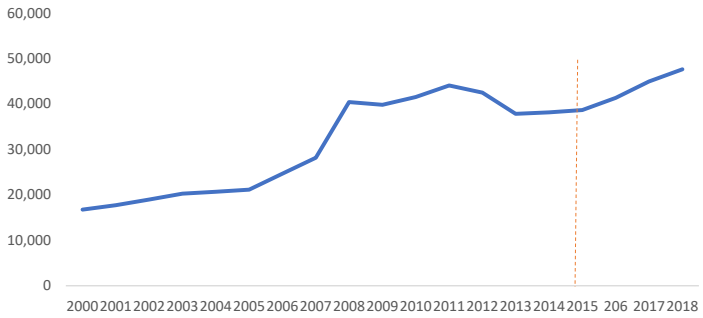
Figure 5. Percentage population aged 25-64 having completed tertiary education.



Source: CSIL elaboration based on EUROSTAT data

The same improvement was observed in the number of researchers, which also registered a positive shock after 2005.

Figure 6. Number of researchers



Source: DGEEC, IPCTN

Overall, we observe a contrast between the enormous effort made to the level of non-business R&D pursuing a "technology push" logic and investment with innovative content supported by PRIME incentive systems (SIME and SIPIE, within CSF III). The link between science and economy was, until 2007, less obvious, and R&D+I policy-mix appeared non-integrated and favourably skewed to public R&D institutions. Thus, a transformation was needed to establish a new growth model based on knowledge and

innovation, leading to a set of more ambitious policies to develop the National Innovation System.

In the policy-mix launched in 2007, new incentives were introduced for knowledge production. The knowledge production sub-system responded to these incentives, and tertiary education underwent a significant boom. This boom also occurred in R&D units by creating new positions and the expansion of scholarships and grants. However, the links to the economy was one of the least successful dimensions of these policies, with the generous incentives serving to create critical mass but not stimulating openness of the institutions to external collaborations, especially with firms.

Figures 2 and 6 demonstrate the level effect of the change in policies with the policy-mix deployed in 2007. It is perceivable a clear discontinuity, which reflected the stronger emphasis on innovation policy that was cross-cutting both universities and businesses.

By 2008, GERD/GDP accounted for 1.45%, with almost 50% being executed by the business sector. Both the business and the public sectors were investing in R&D and building capacity for innovation, but the National Innovation System evolved in parallel rather than in synergy. At the same time, the economy was enduring a dual transformation process. On the one hand, Foreign Direct Investment created drag opportunities to upgrade a portion of the manufacturing industry. On the other hand, the accumulation of human capital and technological entrepreneurship promotion stimulated the emergence of new technology-based firms. Unfortunately, the international financial crisis that spurred in 2008 would hit Portugal very harshly and generated a depression in 2012, with a corresponding drop in R&D investment which, even though it still led to an overall positive impact in comparison to 2007, still had not fully recovered the previous growth trajectory by 2013.

2.1.2. National and regional RTD strategies

Before 1986, science policy was erratic (Rodrigues e Heitor, 2015). With the approval of the Education Law in 1986, a new framework was established for science policy that envisaged boosting the Portuguese population's qualifications. Hence, if by 1986 circa of 80,000 students were enrolled in universities and polytechnical schools, by 1995 these figures topped at 290,000 students. By then, science policy was one of the topics of higher education policy.

From 1995 until 2005, there was a shift in the science-policy conception, targeting Europe’s growth agenda. On the one hand, for the first time, there was a Ministry of Science which represented the gaining importance of the topic in the national development agenda and, on the other hand, the beginning of institutional growth with the creation of the Foundation for Science and Technology and the Innovation Agency. In this period, the first international agreements are forged, namely with Fraunhofer and four leading US universities, in an effort to promote internationalisation. In the CSF III, the commitment to promote human capital creation with high scientific capacity and the incentive to university R&D was clear. The impacts of these policies became particularly visible in the trends after 2007.

In 2005, Portugal launched its “National Technological Plan”, which intended to contribute to this transformation towards a more knowledge-intensive economy. This set of policies were successful in generating R&D inputs, improving the absorptive conditions of the country.

The National Technological Plan was structured in three axes:

i) the Knowledge axis, which promoted the qualification levels' improvement, was essential to provide people with the necessary skills to adapt to new technological paradigms and allow the widespread absorption of new

technologies. The absence of basic skills, closely associated with low levels of education, reduced the economy's technological absorption capacity, thus creating additional difficulties for modernisation and, consequently, for strengthening competitiveness.

ii) the Technology axis aimed at strengthening national scientific and technological competences, both at the public and private sector levels, promoting the continuous creation and technological diffusion, investment in R&D and increasingly qualified job creation.

iii) the Innovation axis had the strategic objectives of promoting qualified employment and changing the economy's specialisation profile (industry and services) towards a more knowledge-intensive model.

The Technological Plan devised a target of R&D investment effort corresponding to 1.8% of GDP, in the distribution of 1 pp by public institutions and 0.8 pp by private institutions, in 2010.

From 2007-onwards, the science-policy's objective concentrated on intensifying the R&D effort and creating new knowledge, increasing RTD in business and promoting effective links between enterprises and knowledge centres, accelerating dissemination, knowledge transfer and valorisation of RTD results. Hence, science policy focussed on stimulating the basis of the STI system to grow and get critical mass by investing in three main pillars - researchers, R&D institutions and internationalisation (across the country and in particular in the convergence regions), and on stimulating the activity of researchers through competitive funding of R&D projects, institutions (research units and infrastructures) and international cooperation.

This change in science policy also reflected on the way operational programmes were organised. In the 2000-2006 programming period, RTD activities were funded through a specific programme (i.e. POCTI - Operational Programme for Science, Technology and Innovation). After 2007, science support was mainly concentrated in the SAESCTN instrument under the COMPETE OP, apart from regional operational programmes investments in infrastructures and the Human Potential Operational Programme (POPH) for advanced scientific training. The integration of an instrument such as SAESCTN in the COMPETE OP, whose fundamental objective was to boost economic competitiveness in convergence regions, can be understood as a paradigm shift in which scientific knowledge should be seen as instrumental for economic and social development.

Concerning the national/regional RTD strategies articulation, it is worth mentioning that Portugal is a centralised country where policies are mostly defined at a national level. Science and technology policies are no exception and are also centrally designed and defined. However, regions have decentralised bodies of the central government, which provide competence centres to operate and manage the ERDF support. This setting has provided the playing field for the conjugation of national and regional strategies on RTD through the interaction of the national COMPETE OP and the regional OPs.

On the national level, especially in RTD, national institutions coordinated education and human capital policies, deploying a vast array of instruments dedicated to consolidating the national innovation system. This includes direct support to RTD activities and international collaboration, whereas regional OPs conveyed instruments targeted mainly at infrastructures. Regions were, therefore, more pro-actively involved in this programming period regarding the support to entities of the scientific and technological system, namely by launching complementary calls that funded research infrastructures in their territories.

In view of the preparation for the 2007-2013 period, regions developed regional action plans and strategies on innovation, with science emerging as one of the main pillars. It is

worth also stressing that innovating in terms of previous practices; regions promoted a novel instrument: "Integrated Programmes of Scientific Research and Technological Development". The new instrument targeted long-term research agendas, distinguishing from other instruments in terms of considerably greater length and size of projects.

2.2. The links between national, regional and European objectives and strategies in the field of RTD support

This section describes the role of the ERDF investments for RTD in the national and regional policy mix, as well as with respect to European framework programmes.

2.2.1. Linkages between national and regional RTD policies and ERDF support

Since 1986, the outcome of European subventions was fundamental to accelerate Portugal's modernisation and its convergence on economic and social levels. The ERDF played a major role in implementing policies, from education and science to the economy.

The NSRF 2007-2013 identified as priorities the qualification of the labour force as a great strategic goal, valuing knowledge, science, technology and innovation, and the promotion of high and sustained levels of economic and socio-cultural development territorial qualification. The NSRF included three national level OPs (i.e. Human Potential, Competitiveness Factors -COMPETE-, and Territorial Enhancement), which targeted:

- reinforcement of the qualification of human resources;
- sustained growth of the economy;
- transition of the national innovation system to a new competitive paradigm based on innovation.

On a different level, regional OPs were linked to cohesion policy objectives setting as goals:

- convergence;
- regional competitiveness and employment;
- European territorial cooperation.

Despite this architecture, RTD policy was essentially national, as were most policy instruments. However, as a novelty, in the preparation of the NSRF, some regions designed strategic plans (e.g. Norte Innovation Plan). Hence, the embryo of regional RTD strategies attempted to orient the regional OPs approach towards reinforcing the national RTD policy's effects.

In this new scenario, regions were responsible for financing new and improved research infrastructures, leading a consolidation of central nodes in the regional innovation systems. Furthermore, a novel instrument was introduced on a regional level, which complemented the national approach. In concrete, the already mentioned "Integrated Programmes of Scientific Research and Technological Development" presented a new time frame and a more structured approach, combining the results of national broadband policies with regions' strategic positioning. Therefore, although not foreseen in the original NSRF architecture, the combination of regional and national OPs produced synergies that have boosted the consolidation of regional and national innovation systems.

It is worth noting the relevance of ERDF to the establishment of a multilevel RTD strategic framework. This multilevel setting implied an articulation between national and

regional OPs. All the programmes (i.e. COMPETE, Norte, Centro and Alentejo) adopted a thematic structure that, although different from one programme to another, allows the implementation of common support mechanisms and main typologies projects in the RTD and innovation fields. Nevertheless, borderlines needed to be established to avoid overlapping and, more importantly, induce synergies. Hence:

- Under Axis 1 - Knowledge and Technological Development, the national OP funded research and technological development (RTD) projects, actions to promote national actors' participation in the Seventh Framework Programme and other European programmes, and RTD projects carried out by medium and large companies. Regional convergence OPs funded scientific and technological infrastructures (including business hosting infrastructures), RTD projects implemented in the framework of funded scientific and technological infrastructures, and RTD projects carried out by micro and small enterprises.
- In Axis 2 - Innovation and Renewal of the Business Model and Pattern of Specialisation, national OP supported investments in innovation (e.g. launching new products/services, new technological and organisational processes) made by large and medium-sized companies. In contrast, regional OPs funded the same type of activities to small and micro-enterprises.
- Axis 3 - Innovation Financing and Venture Capital was funded only by the national OP.
- In Axis 5 - Business Development Networks and Collective Actions, collective innovation strategies (e.g. clusters and technological poles) implemented at the national level were supported by the national OP, whereas collective strategies for innovation and internationalisation undertaken at regional or urban levels were funded by regional OPs.

The ERDF relevance per se for the national RTD was obvious. The ERDF support contributed to leveraging the country's investment capacity and accelerated the growth of RTD institutions and their capacity building. Its impact was amplified amidst the financial crisis and the negative impact of public expenditure on RTD activities. During this period, the increase in the ERDF funding rate from 70% to 85% was crucial to smooth the negative impact on RTD institutions.

2.2.2. Linkages between ERDF support for RTD and the European Research and Innovation Framework Programmes

Within the NSRF 2007-2013, RTD policy targeted three major dimensions of intervention: human capital, infrastructures and R&D activities. Considering the architecture of the different OPs, synergies were fundamental to the success of the strategy. For example, the human capital objective aimed to reinforce significantly not only the share of the population with tertiary education but also the number of researchers. A dedicated programme on human potential (POPH) was launched. Beyond training and other improvements in the education system, it specifically targeted advanced training providing yearly support to more than 45,000 beneficiaries and managing an average of 6,635 PhDs per year [2]. It is worth noticing that synergies between this OP and the COMPETE OP were mostly visible in public research projects. Regarding converging both policy instruments towards a common private goal, what was observed was that PhD grants in companies were seldomly supported.

Regarding international collaboration, synergies between FP7/H2020 and national funds were limited during the reference period. Despite the lack of coordination mechanisms

[2] POPH annual report, 2014.

and the different objectives of the European research and innovation framework programmes and the ERDF OPs, data analysis highlights that the reinforcement of research capabilities positively impacted the capacity to participate in European projects. This link between ERDF support to national/regional institutions and these institutions' participation in the European framework programmes was observed on different levels.

Firstly, a direct causality between levels of participation and ERDF support to national/regional RTD strategies. The latter was essential for the capacity building, and institutional growth of RTD institutions and, hence created the pre-conditions, more and better participation in European networks. In Portugal, a total of 520 institutions participated in FP7 for 2,268 projects and a total investment of EUR 546 million.

Table 1. Participation rate in FP7 vs H2020 projects amongst ERDF beneficiaries

	Number of ERDF RTD beneficiaries (a)	Number of ERDF RTD beneficiaries also benefitting from FP projects (b)	Participation rate (b/a)
FP7	124	58	46.8%
H2020	124	60	48.4%

Source: CSIL elaboration based on Task 1 DB Beneficiaries and Cordis data

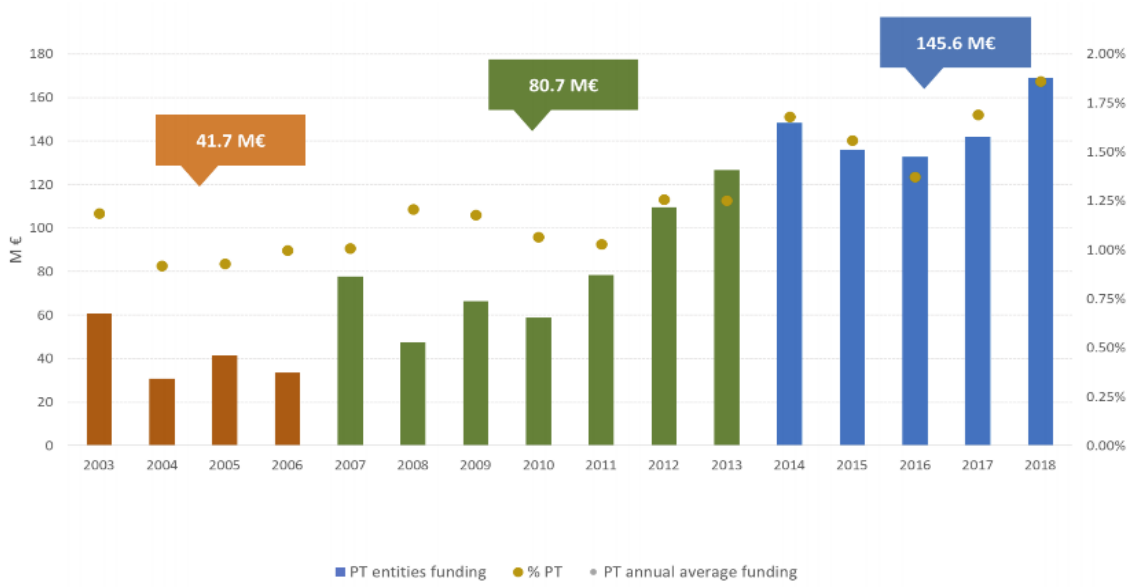
In H2020, the number of national institutions amounted to 698 for 2,710 projects and EUR 886 million. In the context of FP7 and H2020, the total number of ERDF beneficiaries of RTD interventions participating in FP was 58 and 60, respectively.

Table 2. ERDF beneficiaries participating in FP7 and H2020 projects

	ERDF recipients benefitting also from FP	Number of FP projects	Total FP contribution
FP7	58	754	205,964,394.53 €
H2020	60	841	329,142,267.62 €

Source: CSIL elaboration based on Task 1 DB Beneficiaries and Cordis data

Figure 7. Portuguese participation in European Research and Innovation Framework Programmes



Source: ANI - National Innovation Agency

On a second level, the direct funding to internationalisation contributed to preparing and fostering the participation in European networks of RTD, with a shorter transmission mechanism between inputs and outputs. The combination of these two effects positively

impacted the participation of Portuguese institutions and SMEs in terms of both the number of projects and funding raised.

On a third level, if the correlation between ERDF effects and the participation in FP7 is high, when we consider correlation in terms of longer-term outcomes, as mentioned before, synergies between funds was limited. In general, there was no sequential mechanism to guarantee a smooth transition of the results achieved within the framework of one project in FP7/H2020 and the sequence in COMPETE OP, or vice-versa. In other words, in some cases, the results achieved through participation in European projects may have been lost since there was no national mechanism to support the corresponding follow-up and transfer. On the opposite direction, although synergies were also thin, there was an important effort to promote the internationalisation of research units through the establishment of international collaboration programmes (e.g. MIT, CERN, etc.) and the creation of funding schemes to support the application and prepare the participation in FP7/H2020.

2.3. Implementation of ERDF funds for the 2007-2013 period in Portugal

The NSRF 2007-2013 had a total allocation of €21.5 billion, with three national OPs and 7 regional OPs. In the middle of a severe financial crisis, the NSRF became the primary policy instrument for implementing RTD strategies.

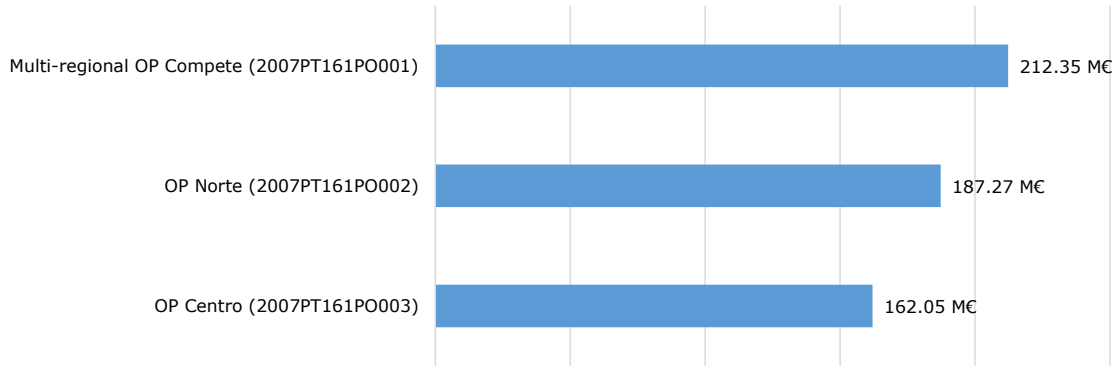
In its design, the NSRF combined a set of instruments to reinforce the capabilities of the knowledge production sub-system (e.g. universities and public R&D units), smoothing the cooperation with firms and strengthening R&D+I capacity in firms, and promoting innovative investments that could induce the commercialisation of RTD results.

2.3.1. Volume of ERDF financing for RTD-related activities and supported OPs

RTD activities concentrated an unprecedented amount of ERDF funding, combining the investment supported by the COMPETE OP and the regional OPs. Globally, RTD and innovative activities accounted for almost EUR 8 billion, where SMEs were the major recipients. The deployment of the OPs instruments was conducted through open calls per typology, with a set of selection criteria combining the quality of the proposal, quality of the proponent and the potential impact on the economy.

In relation to RTD activities, Portugal was the country under analysis which absorbed the highest ERDF contribution in the category of expenditure "01 – R&TD activities in research centres", with a total amount of EUR 561 million, with COMPETE OP accounting for more than EUR 212 million, as can be seen in Figure 8.

Figure 8. Distribution of ERDF funding for RTD in Portugal by OP

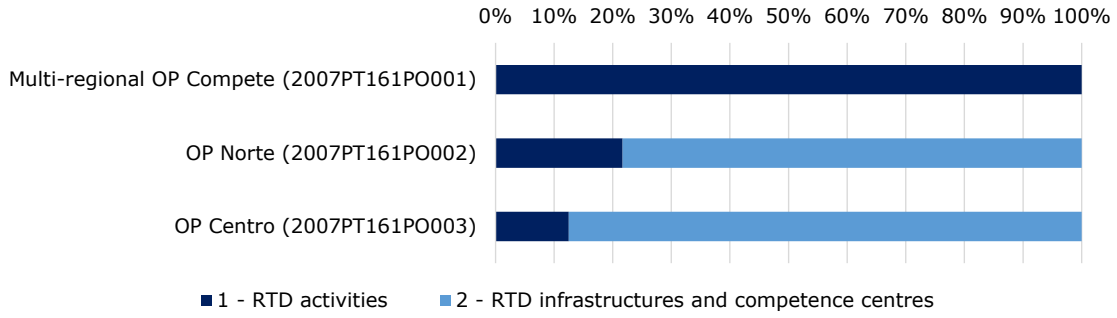


Source: CSIL elaboration based on Task 1 DB Projects and Beneficiaries

The funding provided by the OPs to support RTD-related activities were based upon a subvention scheme that started with a co-funding rate of 70%, which was later enlarged to 85%. Furthermore, amidst the financial crisis, considering the inability to execute the projects, a credit line with the European Investment Bank was activated by the Portuguese government to guarantee the remaining national counterpart.

Whereas the COMPETE OP funded RTD activities led by the scientific and technological system entities, regional OPs mainly invested in RTD infrastructures and competence centres.

Figure 9. Share of RTD themes in ERDF funding for RTD in Portugal by OP, % on total ERDF contribution to RTD themes



Source: CSIL elaboration based on Task 1 DB Projects and Beneficiaries

Combining these instruments was proven fundamental to the consolidation of the national innovation system and its sustainability, especially during a financial crisis that led to a negative shock on the economy with vast repercussions on the innovation system.

2.3.2. The ERDF RTD support policy mix: key instruments and rationale for selection

The ERDF RTD support policy-mix was quite comprehensive and delivered on a multilevel setting.

SAESCTN – Support to Entities of the National Scientific and Technological System was the NSRF 2007-2013 instrument directly addressing Science and Technology Policy and the entities of the scientific system, funding projects aiming at scientific research and technological development, national participation in European framework programmes and other international programmes (whose scope of intervention was later transferred to the SIAC instrument), and the promotion of scientific and technological culture.

SAESCTN materialised essentially through the support to RTD projects encompassing activities of fundamental research, applied research and/or experimental and technological development, involving one or more entities of the scientific and technological system and, complementarily, supporting projects to foster science internationalisation, as well as scientific and technological culture.

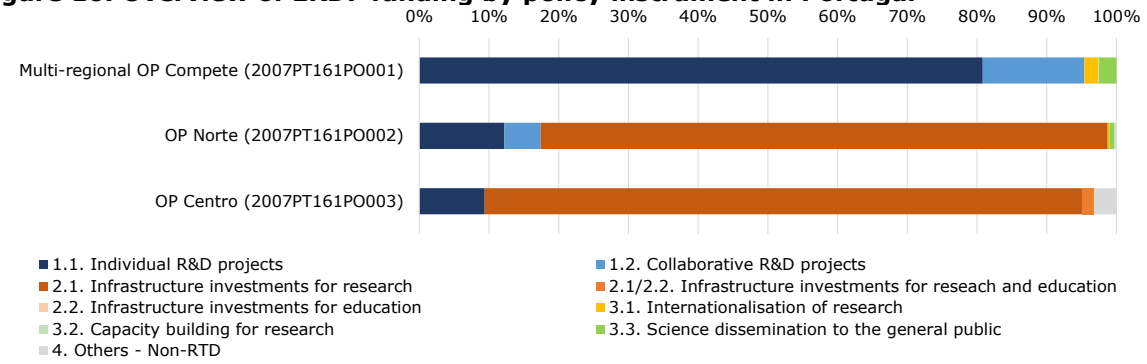
The Support System for Scientific and Technological Infrastructures, mobilised at the regional level, was designed to improve the modernisation of research infrastructures and create new ones, allowing significant investments in equipment and contributing to broaden and strengthen the infrastructure base for science, research and technological development.

Still, in the field of infrastructure, it is worth highlighting the Support System for Science and Technology Parks and Technology-based Business Incubators, funded within regional operational programmes. This instrument significantly increased the infrastructure capacity to support technology-based companies' launch through science and technology

parks and business incubators geared towards innovative entrepreneurship, with links to the main Higher Education Institutions based in the respective regions.

Furthermore, the Integrated Programmes of Scientific Research and Technological Development, introduced in 2011 and funded under the regional operational programmes, were structured around high-quality research lines and developed complementarity with investments related to increasing capacity in facilities and equipment.

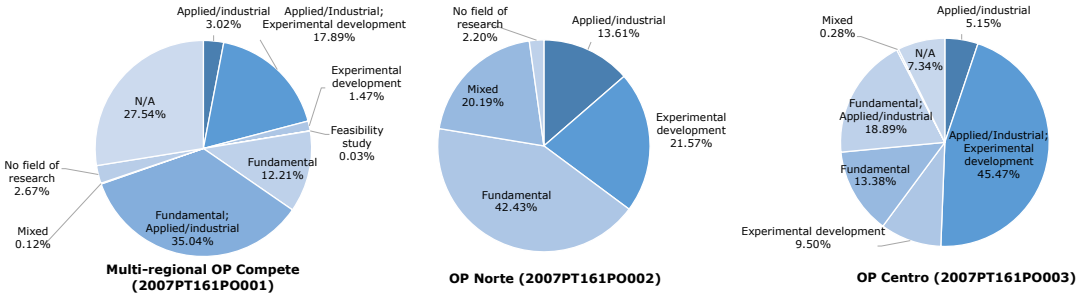
Figure 10. Overview of ERDF funding by policy instrument in Portugal



Source: CSIL elaboration based on Task 1 DB Projects and Beneficiaries

Overall, different patterns were observed with a more significant focus on fundamental science at the multi-regional level and in the Norte region, contrasting with a more applied industrial focus in the Centro region.

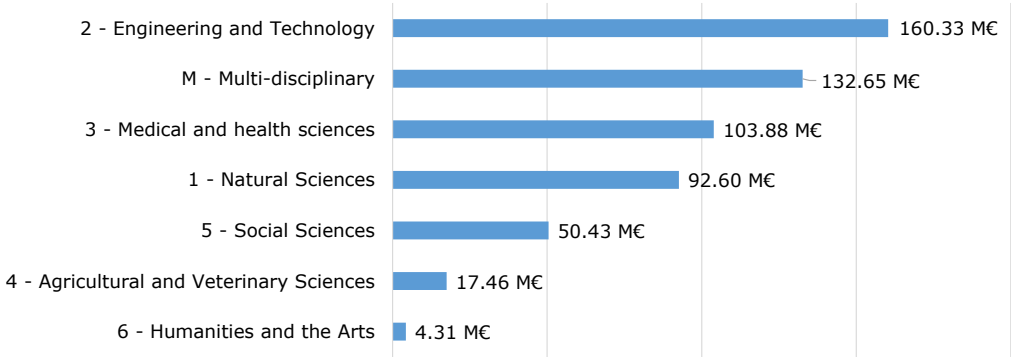
Figure 11. ERDF funding by type of RTD in Portugal



Source: CSIL elaboration based on Task 1 DB Projects and Beneficiaries

Considering the absolute goal of stimulating RTD, policy instruments revealed little thematic pre-selection and hence, the distribution of funding represents the distribution of demand. The concentration of resources around some topics with special relevance for engineering and technology and medical and health sciences is clear.

Figure 12. Overview of ERDF funding by field of science in Portugal



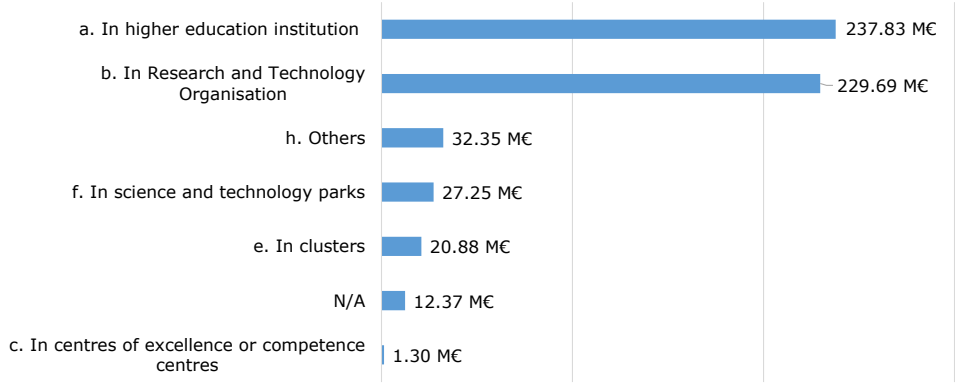
Source: CSIL elaboration based on Task 1 DB Projects and Beneficiaries

Concerning the funding for research infrastructures, this was available only under regional operational programmes (ROPs). The rationale for this allocation was keeping under ROPs the interventions that further benefited from close interaction with the beneficiaries or stemmed from regional, local or urban intervention logics.

The Support System for Scientific and Technological Infrastructures supported the modernisation of existing research infrastructures and the launch of new ones. Among many examples of new RTD entities that emerged or were considerably expanded in this period in mainland convergence regions, the investment in large infrastructures such as the Institute for Research and Innovation in Health (I3S) or the International Iberian Nanotechnology Laboratory (INL) can be highlighted.

The Support System for Science and Technology Parks and Technology-based Business Incubators increased the infrastructure capacity to support technology-based companies' launch.

Figure 13. Overview of ERDF funding by target beneficiary in Portugal



Source: CSIL elaboration based on Task 1 DB Projects and Beneficiaries

The distribution of funding per target beneficiary also enlightens on the policy objectives underlying these policy instruments. As stated above, RTD policy included strengthening research capabilities and institutional growth, with a combined effort between universities R&D units and autonomous research and technology organisations.

3. CONTRIBUTION ANALYSIS OF SELECTED POLICY INSTRUMENTS

As mentioned in the introduction of this report, three policy instruments funded by the COMPETE OP have been selected for a deep dive analysis. The selected policy instruments are:

- Research and Technological Development (RTD) projects in all scientific fields led by entities of the national scientific and technological system (individual projects).
- Research and Technological Development (RTD) strategic projects developed in public interest areas led by entities of the national scientific and technological system (individual projects).
- International cooperation RTD projects.

The analysis of these policy instruments was conducted based on a Contribution Analysis (CA) approach, which in turn has been developed based on a Theory of Change (ToC) defined for each policy instrument. The aim of this chapter is thus threefold:

- To present the OP under which the three policy instruments were funded (some elements have already been presented in the previous chapter).
- To present an overview of the policy instrument ToC developed for this evaluation, then used as the basis to carry out the CA presented in this section.
- To describe the observed effects of the policy instrument based on the expected results identified in the ToC, and based on the data collected by the evaluation team (primary and secondary) and to provide an assessment of the observed effects as direct results of the ERDF funding and support for the policy instruments, as well as an analysis of the extent to which the overall ToC materialised as initially expected.

Section 3.1. below presents the national COMPETE OP under which the policy instruments have been implemented. This overview outlines the rationale of the OP and of the policy instruments and how it links to other measures and ambitions established by the programme.

The subsequent sections, **3.2.**, **3.3.** and **3.4.** present a comprehensive analysis of each of the selected policy instruments for Portugal. Each section includes the subsections outlined below.

- The first subsection section presents the Theory of Change of the policy instrument. Theories of Change were developed by the case study team for the purpose of conducting the contribution analysis. As such, Theories of Change are an ex-post reconstruction of the intended goals and purpose of the policy instrument and of the causal package that was intended to generate such goals. It is worth mentioning, however, that the ToCs presented in each chapter present a snapshot of policy-makers intentions at a given point in time. ToCs generally adapt to the realities of specific territories and of the acting agents. As such, the ToCs presented here often underwent gradual changes, which the case study team tried to reflect both in the design of the ToCs, as well as in the final depiction of the ToC testing.
- The second subsection presents the results of the contribution analysis conducted on the basis of the ToC for each instrument. This section explains what happened when the policy instrument was implemented, as well as why and how this happened. The contribution analysis was carried out by assessing the extent to which the different components identified in the ToC actually took place, as well as the extent to which they influenced the effectiveness of the instrument. As such, the contribution analysis assessed each of the elements given below:

- The extent to which expected result thresholds were achieved: this involved identifying specific ambitions for each type of result (e.g. outputs, immediate outcomes, intermediate outcomes, final outcomes and impacts) and assessing whether these thresholds were reached based on the available data. This section also presents any identified intended or unintended results.
- The extent to which activities were implemented according to the intended plans, rules and procedures.
- The extent to which identified pre-conditions took place: this involved assessing whether the necessary pre-conditions actually existed in reality, as well as the extent to which their existence or absence played a role in achieving intended results.
- The extent to which supporting factors took place and the role they played in achieving the instruments intended goals.
- The extent to which identified risks materialised and whether these were effectively managed or mitigated or limited the effectiveness of the instrument.

- The combination of the results obtained for each of the previously described assessments led to the establishment of a contribution claim for the different results observed and verified by the case study team. On this basis, in the third subsection, it was possible to establish one of the following contribution claims for each type of intended result:
  - The intended threshold was achieved, and the policy instrument was likely to be the main contributor to this result.
  - The intended threshold was achieved, and the policy instrument was only one of the factors which contributed to this result.
  - The intended threshold was not achieved or only partially achieved for one of the reasons below:
    - The activities were not implemented as originally foreseen, or there were flaws in the design of the activities.
    - The necessary pre-conditions did not take place.
    - The necessary supporting factors did not take place.
    - Some risks materialised, effectively hampering the effectiveness of the instrument.

  The third sub-section is thus structured around each of these elements and the results of their assessment. A final conclusion is provided on each policy instrument which presents the overall results of the contribution analysis and the underlying explanation of this result.

3.1. Operational Programme for Competitiveness Factors (COMPETE OP)

3.1.1. The strategic approach and the RTD policy mix mobilised under the OP

The COMPETE Operational Programme was implemented within the Convergence Objective Framework and had a total budget of around €6.7 billion. Community funding through the European Regional Development Fund (ERDF) amounted to about €3.3 billion. The central objective of the OP was to foster sustainable economic growth, making knowledge and innovation the key drivers of national and regional competitiveness.

The programme was structured around six priorities:

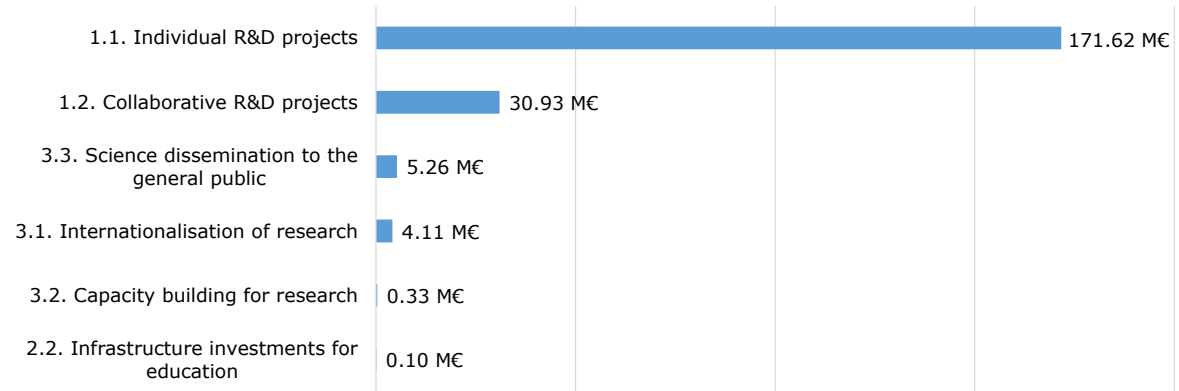
Table 3. COMPETE OP – priorities and goals

Priority	Goal
Knowledge and technological development (16% of total budget)	Increase the effort in research and technological development (RTD), increase the generation of new knowledge, as well as foster the involvement of enterprises in RTD and cooperation between enterprises and centres of knowledge.
Innovation and renewal of the business model and pattern of specialisation (39% of total budget)	Promote business innovation and internationalisation.
Financing and risk-sharing of innovation (12% of total budget)	Develop financial instruments to support firms' growth.
Public Administration (22% of total budget)	Simplification of procedures and ICT development.
Networks and collective actions for business development (8% of total budget)	Support collective innovative actions involving enterprises.
Technical assistance (2.5% of total budget)	OP management, monitoring, control, evaluation and dissemination

Source: own elaboration based on the OP programming documents

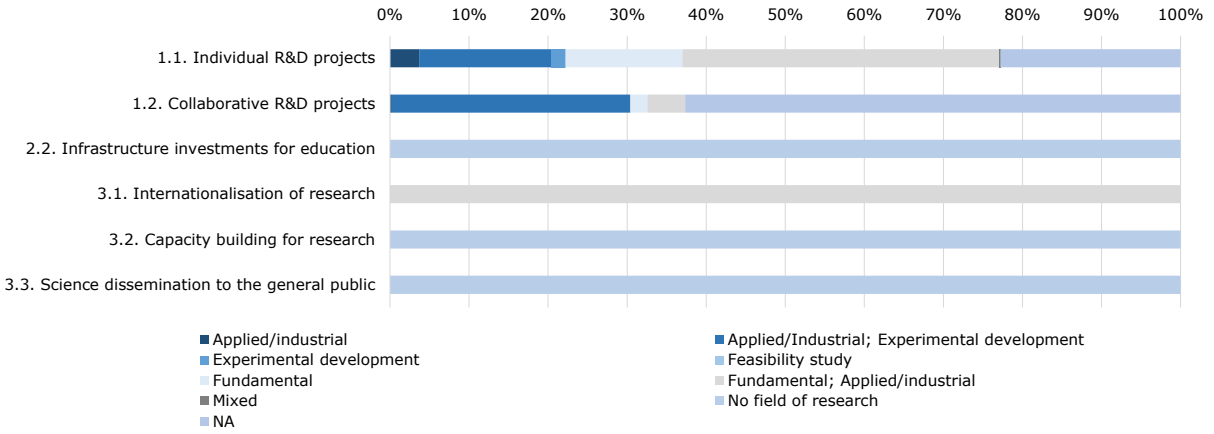
Priorities 1 and 2 were the most relevant vis-à-vis the RTD strategy. It was under Priority 1 that the instruments devoted to increasing scientific production, research and technological development (also run by companies) were allocated. This priority accounted for 16% of the OP budget. In parallel, Priority 2 had a direct impact on the RTD strategy, specifically in the valorisation stage. This priority concentrated a wide array of measures to support SMEs competitiveness, representing 39% of the total budget. Priorities 1 and 2 accounted, therefore for 55% of the OP total budget, which highlights the commitment to change the competitiveness factors of the Portuguese economy.

Figure 14. Overview of ERDF funding by policy instrument in the COMPETE OP



Source: CSIL elaboration based on Task 1 DB Projects and Beneficiaries

Figure 15. Distribution of approved projects per typology and field of application



Source: CSIL elaboration based on Task 1 DB Projects and Beneficiaries

The COMPETE OP provided an integrated framework to address some of the challenges faced by the national innovation system. Overall, it was to strengthen the capacity building of institutions and firms so as to prepare them better to create and absorb knowledge. Portugal was undergoing a structural change process that relied on the transformation of the system but also of the culture of its organisations. Understanding these shortcomings from the knowledge production sub-system side, the COMPETE OP launched calls to support this capacity building (SAESCTN instrument) but also to stimulate participation in international collaborative projects. On the economic sub-system, firms were encouraged to lead R&D projects either individually or in partnership with other firms and academia.

The most relevant measures in the science, technology and innovation field were implemented through four different axes of the OP (corresponding to the OP priorities described above in **Table 3.**):

- **Under Axis 1** - Knowledge and Technological Development, about 3,400 projects were supported, amounting to an eligible investment of €1.1b and ERDF funding of €0.7b. Axis 1 was to support the development of science and RTD through two main support mechanisms: Support to Entities of the National Scientific and Technological System (**SAESCTN**) aiming at fostering R&D activities led by research and technological institutions; and Support System to Research and Technological Development (**SI RTD**) with the aim of encouraging R&D business and cooperation between companies and RTD centres, including technology transfer and use of R&D results by companies. Further details on SAECSTN are provided below, as the three policy instruments presented in the following sections (3.2, 3.3 and 3.4) were implemented under this mechanism.
- **Under Axis 2** - Innovation and Renewal of the Business Model and Pattern of Specialisation, around 2,400 projects were implemented, which totalled €4.6b of eligible investment and €2b of community funding. Two support mechanisms were available mainly to the business community under this axis: Innovation Incentive System (**SI Innovation**) that supported new products, services, processes, technologies, and innovative start-ups; and SME Qualification and Internationalisation Incentive Scheme (**SI SME Qualification**), which focused on the enhancement of diverse business competitive factors, with particular emphasis on internationalisation.
- **Under Axis 3** - Innovation Financing and Venture Capital, business angels' and venture capital schemes were supported in order to promote new technology-based companies, higher risk innovations, and business development.

- **Finally, under Axis 5** - Business Development Networks and Collective Actions, which was a new support mechanism that did not exist in previous programming cycles, support was provided to joint actions for innovation, internationalisation and capacity building through inter-sectoral partnerships, clusters and technology platforms as a way to strengthen businesses' competitiveness (particularly SMEs). It was under this axis through the mechanism **SIAC** - Collective Actions Support System that a call for proposals was launched to promote national participation in FP7.

The various typologies of projects supported under Axis 1 – Knowledge and Technological Development sought to address the main shortcomings that the country, and in particular the mainland convergence regions, had in the RTD field, as regards both activities led by entities of the scientific system (SAESCTN support instrument) and businesses (SI RTD instrument).

The Support to Entities of the National Scientific and Technological System (SAESCTN) was the main national source of funding for R&D projects promoted particularly by Higher Education Institutions and R&D organisations based in the mainland convergence regions and can be seen as the OP most relevant measure to support Science and Technology policy. Under SAESCTN, about 2,600 projects were funded (€335m of eligible investment, €303m EDRF contribution). SAESCTN supported a wide range of actions, including projects in all scientific fields; R&D consortia; and international R&D cooperation projects. While funding the enhancement/adaptation of infrastructures in certain typologies of projects (limited to a reduced percentage of project budgets), the OP did not fund the creation of new RTD infrastructures, as this was assigned to the regional operational programmes.

Table 4. SAESCTN main typologies of projects

Beneficiaries	Main typologies of projects
Higher Education Institutions and their R&D centres **Associate Laboratories** **State Laboratories**	**RTD individual projects:** fundamental research, applied research and/or experimental and technological development, involving an entity from the national scientific and technological system (NSTS)
Non-profit institutions whose main objective was the development of RTD activities	**RTD collaborative projects:** fundamental research, applied research and/or experimental and technological development, involving several NSTS entities (including companies).
Companies within RTD projects led by R&D entities or in the scope of international partnership projects **Other non-profit public and private institutions that promoted RTD activities**	**RTD strategic individual projects:** individual projects promoted by Associate Laboratories and R&D Units that obtained a rating ranging from "very good" to "excellent" in the last international evaluation.
	RTD strategic collaborative projects: collaborative projects promoted by Associate Laboratories and R&D Units that obtained a rating ranging from "very good" to "excellent" in the last international evaluation.

Source: own elaboration based on the OP final implementation report

The SI RTD mechanism funded activities such as RTD projects led by companies (including consortia); R&D vouchers for the purchase of services to the entities of the scientific and technological system; mobilisation projects to promote activities with high innovation content with significant multi-sectoral impact; advanced technology

demonstration projects towards new technological solutions; and creation of RTD centres and development of companies' in-house RTD skills, among others.

3.1.2. The implementation of the OP

The OP implementation took place in an extremely unfavourable context for the national economy caused by the international economic crisis and the need to consolidate public finances. The OP, together with the several regional operational programmes, was the main public instrument to enhance the competitiveness of the Portuguese economy, funding strategic dimensions such as research and technological development, innovation, internationalisation, and entrepreneurship.

All in all, the OP supported a total of about 6,400 projects, which amounted to an eligible investment of €6.7b and ERDF funding of about €3.3b. It funded more than 8,000 companies and 600 other different organisations. It was estimated at the end of the programme [3] that participating companies' turnover will have increased 52% and their exports 69% and that approximately 18,000 jobs were created, which highlights the role ERDF funding had to encourage competitive investment in the country while minimising the negative impacts of the adverse economic situation.

The OP main action lines related to RTD and innovation were Axis 1 - Knowledge and Technological Development, under which about 3,400 projects were supported amounting to an eligible investment of €1,1b and ERDF funding of €0.7b; and Axis 2 - Innovation and Renewal of the Business Model and Pattern of Specialisation that funded approximately 2,400 projects, totalling €4.6b of eligible investment and €2b of community funding.

Throughout the OP, there were three reprogramming actions (2011, 2012, 2015). All reprogramming actions were geared at essentially introducing financial adjustments with no significant changes in the policy mix.

In terms of the OP axes most directly related to RTD and innovation, ERDF funding was reinforced under Axis 1 - Knowledge and Technological Development over the three reprogramming actions from €500m (OP beginning) to €642m (last reprogramming in 2015). The average percentage of ERDF contribution to projects supported in this axis also increased from 65% (OP beginning) to 72% (2015). After reprogramming, Axis 1 reinforced its relevance in OP total budget by increasing from 16% (initial programming) to 20% (2015 programming).

Through reprogramming actions, a number of measures were carried out in order to make the funding to the beneficiaries (particularly businesses) more flexible, namely increased ERDF co-funding percentages, acceleration of payment processes to the beneficiaries, higher advancement payments to beneficiaries, extension of payment periods regarding repayable incentives, and broadening of the typologies of supported innovation projects (e.g. inclusion of new typologies of innovative projects such as projects with impact on employment, exports, energy and environmental efficiency etc.), among others.

As regards the OP initial financial plan (approved ex-ante by the European Commission in October 2011), the budget for Axis 1 - Knowledge and Technological Development was reinforced over the years from a planned investment of €0.77b (€0.5b ERDF co-funding) to a total of €1.1b (€0.7b ERDF). It was within this axis that the main support

[3] COMPETE OP final implementation report, 2017.

mechanisms for R&D activities of scientific and technological entities and companies were concentrated.

3.2. Policy instrument: RTD projects led by entities of the scientific and technological system (individual projects)

3.2.1. Theory of Change of the policy instrument

Individual RTD projects led by entities of the scientific and technological system under the COMPETE OP were funded through non-reimbursable grants up to 85% (70% in the period 2008-2010) of eligible expenditure. Grants funded research and technological development projects in all scientific fields, involving an entity of the national scientific and technological system (NSTS) located in a mainland convergence region (i.e. Alentejo, Centro or Norte). In practice, however, the beneficiaries of the measure had 100% of funding to cover eligible costs, as the percentage not covered by the ERDF was provided by national funds through the Foundation for Science and Technology (FCT, Ministry for Science, Technology and Higher Education).

Under this instrument, five general calls for proposals were delivered throughout the 2007-2013 period to support RTD individual projects in all scientific fields carried out by entities of the NSTS (Measure I.1.1, SAESCTN - Support to Entities of the National Scientific and Technological System, COMPETE OP 2007-2013). In the analysis of this measure carried out as part of this case study, RTD individual projects funded under specific calls (e.g. international research projects with North American universities and CERN) were not considered, neither were projects supported under calls launched during the transition period to the programming cycle 2007-2013 (e.g. call for proposals for RTD projects launched in 2006).

Table 5. Call for proposals for RTD individual projects led by entities of the NSTS in all scientific fields

Call for proposals	Nº projects approved	Approval rate	Total investment (million €)	ERDF contribution (million €)
2008	310	24%	36.8	31.3
2009	163	17%	18.1	15. 4
2010	144	14%	14.4	12.2
2012				
RTD	85	10%	11.0	9.3
Exploratory	26	10%	1.2	1.0
Skills/resources	7	18%	3.0	2.6
Lines of excellence	4	11%	1.1	0.9
2013				
Exploratory	63	11%	2.6	2.2

Source: own elaboration based on data provided by the Foundation for Science and Technology

From 2008 to 2011, RTD individual projects were funded in the framework of three general calls for proposals in all scientific fields. As of 2012, projects were funded under two calls in the following categories: "RTD projects", "RTD exploratory projects", "RTD

projects in research lines of excellence", and "RTD projects to consolidate skills and resources". One of these two calls for proposals (2013) was fully dedicated to exploratory projects.

Thus, in the year 2012, applicants who had their projects approved for funding were provided grants for four types of individual projects:

- "RTD projects": up to €200,000 and two years of implementation.
- "RTD exploratory projects": up to €50,000 and one year of implementation.
- "RTD projects in research lines of excellence": up to €500,000 and five years.
- "RTD projects to consolidate skills and resources": up to €500,000 and three years.

This explains why activities presented in the ToC below have been divided into two boxes (i.e. before and after this change was introduced).

The regulation of SAESCTN and respective calls for proposals emphasised that the priorities of the projects funded under the measure were **the strengthening of scientific and technological skills of applicant institutions through the participation of their research teams in RTD projects in all the scientific fields** so as to reinforce the National Scientific and Technological System (NSTS), making it more competitive at international level. Eligible projects were submitted by Higher Education Institutions and their R&D centres, associate laboratories, state laboratories, non-profit institutions dedicated to the development of RTD activities, and companies under projects led by R&D entities or within international partnership projects.

The implemented individual RTD projects in all scientific fields funded by the COMPETE OP through the ERDF represent the main **outputs** of the instrument, upon which all further effects (i.e. immediate, intermediate and final outcomes, as well as impact) were meant to be generated. The Theory of Change (ToC) developed for this instrument distinguishes between four levels of results generated through a causal chain:

- **Immediate outcomes**, which were short-term effects that occurred once the outputs were achieved: **1)** the development of new knowledge (basic and applied) by the supported entities observable through outcomes such as scientific publications, communications in events, prototypes, pilot plants etc.; **2)** development of new and enhanced scientific skills of the participating research groups; and **3)** generation of intellectual property rights.
- **Intermediate outcomes**, which were medium-term effects generated once previous immediate outcomes were achieved, typically after the funded projects have been completed, including **1)** strengthened scientific and technological capacity of supported entities, and **2)** RTD project results transferred to external users for economic/social valorisation.
- **Final outcomes**, which were the most fundamental changes to which projects contributed through the achievement of intermediate outcomes and taking the form of a sustainable change of state among beneficiaries. The following expected final outcomes have been considered in the study: **1)** supported entities empowered to participate in new and more ambitious RTD projects; **2)** international profile of supported entities strengthened; **3)** economic benefits for supported entities through the exploitation of RTD results.

Impact, which refers to potential long-term effects generated after the 2007-2013 period (with some potentially still being generated today), having been considered for this level of results the **growth and strengthening of the national scientific and technological system**.

Formal documentation from the COMPETE OP provided a starting point for the development of a Theory of Change (ToC) for the RTD individual projects measure, especially regarding the identification of some of the intended effects. However, a major challenge in developing the ToC and conducting its assessment stems from the fact that no specific thresholds were formally identified for the measure, with the exception of a number of immediate outcomes for which goals were set by the Foundation for Science and Technology.[4]

As a result of this, the assessment of the extent to which intended effects have been generated has mainly relied on criteria defined by the evaluation team, as well as on data and information collected through secondary sources.

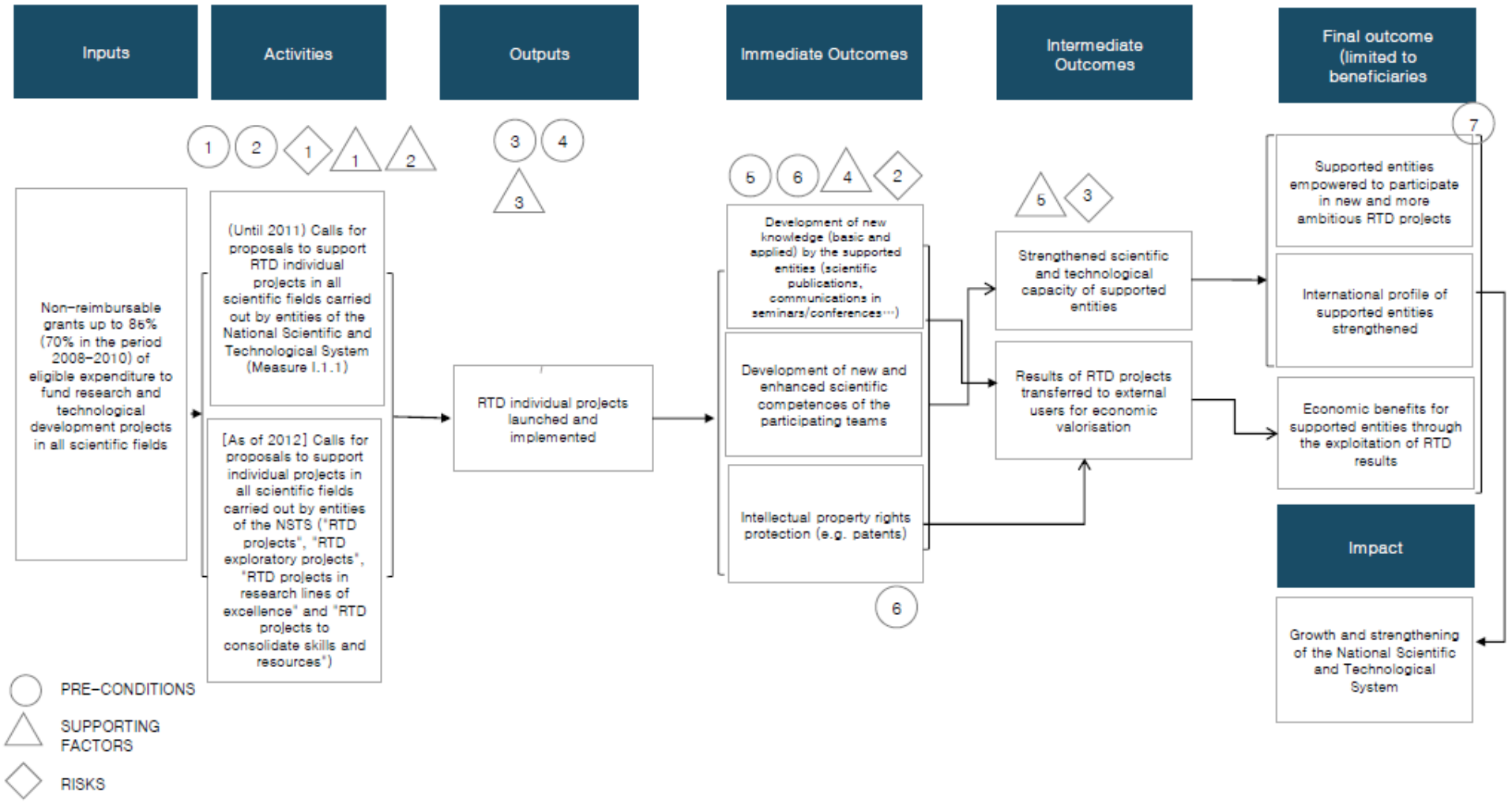
As can be seen in the figure presenting the results of the contribution analysis, the level of achievement of intended immediate, intermediate and final outcomes, as well as impact, is generally high, although with some exceptions particularly related to the valorisation of project results. A table is presented in the Appendix containing more specific information on the data collected for each of the expected effects and the assessment of the expected threshold for each one of these.

The ToC figure presented below uses arrows to illustrate the causal pathways between the different levels of instrument intended effects. In order to build a complete ToC, the evaluation team had to recur to a number of additional sources, including literature review carried out as part of this evaluation, interviews with programme managers and beneficiaries, as well as own knowledge and insight about the operational programme and local contextual factors. This has led to the development of the ToC presented in the following figure with the intention of illustrating the intended effects of the policy instrument, the underpinning pre-conditions, supporting factors and potential risks and threats.

[4] As the Intermediate Body appointed by the COMPETE OP to be in charge of the SAESCTN instrument.

Figure 16. ToC for RTD individual projects instrument

MEMBER STATE: PORTUGAL OP: COMPETE 2007PT161PO001 POLICY INSTRUMENT: RTD INDIVIDUAL PROJECTS (measure I.1.1.)



Source: Evaluation team based on primary and secondary data collected.

Legend:

Pre-conditions

1. The measure meets the effective needs of potential applicants
2. Calls for proposals reach potential applicants
3. Demand level for the measure induces selectivity of beneficiaries and projects
4. Applicants have the necessary capacity and resources (human, financial, infrastructure) to implement the projects
5. Results stemming from the supported projects have potential to produce relevant new knowledge.
6. Results stemming from the supported projects have potential for economic valorisation.
7. Existence of suitable regulation allowing the beneficiary organisations to achieve economic benefits generated from the transfer of any type of knowledge or exploitation of intellectual property

Supporting factors

1. The measure is aligned with other similar measures implemented in the previous ERDF cycle (2000-2006), which contributed to the continuous growth of the scientific and technological system.
2. The measure is part of a broader policy mix to support national RTD entities
3. Many beneficiaries have previous experience in applying and managing research grants given their implication on national funding programmes
4. Existing positive growth and development of the national scientific and technological system
5. Continuous public investment in science, technology and innovation, including in the following ERDF cycle

Risks and threats

1. The financial resources allocated under the measure may lead to an average size of projects with limited critical mass
2. Inherent risks to the implementation of RTD project s (i.e. trying out new, untested ideas, including risks related to time, costs, resources, technology etc)
3. Reduced links of the supported entities to industry may hinder the economic valorisation of the project results.

3.2.2. Contribution analysis

Verification of intended intervention implementation

In the interviews with the OP Managing Authority and the Intermediate Body (i.e. Foundation for Science and Technology (FCT)), a number of issues were reported with regard to the implementation of calls for proposals and the follow-up of projects.

As the Intermediate Body of COMPETE for the SAESCTN instrument, FCT was in charge of evaluating and approving project applications, as well as managing and monitoring project implementation. In this interaction between the two entities, constraints arising from the information systems used for data sharing were stated. Contrary to what happened with other intermediate bodies, the COMPETE information system was not solely deployed in this case; it has also continued to be used as an FCT system. This would have caused difficulties in data sharing in due time on the implementation of activities. Although no evidence has been found that such difficulties in the systems interoperability had direct negative consequences for project beneficiaries, it raised problems in terms of real-time reporting to national and European monitoring authorities, as well as in funding management.

The existence of projects approved without financial execution during the first years of the OP implementation was also reported. During the first OP reprogramming action, approximately €140m was withdrawn from the SAECSTN instrument. However, that amount would practically be restored in full until the end of the programming cycle. However, for all reprogramming exercises, the ERDF amount initially estimated for SAESCTN would roughly be invested until the end of the NSRF 2007-2013.

There were also difficulties concerning the national co-funding caused by the global crisis that hit national public finances severely. As of 2011, the ERDF funding rate rose from 70% to 85%, country's public co-financing effort decreased. Since the entities funded by SAECSTN were public or private non-profit, they were entitled to be financed 100% of their costs. The part not financed by the ERDF was covered by national public funds. However, as the Portuguese State was unable to guarantee its contribution at the height of the crisis, a loan was obtained from the European Investment Bank (EIB). SAECSTN was one of the OP instruments that benefited from the loan.

Despite all the aforementioned operational and financial constraints, it seems that generally approved projects for funding were not adversely affected, and the calls for proposals were effectively implemented.

Data provided directly by FCT show that a rather high level of grant applications was received regarding RTD individual projects in all scientific fields, and the percentage of projects approved for funding was relatively low. Except for a call for proposals in 2008, where the approval rate of funding projects was around 24%, approval rates were always below 20%, ranging from 10% to 18%. Although the OP underwent three reprogramming actions, the underlying logic of the measure for RTD individual projects remained unchanged throughout the programming period.

In any case, as mentioned in the previous section, in the year 2012, in addition to the general "RTD projects" typology (eligible costs up to €200,000 and project duration up to two years), which aimed at addressing original and relevant scientific issues that could significantly contribute to the advancement of the scientific knowledge, it was decided to fund three new types of projects:

- "RTD exploratory projects" (up to 50,000 and up to one year of implementation), aiming at exploring ideas or concepts that were considered to have great originality and/or potential for innovation.

- "RTD projects in research lines of excellence" (up to €500,000 and duration up to five years), which should involve a coherent organisation of scientific activity in broad lines of research. Projects' scientific or technological objectives should be based on clear performance indicators in emerging and/or consolidating areas of excellence considered priority areas for national scientific and technological development.
- "RTD projects to consolidate skills and resources" (up to €500,000 and up to three years of implementation) intended to support research activities which, due to their nature and specificity, depended heavily on material resources and highly qualified human resources, namely in view of the participation in international programmes.

However, after 2012, only two calls for proposals were launched, one of them dedicated exclusively to RTD exploratory projects.

Achievement of intended and unintended effects at the level of the expected threshold

The supported RTD individual projects in all scientific fields had an overall positive impact on the scientific production in the target regions (particularly in Norte and Centro), contributing to upgrade the scientific skills of participating research teams and accumulate relevant knowledge in the scientific and technological system.

The RTD individual projects measure gave rise all in all to 22,415 publications (99% of the projects produced publications; an average of 15.4 publications/project); and led to 22,710 communications in seminars/conferences (85% of the projects generated communications; an average of 18.1 communications/project). Furthermore, a total of 1,673 prototypes and pilot plants were generated (27% of the projects supported by this measure led to a prototype or pilot installation, an average of 4.2 prototypes/pilot plant per project) and 128 patents (5% of the projects led to patent applications)5.

For these project results (immediate outcomes), thresholds were established by the Foundation for Science and Technology (FCT), namely for indicators such as the number of papers and books, communications at scientific meetings, organisation of seminars and conferences, advanced training (e.g. Master and PhD theses), computational applications, pilot plants, prototypes and patents. Goals were established for each call for proposals taking these indicators into account.

As an example, these were some of the results initially planned and then achieved in the call launched in 2012, within which 122 individual projects were funded: papers and books (estimated: 866 / achieved: 1381); communications (1021 / 2113); seminars and conferences (118 / 232); pilot plants (4 / 15); prototypes (23 / 50); patents (13 / 12).

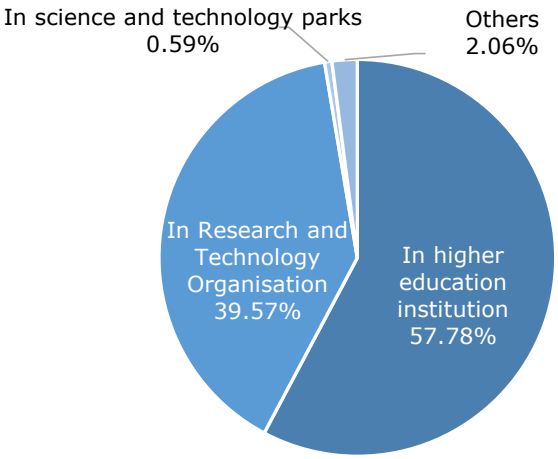
Looking at the data provided directly by FCT for this study, it can be concluded that in all calls for which information is available, achieved results have almost always exceeded the goals established for all indicators. However, given the fact that it is unclear how baselines and target values were established, these figures can only be seen to represent part of the overall story of the instrument and its performance.

The effects on **immediate outcomes** stated above suggest that the measure contributed to the increase of scientific production in the country and the **development of new scientific knowledge by the supported entities**. It can actually be perceived as the main instrument to support RTD individual projects in all scientific fields in the

[5] Augusto Mateus & Associados, 2018. "Avaliação do contributo dos FEEI para as dinâmicas de transferência e valorização de conhecimento em Portugal", Agência para o Desenvolvimento e Coesão, IP

mainland convergence regions during the 2007-2013 period, mainly benefiting HEIs and RTOs based in those regions.

Figure 17. ***Typologies of target beneficiaries in the context of RTD individual projects***



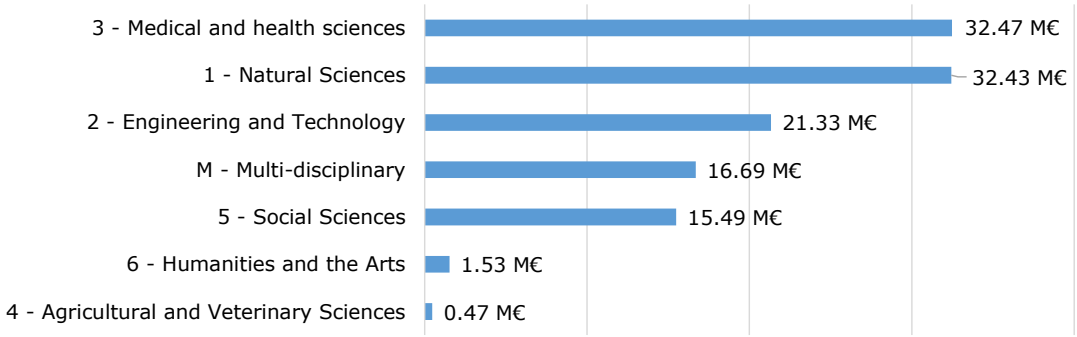
Source: CSIL elaboration based on Task 1 DB Projects and Beneficiaries

Interviews with programme managers and direct beneficiaries provided anecdotal evidence on the positive effects of the projects on the **development of new and enhanced scientific skills of the participating research groups**. Although it has been proven that supported projects have generated some **intellectual property rights**, it seems, however, that results have been somewhat limited regarding this specific outcome.

Regarding **intermediate outcomes**, the **reinforcement of the scientific and technological capacity** was often referred to in interviews with beneficiaries as one of the most relevant effects of the projects for the respective research centres. In fact, the provision of additional resources for the participating research groups - namely human resources and equipment – and the relatively high volume of results achieved in general by the projects supported by the measure, namely publications and communications, demonstrate that supported entities must have strengthened their scientific capacity.

As for results of **RTD projects transferred to external users for economic and social valorisation**, the overall project effects seem to have been relatively limited, although the technological deliverables resulting from some of them (e.g. prototypes, pilot plants, patents) suggested some potential for exploitation. The most represented fields in the approved projects were, by this order, Medical and Health Sciences, Natural Sciences and Engineering and Technology, naturally more prone to technology transfer activities.

Figure 18. ***Typologies of fields of science in the context of RTD individual projects***



Source: CSIL elaboration based on Task 1 DB Projects and Beneficiaries

However, it seems that, in general, the priority of these projects since its conception was not technology transfer. Information collected in the interviews confirmed nevertheless that some projects generated knowledge that was later economically and socially valorised, namely through research contracts, consulting services, technology transfer agreements, and patent licensing (although rare). A number of interviewees said that the public disclosure of project results led other entities (e.g. research groups and companies) to use them for scientific and commercial purposes in the following years.

The effects on expected **final outcomes** support the conclusion that **funded entities were empowered to participate in new and more ambitious RTD projects**. The strengthening of competences of scientific and technological entities allowed them to access more ambitious projects, whether with other scientific organisations or companies. It also empowered them for international cooperation. The results of a survey (Mateus & Associados, 2018) carried out with RTD entities funded under the COMPETE OP SAESCTN - Support to Entities of the National Scientific and Technological System, the instrument under which RTD individual projects in all scientific fields were supported - reported that 89% of beneficiaries said that there was an increase in their capacity for RTD activities in the future; 79% considered that projects facilitated their entry or reinforced their presence in international research networks; 90% reported that there was the production of new knowledge with potential for economic valorisation; 85% said they were better prepared to provide technological and consulting services to external organisations. These effects on the beneficiaries that carried out projects under the measure were partly confirmed by the interviewees, especially those who participated in projects with larger budgets (e.g. "RTD projects in research lines of excellence" and "RTD projects to consolidate skills and resources" modalities).

Concerning another expected final outcome – i.e. **strengthened international profile of supported entities -** the improvement of scientific and technological skills may have allowed national entities to reinforce their international visibility and access international projects more easily. In fact, the participation of Portuguese RTD entities in international programmes, and particularly in FP7, increased considerably in the period 2007-2013. There were around 2,400 participations of national entities in FP7 funded projects, raising about 520 million EUR (approximately 1% of the total budget; Portugal ranked 14th in the EU). The largest funding was obtained by RTOs (38% of total funding allocated to Portuguese entities), while Education Institutions (particularly universities) absorbed 28%. A significant number of RTOs and HEIs located in the convergence regions (those supported by the COMPETE OP) are among the main beneficiaries of FP7 support. The Portuguese participation in Horizon 2020 in the following years, 2014-2016, would achieve an even more positive evolution, reaching 1.6% of the total funding granted.

Interviewees stated that their participation in projects supported by the measure reinforced their capabilities to internationalise their activities, which is in line with the results of the survey referred to in the previous paragraph where 79% of SAESCTN beneficiaries considered that the projects facilitated their entry or reinforced their presence in international research networks. In spite of this, it was difficult to assess the extent of the contribution made by this measure to increase the participation of national scientific and technological entities in FP7 and H2020. RTD individual projects funded, for instance, missions abroad provided they were justified within the project activities, and this may have had some effect in terms of the presence in international science networks or projects. However, it is perfectly plausible that an increased scientific capacity may have contributed to making RTD actors better prepared to compete for European programmes funding.

Regarding the final outcome linked to **economic benefits for supported entities through the exploitation of RTD results**, anecdotal evidence collected from the interviews show that some projects with higher budgets (particularly those financed under the "RTD projects in research lines of excellence" and "RTD projects to consolidate skills and resources" modalities, or in the context of regular calls for proposals but with well above average approved budgets) have enabled the respective R&D centres to be in a better position to increase their revenues through commercial activities. In fact, information collected from the interviews suggests that only a minority of projects led to an increase in RTD centres' revenues through economic activities. And such revenues over the following years were obtained not so much from direct exploitation of project results (e.g. industrial property licensing agreements) but more from activities such as collaborative research established with companies, typically implemented under publicly funded projects for business innovation (more rarely in the context of direct financing from national or foreign firms).

The results of the above-mentioned survey carried out in 2018 with RTD entities funded under the SAESCTN reported that 16% of beneficiaries indicated that the projects led to the establishment of intellectual property rights licensing contracts; 28% had after the projects more collaborative contracts with companies for R&D projects; 28% had more technology service contracts, as well as more contracted research and services; 26% said that new spin-off companies were created; 22% reported that implemented new initiatives to demonstrate the developed technologies under the projects (e.g. pilot plants, demonstration projects). The conclusions drawn from the interviews conducted in this study suggest that those percentages will have been lower with respect to projects implemented within this measure.

The expected **impact** considered in the study regarding the **growth and strengthening of the National Scientific and Technological System** was achieved to a full extent, and all the evidence suggests that RTD individual projects in all scientific fields measure contributed to it. The national scientific and technological system did, in fact, become larger and enhanced during and after the implementation of COMPETE OP. The projects of the SAESCTN instrument generated a set of results (production of new fundamental and applied knowledge, generation and demonstration of ideas and technologies with the potential for valorisation, intellectual property rights etc.), giving rise to 95,720 publications, 94,845 communications in events, 6,130 prototypes or pilot plants, and 696 patent applications. Scientific production in Portugal observed significant high growth rates in the process of convergence with the EU average. From 2005 to 2014, the Portuguese contribution to published knowledge more than doubled, having an average annual growth rate of 11%.

Box 1. Examples of projects supported under the RTD individual projects instrument

ESPRESSO: a new spectrograph for the VLT - completing the coudé train
University of Porto
The project was the fourth component of the planned Portuguese support for the national participation in the project of a new high-resolution super-stable spectrograph for the European Southern Observatory (ESO) Very Large Telescope (VLT): ESPRESSO. It focused on the construction of some of the optical and optomechanical components of the "coudé trains" of the instrument.
http://www.iastro.pt/research/projectDetails.html?ID=125#

LabOPTO
University of Aveiro
The project enabled the I3N Associate Laboratory to reinforce its capacity on the development of micro and nanostructured materials, namely in the fields of medical physics and biomedical applications (e.g. optimisation of optical properties of materials), and sustainability and energy efficiency (e.g. development of highly efficient materials for photovoltaic, solid-state light emitters and NIR photodetectors).
http://labopto.web.ua.pt/

DURCOST - Innovation in reinforcing systems for sustainable prefabricated structures of higher durability and enhanced structural performance
University of Minho
A highly effective reinforcing system was developed for the prefabrication of concrete structures of a larger life cycle, combining glass fibre reinforced polymer and steel bars with a reinforcing ratio and a pre-stress level that assured required load capacity and ductility, as well as suitable thermal behaviour, mechanical resistance and durability.
http://repositorium.sdum.uminho.pt/handle/1822/21554

MASSIVE - Multimodal Acknowledgeable MultiSenSorial Immersive Virtual Environments
INESC TEC
The project led to the creation of the **MASSIVE Virtual Reality Lab dedicated to the** multidisciplinary study of the relationship between virtual reality technologies and different dimensions of human performance. It is considered a reference in the field of multisensory virtual reality nowadays.
https://massive.inesctec.pt/

Source: interviews with direct beneficiaries

Verification of assumed pre-conditions

Pre-conditions identified in the ToC were found to either have taken place to a full extent or to some extent.

Opening calls for proposals in all scientific topics (i.e. Health and Life Sciences, Engineering and Exact Sciences, Natural and Environmental Sciences, and Social Sciences and the Humanities) created opportunities for a wide range of RTD actors, while selectivity (project merit and research team scientific merit) was applied. This suggests the calls met, in general, the needs of the potential applicants (**pre-condition #1**), which was also the opinion of the interviewed beneficiaries. The change introduced as of 2012, with three new types of projects offered through two calls for proposals – "RTD exploratory projects" (one of the calls exclusively dedicated to this modality), "RTD projects in research lines of excellence", and "RTD projects to consolidate skills and resources" – may have better suited the funding available to the different applicants' needs.

The high number of project applications received shows that potential applicants were aware of the calls (**pre-condition #2**). Since this funding was very important for HEIs and RTOs, which would otherwise be difficult to obtain, interviewed direct beneficiaries thought that the scientific system was well aware of such opportunities. In the five calls for proposals analysed under the measure, more than 5,000 applications for individual projects were submitted.

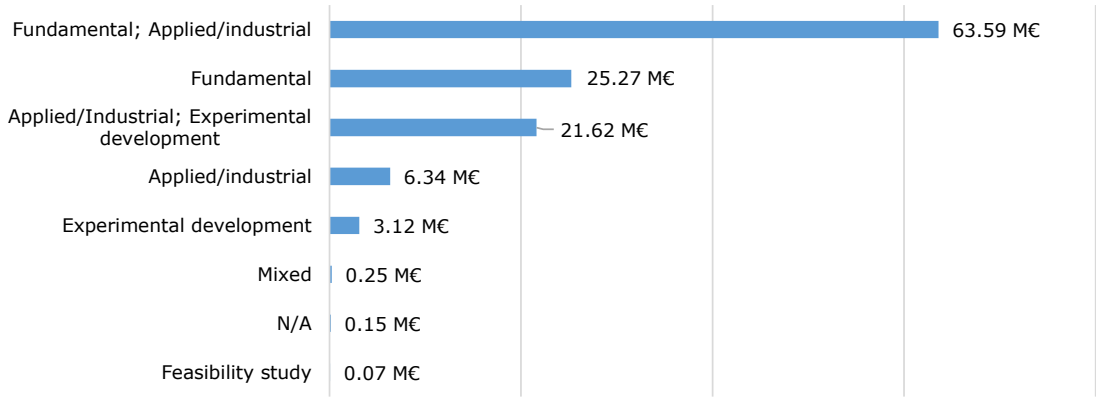
Evidence was collected that there was considerable selectivity regarding projects and beneficiaries (**pre-condition #3**) through peer reviewing evaluation processes. Project approval rates for funding ranged between 10% and 24%. In fact, many RTD actors failed to obtain funding under the measure, as ERDF funding seems to have been concentrated in HEIs (particularly universities) and RTO's that demonstrated greater capacity.

Necessary capacity and resources (human, financial, infrastructure) to implement the projects on the beneficiary side (**pre-condition #4**) was demonstrated to some extent. Many beneficiaries should already have experience in this type of calls, from both previous calls under the OP and previous ERDF cycle. Furthermore, also considering the selectivity applied, it is likely that many of them demonstrated effective capacity to implement the projects. On the other hand, the fact that the average of ERDF funding per project under the measure was about €87,000 raises the question of whether the projects had the necessary resources to achieve their goals. The interviewees - particularly direct beneficiaries - reported, however, that the financial scale of the projects was in general adequate. Nonetheless, it should be noted that the majority of projects interviewed were those with the highest budgets.

Another pre-condition considered under this exercise was that results stemming from the supported projects would have the potential to produce relevant new scientific knowledge (**pre-condition #5).** This pre-condition should have taken place. The fact that was a key measure to support RTD individual projects in all scientific fields, considering the immediate outcomes produced by the projects (e.g. papers, scientific communications, prototypes etc.), and also taking into account the applied selectivity regarding both funded projects and beneficiaries (capacity demonstrated by applicants was an important evaluation item), all suggest that supported projects must have produced new relevant knowledge.

Although the measure was strongly oriented towards the production of scientific knowledge, there were projects that achieved promising technological results regarding prototypes and patents with potential for economic valorisation in the medium and long term (results stemming from the supported projects with potential for economic valorisation was **pre-condition #6**). But observing the numbers related to immediate outcomes and also taking into account what was said by the interviewees, these projects seem to be a small minority. As such, this pre-condition took place only to some extent. As can be seen in the figure below on the types of RTD activities that absorbed more ERDF funds, projects that had only fundamental research activities ranked second. Such projects often lead to results at TRL levels 2 and 3, highlighting the fact that the measure supported many projects whose results were still far from the market.

Figure 19. Typologies of RTD activities in the context of RTD individual projects



Source: CSIL elaboration based on Task 1 DB Projects and Beneficiaries

The regulation established in the NSRF 2007-2013 period, which also apply to the COMPETE OP, established that in projects participated by several organisations, a consortium contract should be signed clarifying rights and duties of the participants regarding intellectual/industrial property. The project results that did not give rise to intellectual property rights could be widely disseminated, being the RTD entity the holder of all intellectual property rights resulting from its activity in the project. Scientific and technological entities were entitled to receive compensation equivalent to the market price from companies participating in the project for intellectual property rights that resulted from their activity in the project. Since this measure focused on individual projects, this issue was not directly related to the projects under analysis.

Concerning the existence of suitable regulation allowing the beneficiary organisations to achieve economic benefits generated from the transfer of any type of knowledge or exploitation of intellectual property (**pre-condition #7**), direct beneficiaries interviewed on this issue said that in general, the teaching career in higher education did not value joint activities with businesses. Institutional policies in HEIs regarding the participation of professors/researchers in knowledge transfer activities varied from one to the other, but in general, it was considered that university staff was not sufficiently motivated from the point of view of financial return or other types of compensation. Interviewees from Research and Technology Organisations (RTOs), which are entities more oriented towards applied and experimental research, expressed slightly different opinions, considering that their organisations motivated researchers for technology transfer activities satisfactorily. It is therefore considered that this precondition occurred only to a limited extent.

Verification of supporting factors

Evidence collected allowed to conclude that all identified supporting factors took place and positively influenced the level of achievement of intended results.

Alignment with other similar measures implemented in the previous ERDF cycle (**supporting factor #1**) was considered relevant to allow the measure to achieve the intended effects. In the literature review and interviews with programme managers, it was verified that the support measures for RTD entities in the period 2007-2013 meant a line of continuity in relation to the ERDF programming period 2000-2006, although the context of the support granted changed, as it was moved from a specific operational programme for science, technology and innovation (POCTI) to be included in a transversal operational programme to support economic competitiveness (COMPETE).

It was also considered that the measure would be more effective if there were other complementary measures that were part of a broader policy mix to support RTD entities within the National Strategic Reference Framework (NSRF) 2007-2013 (**supporting factor #2**). Indeed, as best described above in Section 2.3. and Section 3.1. there was a range of instruments that supported the entities of the scientific and technological system throughout this period, not only within the COMPETE OP (for example, the Support System to Research and Technological Development (SI RTD) in Axis 1 that promoted the relationship of NSTS entities with businesses), but also outside the OP (including, for example, the support available under regional operational programmes, or the Human Potential Operational Programme (POPH) that promoted scientific employment).

It was also admitted under this analysis that many beneficiaries had previous experience in applying and managing research grants, given their implication on national funding programmes (**supporting factor #3**). Actually, there is evidence that supports the hypothesis that this being a relevant measure to support the research carried out by scientific and technological entities in the mainland convergence regions, and considering that the measure comes in line with similar instruments available in the previous ERDF cycle, many of the supported entities should already have experience in applying for this type of funding. A survey carried out in 2012 to the coordinators of projects funded under the SAESCTN instrument concluded that 61% of respondents had already projects funded in the previous 2000-2006 cycle.[6]

The continuous growth and development of the national scientific and technological system were another of the supporting factors considered (**supporting factor #4**). Over the 2000-2010 period, the Portuguese R&I system benefitted from relevant developments regarding its scientific and technological base. For the first time, R&D expenditure was above 1% of GDP, reaching 1.6% in 2010 (it was 0.73% in 2000). Over that decade, the country registered one of the highest rates of growth in scientific production in Europe, including aspects such as R&D expenditure, tertiary education, R&D personnel, and scientific publications. Undoubtedly, this positive trajectory began to take place many years before and had an important boost within the previous EU support cycle (2000-2006). There is, therefore, evidence that this factor took place and positively influenced the measure under assessment.

It was also considered that continuous public investment in science, technology and innovation, including in the following ERDF cycle, would positively benefit the measured effectiveness (**supporting factor #5**). Within COMPETE OP Axis 1 - Knowledge and Technological Development, under which the RTD individual projects measure was allocated, ERDF funding was reinforced over three reprogramming exercises from €500m (OP beginning) to €642m (last reprogramming in 2015). The usual percentage of ERDF contribution to RTD individual projects also increased from 70% (OP beginning) to 85% (after 2012), which decreased the national co-funding effort. After all reprogramming actions, Axis 1 reinforced its relevance in OP total budget by increasing from 16% (initial programming) to 20% (last reprogramming of 2015). As indicated above in this section under the headline on the verification of intended intervention implementation, although it underwent a budget reduction with the first reprogramming action, the SAESCTN instrument ended the programming period with roughly the initial planned budget. Last but not least, the financial envelope for Science, Technology and Innovation actions was

[6] Augusto Mateus & Associados and PwC Portugal, 2013. "Estudo de avaliação intercalar do Programa Operacional Fatores de Competitividade", Programa Operacional Fatores de Competitividade – COMPETE.

also increased in the following ERDF cycle (2014-2020). It can, therefore, be concluded that this supporting factor has, in fact, occurred.

Verification of risks and threats

All potential risks and threats taken into account for this measure have materialised in some way, conditioning the intended results to some extent.

The ERDF contribution to RTD individual projects in all scientific fields (projects classified as ERDF priority theme #01 – R&TD activities in research centres) was about €120m. On average, each project received an ERDF funding of around €87,000 (ranging per project between €3,800 (minimum) and €421,000 (maximum)).

Table 6. Financial scale of RTD individual projects

Total ERDF contribution	Min ERDF contribution	Max ERDF contribution	Average ERDF contribution
120,416,927.52 €	3,765.93 €	420,612.90 €	86,630.88 €

Source: CSIL elaboration based on Task 1 DB Projects and Beneficiaries

Financial resources allocated to the measure may, therefore, have led to an average size of projects with limited critical mass hindering the implementation of more complex projects **(risk #1)**. Although this risk may have been materialised in some way, it must be taken into account that the funding of projects with relatively high budgets (i.e. close to €200,000) was possible in the context of regular calls for RTD individual projects in all scientific fields. In order to support more ambitious and resource-intensive projects, a call was launched in 2012 to fund activities up to €500,000 through the "RTD projects in research lines of excellence" and "RTD projects to consolidate skills and resources" typologies.

Looking at the low approval rates of funded projects, it appears that given the limited existence of financial resources, it was decided to support fewer projects and guarantee them a minimal scale instead of funding more projects with lower budgets. On the other hand, in the interviews carried out, the level of funding was considered satisfactory by project beneficiaries, although it should be emphasised that most of the interviews involved projects with a larger financial scale than average.

Furthermore, evidence collected in the framework of other assessment exercises on the OP highlighted that SAESCTN's projects performed overall better in the number of scientific and technological deliverables (e.g. scientific papers, pilot installations, patents) per million euros of funding than projects that also produced scientific deliverables carried out under other OP instruments, revealing a higher degree of efficiency of the SAESCTN instrument compared to others.

Inherent risks to the implementation of RTD projects (trying out new, untested ideas, including risks related to time, costs, resources, technology etc.) may also have occurred (**risk #2**). Although the materialisation of these risks may have happened differently at the level of each project, anecdotal evidence gathered from interviews - both with project beneficiaries and OP managers - suggests that, in general, there were no significant deviations between goals and results achieved (although with identified exceptions).

Actually, scientific results of the projects were in general higher than estimated goals, which was confirmed both by data provided by FCT and by numbers revealed by the interviewees.

It was also considered that reduced links of supported entities to the business community and society at large might have hindered the economic and social valorisation of project results (**risk #3**). The fact that these were individual projects run by NSTS entities and their objectives were mainly related to the production of scientific knowledge may have

hindered the valorisation of results. Although the 2007-2013 ERDF cycle encouraged collaboration between RTD actors and industry (including, for instance, specific measures to support business innovation in which scientific and technological entities took part), until this period, there was in general relatively little tradition of science-business collaboration. This risk is therefore considered to have materialised, moreover because, at that time, many R&D institutions (namely HEIs and RTOs) had internal structures for interfacing with businesses performing incipiently.

3.2.3. General assessment

On the basis of the effects observed by the evaluation team, RTD individual projects led by entities of the scientific and technological system have, in general, been effective in reaching their intended activities, outputs and outcomes. Given the confirmation of the existence of the necessary pre-conditions and supporting factors, the contribution of the instrument to the observed results is considered to be high.

Intended outputs of the instrument – grants delivered to beneficiaries and projects effectively implemented - were generally achieved as expected, benefiting from the existence of the necessary pre-conditions (e.g. applicants' resources and capacity), supporting factors (e.g. previous experience in managing research grants), and non-occurrence of influential risks that could significantly jeopardise the measured effectiveness. The activities of the policy instrument (i.e. calls for proposals to support individual projects led by entities of the scientific and technological system in all scientific fields) was the main cause leading to the observed outputs.

The supported projects generated a relatively high number of scientific deliverables – immediate outcomes - including 22,415 publications (99% of the projects produced publications; an average of 15.4 publications/project), as well as 22,710 communications in seminars/conferences (85% of the projects generated communications; average 18.1 communications/project). Furthermore, a total of 1,673 prototypes and pilot plants were delivered (27% of the projects led to a prototype or pilot installation, an average of 4.2 prototypes/pilot installation per project) and 128 patents (5% of the projects led to patent applications).

The effects on immediate outcomes stated above demonstrate that the measure contributed to the advancement of knowledge (mainly fundamental and applied) and new and enhanced scientific skills in the supported entities, although with limited results in generating intellectual property rights. The supported projects contributed to such developments being one of the causes leading to the observed immediate outcomes.

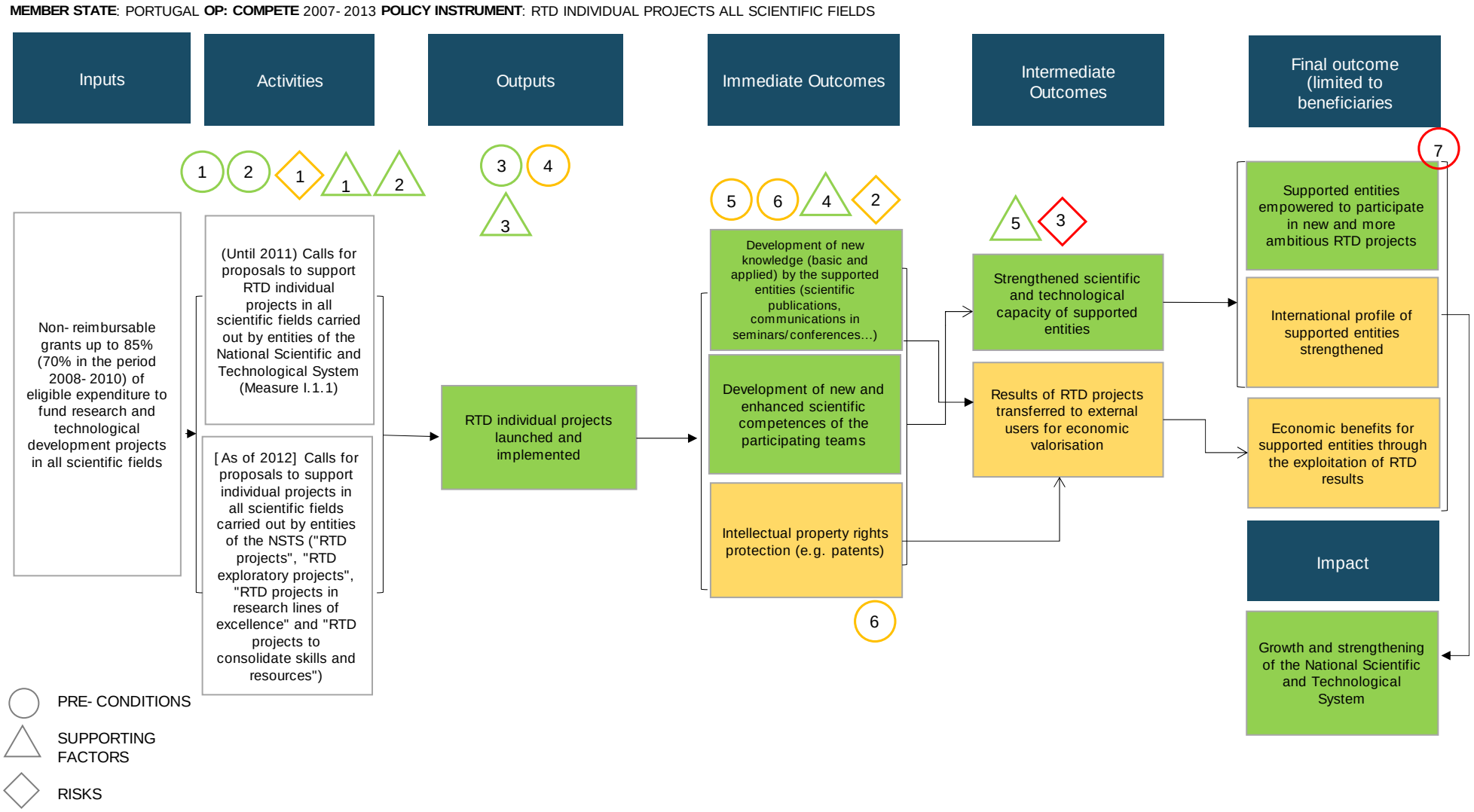
The strengthening of scientific and technological capacity was often referred to by the interviewed project beneficiaries as one of the most relevant intermediate outcomes for the respective research centres. In fact, the relatively high volume of scientific production achieved in general by these projects shows that participating entities must have strengthened their scientific capacity. The development of new scientific knowledge and skills by the supported entities under the previous immediate outcomes is one of the causes that led to this effect.

Another expected intermediate outcome – knowledge transfer to the market – seemed to have taken place with limited relevance, although there was a number of projects whose results could, in principle, have some market potential. This performance, in addition to being projects that did not have knowledge transfer as a priority, contributed to the fact that not all pre-conditions occurred at this stage of the causal chain, namely the existence of project results at higher TRL levels that could be economically exploited in the short term and, in some cases, still few links to the business community (one of the identified risks that seem to have materialised).

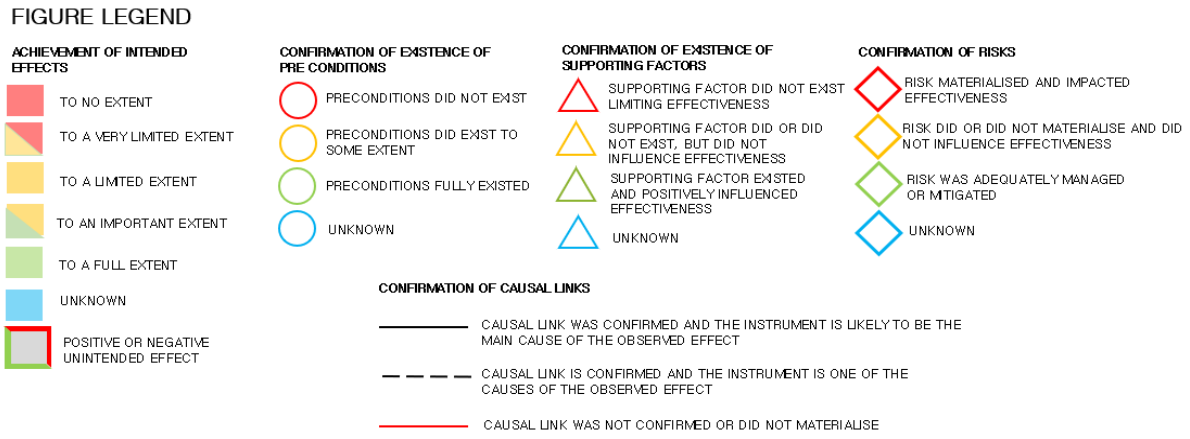
Expected final outcomes regarding the empowerment of the supported entities to participate in more ambitious RTD projects and the strengthening of their international profile have been achieved. The reinforcement of scientific and technological capacity (intermediate outcome) mentioned in the previous paragraph was one of the causes enabling such final outcomes. On the other hand, rather limited benefits were identified for the supported entities generated by the economic exploitation of project results.

Despite the fact that some of the intended outcomes have been achieved to a limited extent, there is sufficient evidence to conclude that the measure contributed in a relevant way to the growth of the national scientific and technological system (final impact).

Figure 20. Representation of the results of the contribution analysis for RTD individual projects in all scientific fields



Source: Evaluation team based on primary and secondary data collected



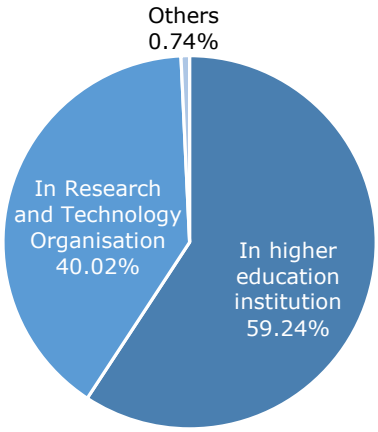
3.3. Policy instrument: RTD strategic projects developed in areas of public interest led by entities of the scientific and technological system (individual projects)

3.3.1. Theory of Change of the policy instrument

The measure was intended to support R&D centres of excellence in the convergence regions, providing them with human and material resources so as to contribute to increasing their scientific and technological capacity. Only Associate Laboratories and R&D entities rated as "very good" or "excellent" were eligible to apply for available funding.

The "Associate Laboratory" label was granted to RTD entities by the Ministry of Science, Technology and Higher Education through an assessment and selection process. Associate Laboratories usually consisted of R&D units or institutes from different HEIs that should have a strategic research agenda, carry out research of excellence, and demonstrate suitable capacity to address research challenges with a global dimension.

Figure 21. Typologies of target beneficiaries in the context of RTD strategic individual projects



Source: CSIL elaboration based on Task 1 DB Projects and Beneficiaries

Two calls for proposals were launched under this measure throughout the NSRF 2007-2013. In the first call (2011), they were eligible to apply Associate Laboratories, and R&D Units rated as "very good" in the last international evaluation carried out by the Foundation for Science and Technology. In the second call (2013), Associate Laboratories and R&D Units rated as "excellent" were eligible.

Altogether in the two calls, 106 projects were approved for funding (92 individual projects and 14 collaborative projects), accounting for an eligible investment of about €94m (ERDF contribution of €79.5m). The 92 individual projects had an ERDF support of €51.2m. Since these were calls where the entities to be financed were identified from the beginning, the number of applications corresponding to the number of funded projects (i.e. 106). All projects had their eligible expenses 100% funded, as in addition to the percentage financed by ERDF (up to 85%), national funds delivered by FCT covered the remaining 15%.

A change was introduced from the first to the second call. While in the first call, applicants could be R&D Units rated as "very good" by the international assessment run by FCT, in the second call, applicants were required to be rated as "excellent". As a result, the number of projects approved for funding decreased considerably from the first to the second call (i.e. from 71 to 35 projects).

In fact, these calls addressed the most outstanding R&D organisations in the target regions with the aim of strengthening their capacity and making them competitive on a global scale. The average size of projects in terms of funding was relatively high (average ERDF contribution was about €560,000 per project for two-year projects), which must be considered as significant support, taking into account the average funding for RTD projects supported in other measures.

Total ERDF contribution	Min ERDF contribution	Max ERDF contribution	Average ERDF contribution
51,205,747.41 €	59,109.11 €	3,522,162.28 €	556,584.21 €

Table 7. Financial scale of RTD strategic individual projects

Source: CSIL elaboration based on Task 1 DB Projects and Beneficiaries

The projects typically aimed at developing the main research lines of supported entities, which in turn committed to achieving certain goals related to their scientific production (e.g. number of papers, communications, organisation of seminars/conferences, Master and PhD theses, prototypes, patents etc.). These can be seen as projects of an institutional nature, structuring the activities of the respective research groups, and well embedded in strategic research plans, aiming at guaranteeing certain basic funding that could leverage the work of supported R&D centres.

Table 8. Top 10 institutions where ERDF contribution was concentrated in the context of RTD strategic individual projects

Institution	Type of direct beneficiary	ERDF contribution (EUR)	ERDF contribution as % of the total ERDF contribution policy instrument
University of Aveiro	HEI	11,463,847.14	22.39%
University of Coimbra	HEI	6,441,199.47	12.58%
Centre for Neuroscience and Cell Biology - University of Coimbra	RTO	6,200,566.53	12.11%
University of Minho	HEI	5,046,817.63	9.86%
LIP - Laboratory of Instrumentation and Experimental Particle Physics	RTO	4,215,827.93	8.23%
IPATIMUP - Institute of Molecular Pathology and Immunology – University of Porto	RTO	3,653,053.50	7.13%
CES - Centre for Social Studies - University of Coimbra	RTO	3,585,735.10	7.00%

Faculty of Engineering - University of Porto	HEI	1,900,552.82	3.71%
University of Évora	HEI	1,609,523.15	3.14%
ICETA - Institute of Sciences, Technologies and Agro-Environment - University of Porto	RTO	1,125,043.57	2.20%
Total ERDF contribution to top 10 institutions		45,242,166.84	88.35%
Total ERDF contribution to the policy instrument		**51,205,747.41**	

Source: CSIL elaboration based on Task 1 DB Projects and Beneficiaries

The implemented RTD individual strategic projects funded by the COMPETE OP through the ERDF represented the main outputs of the measure, upon which all further effects (i.e. immediate, intermediate and final outcomes, as well as impact) were meant to be generated.

The development of a Theory of Change (ToC) exercise distinguishes between four levels of results generated through a causal chain:

Immediate outcomes, which were short-term effects that occurred once the outputs were achieved: **1)** the development of new knowledge (basic and applied) by the supported entities observable through results such as scientific papers, communications in events, prototypes, pilot plants, patents etc.; **2)** development of new and enhanced scientific skills of the participating research groups; and **3)** generation of intellectual property rights.

Intermediate outcomes, which were medium-term effects generated once previous immediate outcomes were achieved, typically after the funded projects have been completed, including **1)** strengthened scientific and technological capacity of supported entities, and **2)** RTD project results transferred to external users for economic/social valorisation.

Final outcomes, which were the most fundamental changes to which projects contributed through the achievement of the intermediate outcomes and taking the form of a sustainable change of state among beneficiaries. The following expected final outcomes have been considered in the study for this measure: **1)** supported entities empowered to compete on the European and global markets of R&D; **2)** benefits for supported entities through the valorisation of RTD results.

Impact, which refers to potential long-term effects generated after the 2007-2013 period (with some potentially still being generated today), having been considered for this level of results **1)** the growth and strengthening of the national scientific and technological system (NSTS), and **2)** economic development, competitiveness and innovation capacities of mainland convergence regions.

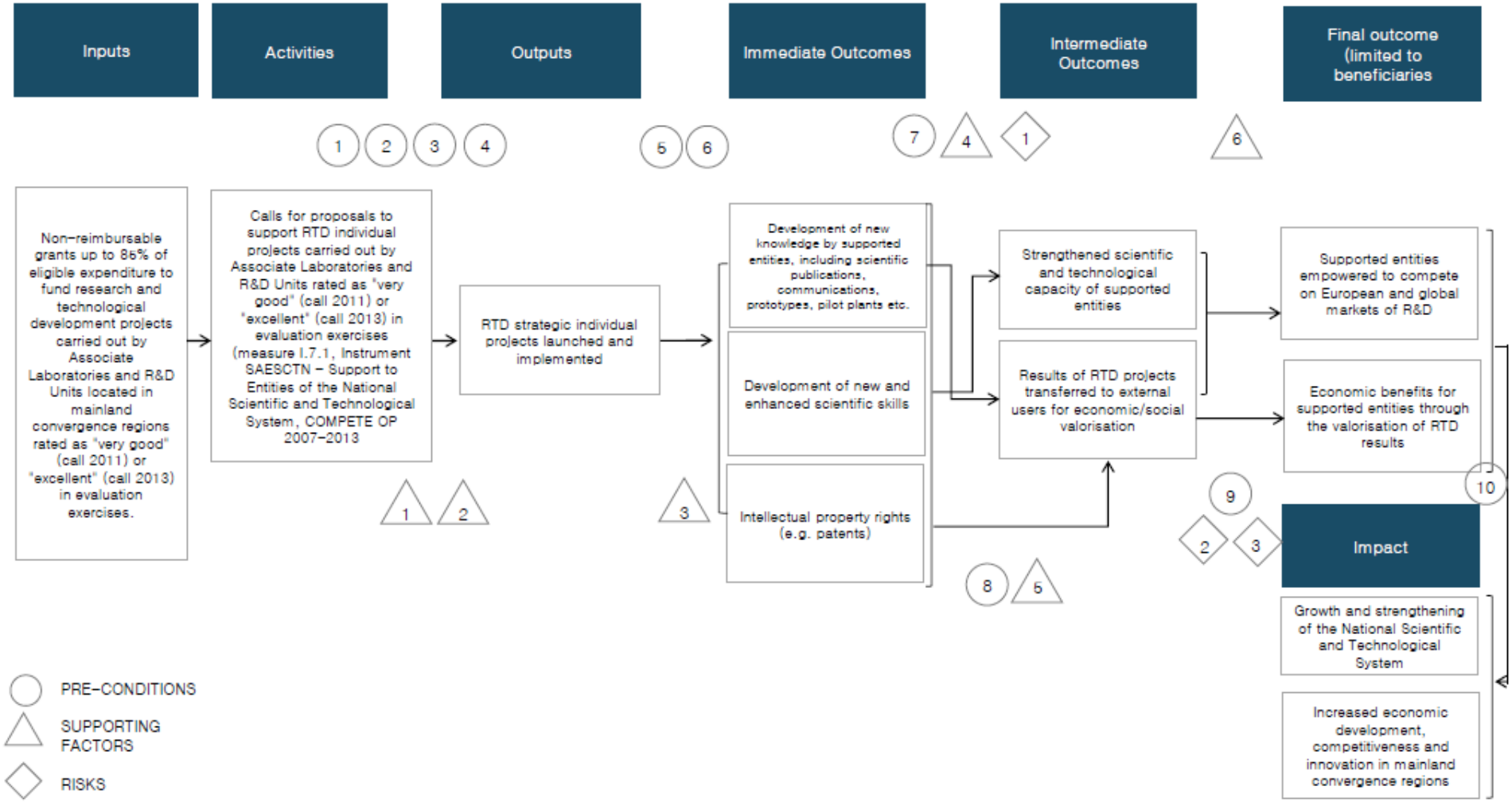
As is the case for the individual RTD projects instruments, formal documentation from the COMPETE OP provided a starting point for the development of a Theory of Change (ToC) for the RTD strategic individual projects measure, especially regarding the identification of some of the intended effects. The fact that no specific thresholds were formally identified for the measure within the OP, with the exception of a number of immediate outcomes for which goals were set by the Foundation for Science and Technology, also represented a challenge for the contribution analysis. As a result of this, the extent to which intended effects have been generated has mainly relied on criteria defined by the evaluation team, as well as on data and information collected through secondary sources.

As can be seen in the figure below, the level of achievement of intended immediate, intermediate and final outcomes, as well as impact, is generally high, although with some exceptions particularly related to the valorisation of projects results. A table is presented in the Appendix containing more specific information on the data collected for each of the expected effects and the assessment of the expected threshold for each one of these.

The ToC uses arrows to illustrate the causal pathways between the different levels of instrument intended effects. In order to build a complete ToC, the evaluation team had to recur to a number of additional sources, including literature review carried out as part of this evaluation, interviews with programme managers and beneficiaries, as well as own knowledge and insight about the operational programme. This has led to the development of the ToC presented in the following figure with the intention of illustrating the intended effects of the policy instrument, the underpinning pre-conditions, supporting factors and potential risks and threats.

Figure 22. ToC for the RTD strategic individual projects instrument

MEMBER STATE: PORTUGAL OP: COMPETE 2007PT161PO001 POLICY INSTRUMENT: RTD Strategic Individual projects (Measure I.7.1.)



Source: Evaluation team based on primary and secondary data collected.

Legend:


Pre–conditions
1 The measure meets the effective needs of potential applicants
2 Calls for proposals reach potential applicants
3 Applicants have the necessary capacity to prepare suitable project proposals
4 The implementing agent of the policy instrument has the necessary capacity to effectively carry out the calls
5 Applicants have the necessary capacity and resources (human, financial, infrastructure) to implement the projects
6 Project grant agreements include KPIs and are evaluated through appropriate performance assessment
7 Results stemming from the supported projects have potential to produce relevant new knowledge at international level
8 Results stemming from the supported projects have potential for economic, social and/or cultural valorisation
9 The industrial sector has the capacity to launch innovations based on R&D project results
10 Existence of suitable regulation allowing the beneficiary organisations to achieve economic benefits generated from the transfer of any type of knowledge or exploitation of intellectual property
Supporting factors
1 The measure is aligned with other similar measures implemented in the previous ERDF cycle (2000-2006), which contributed to the continuous growth of the scientific and technological system
2 The measure is part of a broader policy mix to support entities of the scientific and technological system
3 Beneficiaries have previous experience in applying and managing research grant given their implication on national funding programmes
4 Existing growth and development of the national scientific and technological system
5 Existing mechanisms to support knowledge and technology transfer (e.g. technology transfer offices and technology brokers)
6 Continuous public investment in science, technology and innovation, including in the following ERDF cycle
Risks and threats
1 Inherent risks to the implementation of RTD project s (i.e. trying out new, untested ideas, including risks related to time, costs, resources, technology etc)
2 Reduced links of the supported entities to industry may hinder the economic valorisation of the project results
3 RTD project results are not appealing for industry to exploit them economically

3.3.2. Contribution analysis

Verification of intended intervention implementation

In the contribution analysis of the previous measure on individual projects in all scientific fields (section 3.2.2.), some difficulties were mentioned in the initial implementation of the SAESCTN instrument, namely communication issues between the OP Management Authority and the Intermediate Body and a reduction of the budget proposed for SAESCTN when the OP was reprogrammed for the first time (budget cut that would later be returned). From the information collected in the interviews, none of these problems seems to have affected this measure in particular, which was carried out as planned from an operational viewpoint. This includes the operationalisation of the two calls, as well as the implementation of the projects regarding both technical and financial execution.

Despite the reprogramming actions in the OP COMPETE, there was no change in the intervention logic of the measure for RTD strategic individual projects all over the programming period. However, a change occurred from the first to the second call. While in the first call, applicants could be R&D Units rated as "very good" by the latest international assessment run by FCT, in the second call, applicants were required to be rated as "excellent". As a result, the number of projects approved for funding decreased considerably from the first to the second call (i.e. from 71 to 35 projects). This change had mainly to do with budgetary constraints (in order to avoid reducing the budget of the projects, it was decided to decrease the number of entities eligible for funding) but also coincided with a political change with the entry into office of a new government that will have chosen to concentrate available funding on a more restricted number of entities.

In the interviews with beneficiaries, no relevant deviations were reported regarding project implementation. Some difficulties were mentioned with regard to public procurement procedures (purchase of goods, services and equipment, including acquisitions at the international level), mainly due to the delays they entailed, but which will not have greatly affected final results. One of the remarks most mentioned by beneficiaries was the scarcity of time to implement planned activities, as it was not always possible to extend the deadline for closing the projects. The Intermediate Body recognised difficulties in extending project deadlines - also for other types of RTD projects – and particularly for projects that started closer to the end of the programming cycle, but such requests could not be met due to the need to respect the rules of the ERDF funding (i.e. end date of projects could not exceed the end of the programming period).

A remark also mentioned by the interviewees was the relatively frequent delay in signing contracts/acceptance forms with the Intermediate Body, meaning that projects often formally started with dates prior to the dates of signature of the acceptance forms. Such delays could reach a few months and, in practice, implied that in the time that elapsed between the formal start date and the signature of the forms, projects might have had rather a low level of activity.

Achievement of intended and unintended effects at the level of the expected threshold

The RTD strategic projects (typology individual projects) generated 42,711 publications (100% of the projects produced publications; an average of 464.3 publications/project); and led to 42,265 communications (100% of the projects generated communications; an average of 459.4 communications/project).

Furthermore, strategic individual projects gave rise to 1,429 prototypes and pilot plants (45% of the projects led to a prototype or pilot plant, an average of 35 prototypes/pilot plant per project) and 290 patents (50% of the projects led to patent applications).

It is interesting to compare the results of the RTD strategic individual projects with the outcomes of the general RTD individual projects funded under the measure described above in Section 3.2. While strategic projects generated an average per project of 464 publications, 459 communications, 35 prototypes and pilot plants and 6 patents; individual projects supported by regular calls for all scientific topics generated an average of, respectively, 15 publications, 18 communications, 4 prototypes/pilot plants and less than 2 patents.

The number of papers and books, communications, seminars and conferences, advanced training actions (e.g. Master and PhD theses), computational applications, pilot plants, prototypes and patents, are among the project deliverables (immediate outcomes) for which the Foundation for Science and Technology (FCT) established thresholds.

Through data provided directly by FCT for this study, it can be concluded that in the two calls mentioned above, achieved results have almost always exceeded the goals established for all indicators. Considering as an example, the first of these calls (implemented in 2011), these were the estimated and achieved results taking into account 71 funded projects (also including some collaborative projects):

- Books: estimated 777 / achieved 3,222;
- Papers: 14,037 / 20,577;
- Communications: 16,821 / 31,812;
- Seminars and conferences: 2,262 / 4,249;
- Theses (e.g. Master, PhD): 6,417 / 10,351;
- Pilot plants: 68 / 802;
- Prototypes: 220 / 269;
- Patents: 180 / 239.

In addition to the production of new knowledge that the above results prove, another immediate outcome for which there is sufficient evidence was the development of key scientific skills. In fact, the considerable volume of scientific production should have led to the strengthening of beneficiaries' skills. Furthermore, in the scope of the 106 projects financed by the measure (including here collaborative projects), 15,805 theses (mostly PhD and Master theses) were carried out, and many (especially young) researchers were hired, which reinforced the human capital of the involved research groups. This was indeed one of the effects stemming from the projects most valued by the interviewed beneficiaries.

As mentioned above, 290 patent applications were filed from strategic individual projects. About 50% of projects generated industrial property rights, so this expected outcome took place to a relevant extent.

Box 2. Examples of projects supported under the RTD strategic individual projects instrument

Centre for Neuroscience and Cell Biology (CNC) - University of Coimbra

The Strategic Project "LA1 - 2013-2014" was carried out by the Centre for Neuroscience and Cell Biology (CNC) at the University of Coimbra. With a duration of two years and a budget of €3.3m, the project focused on the development of CNC main research lines in areas such as neurodegenerative disorders, stem cells, mitochondria, and drug carriers. It involved 381 full-time equivalent (FTE) researchers, giving rise, among other outcomes, to 5 books, 199 publications in international journals, 81 communications at international scientific meetings, 128 communications at national scientific meetings, organisation of 82 seminars and conferences, 69 PhD theses, 84 Master theses, and 5 patents.

CESAM - Centre for Environmental and Marine Studies - University of Aveiro

The Strategic Project "LA17 - 2011-2012", led by CESAM - Centre for Environmental and Marine Studies of the University of Aveiro, had a budget of €2.2m for a period of two years. The project was developed around several topics related to marine sciences and the environment, such as coastal environment, global changes, marine resources, and biodiversity. It generated, among other deliverables, 13 books, 742 publications in international journals, 833 communications at international scientific meetings, 151 communications at national scientific meetings, 61 PhD theses, 182 Master theses, 9 models, 3 patents, and 1 laboratory prototype.

Source: interviews with direct beneficiaries

On the topic of **intermediate outcomes**, it is also evident that these projects have **strengthened the scientific and technological capacity** of the funded entities, being this one of the main objectives of the calls under which the projects were supported. The reinforcement of teams with more human resources, the provision of new equipment (in some cases large equipment) and the acquisition of essential materials and services ensured the beneficiaries enhanced conditions to develop their main research lines.

Concerning another expected outcome - **RTD project results transferred to external takers for economic and social valorisation –** there is a significant difference here in relation to the majority of projects supported by other measures of SAESCTN, as the interviews carried out with the beneficiaries of strategic projects revealed that there was indeed a certain level of knowledge and technology transfer from the project results.

Activities such as licensing agreements and the creation of university spin-off companies were identified in the interviews. But other ways of transferring knowledge outside the research centres have also been found, including other types of technology transfer agreements (e.g. material transfer agreements, contracts for facilities use and service agreements), joint doctoral theses with companies, research contracts, and new publicly funded projects (particularly with national companies, as cooperation with foreign firms took place mainly through direct research contracts).

The survey conducted in 2018 that has been referred to in this case study revealed that 16% of SAESCTN beneficiaries reported that their projects led to the establishment of intellectual property rights licensing contracts; 28% had after the projects more collaborative contracts with companies for R&D projects; 28% had more technology service contracts, as well as more contracted research and services; 26% said that new spin-off companies were created; 22% reported that they implemented new initiatives to demonstrate technologies developed under the projects (e.g. pilot plants, demonstration projects). The information collected from the interviews conducted by the evaluation team for this case study support the numbers obtained in the survey. Actually, the percentages achieved by individual strategic projects may even have been higher for a number of indicators.

Evidence was also collected from project beneficiaries indicating that strategic projects have contributed to increasing the international visibility of supported research groups. The dissemination of research results in international journals and events, organisation of

events with the participation of renowned foreign scientists, recruitment of foreign researchers, and eligibility of expenditure related to missions abroad in order to have a greater presence in international consortia are among identified activities that helped beneficiary entities to strengthen international connections and participate more frequently in projects funded by FP7 and H2020. In some cases (although rarer), there were also agreements established with foreign companies (typically large multinational firms) for carrying out collaborative research contracts. One of the expected **final outcomes** from strategic projects - **funded entities empowered to compete on the European and global markets of R&D** - seems, therefore, to have been achieved.

Furthermore, within the scope of the survey mentioned above, 79% of SAESCTN beneficiaries considered that the projects facilitated their entry or reinforced their presence in international research networks.

Concerning another intended final outcome – **economic benefits for supported entities through the valorisation of RTD results** – it was possible to identify in the interviews several activities of technology transfer, including licensing agreements, creation of spin-off companies, provision of technological services, and establishment of new research contracts with companies. New RTD-funded projects with companies were also reported, both at national and European levels.

These activities have meant some financial return for the entities participating in this measure. However, the one that in general perhaps generated the most significant revenue was the implementation of new RTD-funded projects with national companies under the following ERDF programme period 2014-2020, which obviously does not entail income from the market.

The overall results generated by the strategic individual projects contributed to a full extent to achieve one of the expected impacts considered in this study, which was the **growth of the National Scientific and Technological System.** In fact, the scientific system did become larger during and after the implementation of the COMPETE OP. The projects supported under the SAESCTN instrument caused a considerable volume of results with visible positive effects in the production of fundamental and applied knowledge and in the generation and demonstration of ideas and technologies with the potential for valorisation. 95,720 publications, 94,845 communications in events, 6,130 prototypes and pilot plants, and 696 patent applications are among the numbers that illustrate the scale of results. In the period to which COMPETE OP 2007-2013 is concerned, the scientific production in the country observed significant growth rates in the process of convergence with the EU average. In the 2005 to 2014 period, the Portuguese contribution to published knowledge more than doubled, having an average annual growth rate of 11%.

One of the potential impacts taken into account in this study resulting from the implementation of the measure was the **increase of competitiveness and innovation in mainland convergence regions.**

As described in previous sections, SAESCTN - Support to Entities of the National Scientific and Technological System was an instrument to support Science and Technology policies, being a crucial source of funding for RTD projects carried out mostly by Higher Education Institutions and Research and Technological Organisations based in convergence regions. Essentially, these were projects with scientific objectives whose results in most cases were still far from the market. Moreover, the participation of companies in all SAECSTN measures was, in fact, very low.

It is also important to note that projects funded by SAESCTN, which had goals and activities more related to technology transfer, were classified in terms of ERDF expenditure category as thematic priority "03 - Technology Transfer", and as such not

considered in the scope of this case study. However, as highlighted above, individual strategic projects have generated a number of effects in terms of potential economic and social valorisation, such as licensing agreements, knowledge transfer agreements and other types of technology transfer agreements; creation of spin-off companies; provision of technological services; research contracts with companies; and new RTD projects with businesses, among others. According to the information collected from the interviews, those were the main ways the projects supported by the measure contributed directly to innovation and competitiveness in convergence regions.

On the other hand, as explained above in section 3.1., the main contribution of the COMPETE OP to increase business competitiveness and innovation was made through other implemented instruments, particularly under the OP Axes 1 and 2, addressing topics such as knowledge and technology transfer, business R&D and innovation, and innovative entrepreneurship. Such instruments include, for instance, the Support System to Research and Technological Development (SI RTD, Axis1), which supported business R&D activities in conjunction with actors from the scientific and technological system; and instruments funded under Axis 2, namely SI Innovation - Innovation Incentive System (new products, services, processes, technologies) and SI SME Qualification and Internationalisation Incentive System (competitive business factors such as quality, management, design, internationalisation etc.). The OP intervention to boost innovative entrepreneurship was implemented through instruments such as SI RTD, SI Innovation, venture capital schemes and business angels (launched under OP Axis 3) and some actions supported by the Collective Actions Support System (SIAC) under OP Axis 5.

One of the main impacts sought by the COMPETE OP was to change the pattern of specialisation of the national economy, namely by increasing the relevance of economic activities with greater knowledge and technology intensity. Studies carried out after the NSRF 2007-2013 concluded, however, that there was no clear increase in more knowledge and technology-intensive activities, especially in the manufacturing industry (in the tertiary sector, the evolution will have been a little more positive). In fact, the Gross Value Added (GVA) of sectors of low-, medium-low, medium-high and high-technology remained practically unchanged throughout the period 2008-2015. Although a very significant investment was made in RTD activities (including also a wide range of measures that supported business innovation), it looks like it would take a few more years to observe an effective trend with more technology-intensive activities in the national specialisation pattern.

Verification of assumed pre-conditions

Most of the pre-conditions identified in the ToC were found to either have taken place to a full extent or to some extent.

The measure was intended to support the country's R&D centres of excellence so that they could be a reference on a global scale. The funded projects had an institutional nature, aiming at developing the main research lines of supported entities and ensuring certain basic funding that could leverage their activities. By involving Associate Laboratories and R&D units rated as "very good" and "excellent" by the Foundation for Science and Technology, the measure will have met the needs of these specific applicants (**pre-condition #1**), which was also the opinion of the interviewed beneficiaries. The average size of projects in terms of funding was relatively high (average ERDF contribution was €560,000 for two-year projects), which must be considered as significant support, taking into account the average funding for RTD projects supported by other measures.

Since these were calls for proposals where the entities to be funded were identified from the beginning, the number of applications corresponding to the number of funded

projects. The assumption that the calls for proposals would reach the potential applicants (**pre-condition #2)** thus seems to have occurred. Each entity could only submit one project under each call, and there is evidence that all applicants had approved projects.

Capacity and resources to prepare suitable project proposals were demonstrated by the applicants (**pre-condition #3**). In general, applicants were entities with relevant experience in submitting project proposals, either to national or European programmes. The interviews showed that many of the beneficiaries already had experience in preparing and submitting project applications in previous ERDF programming cycles.

The Intermediate Body responsible for managing these calls was the Foundation for Science and Technology (FCT, Ministry of Science, Technology and Higher Education). Created in 1997, FCT is the state entity in charge of the implementation of science and technology policies, namely by funding R&D institutions and infrastructures, R&D projects, scientific employment, advanced scientific training, science internationalisation etc. Within the COMPETE OP 2007-2013, FCT was, therefore, the public organisation best positioned to take the role of Intermediate Body and to deal with the measures aiming at supporting entities of the scientific and technological system. In interviews with beneficiaries, the necessary capacity of the implementing agent to effectively carry out the calls for proposals (**pre-condition #4**) was considered to be positive.

Nevertheless, despite the accumulated experience in previous programming cycles in the management of calls for proposals and monitoring of science and R&D projects, FCT would also experience some difficulties in the implementation of SAESCTN. In fact, FCT considered that the transition from an operational programme dedicated to science and technology in the previous programming period to a transversal operational programme whose focus was to support economic competitiveness (COMPETE) resulted in greater and more complex administrative and bureaucratic burden. The high number of project applications received under the calls launched in this period, and the more than 2,500 projects funded and monitored in all measures of SAECSTN, meant a demanding challenge for the Foundation as the Intermediate Body.

Necessary capacity and resources (human, financial, infrastructure) to implement the projects by the beneficiaries (**pre-condition #5**) was demonstrated. These were the R&D centres with the best performance in international assessments launched by FCT. Most of them had extensive experience in the execution of funded projects.

One of the pre-conditions considered for the effectiveness of the measure was the existence of KPIs in order to ensure an appropriate project performance assessment (**pre-condition #6**). Since the measure mainly supported the development of beneficiaries' main lines of research, performance measurement focused on scientific production indicators such as books, articles, communications, events, advanced scientific training, computer applications, pilot plants, prototypes, and patents. Given the nature of the projects, the indicators are considered to be adequate. But looking at the global data on estimated and reached goals for all projects in both calls, it seems that, in general, achieved goals are considerably higher than expected, which suggests that for the majority of beneficiaries, it will not have been difficult to meet the objectives set at the beginning of the projects. This was also confirmed in the interviews, as it was generally reported that final results were almost always above estimated goals. This pre-condition is therefore considered to have materialised to some extent.

Taking into consideration, this was a key measure to support top R&D units in the country's mainland convergence regions, as well as the immediate outcomes accomplished, supported projects should have produced relevant new knowledge at the international level (**pre-condition #7**), which was an objective of the respective calls. Activities such as published papers in international journals and organisation and

participation in international events have taken place extensively, which facilitated entry in international research networks and in FP7 and H2020 consortia.

Although being a measure strongly oriented towards the production of scientific knowledge, there were projects that reached interesting results concerning their transfer to the market. The interviews showed that the results of the projects allowed some entities to carry out technology transfer activities, thus proving that to some extent, outcomes stemming from supported projects had potential for economic and social valorisation (**pre-condition #8**).

The pattern of specialisation of the Portuguese economy in the period considered, and particularly in the convergence regions, was largely based on low-tech industries (scarce presence of SMEs in medium- and high-tech sectors and still scarce high-tech entrepreneurship) although observing relatively slow growth in medium and high technology sectors. Nevertheless, it is worth highlighting that companies supported by the COMPETE OP under the different business incentive systems were the ones that at that time most invested in RTD and innovation, some of them coming from medium-high and high-technology sectors. This trend may have helped the absorption of knowledge produced by entities of the scientific and technological system. Thus, the assumption that the industrial sector in the convergence regions had the capacity to launch innovations based on R&D project results (**pre-condition #9**) has materialised to some extent.

The regulation established in the NSRF 2007-2013 period, which also apply to the COMPETE OP, established that in projects participated by several organisations, a consortium contract should be signed clarifying rights and duties of the participants regarding intellectual/industrial property. The project results that did not give rise to intellectual property rights could be widely disseminated, being the RTD entity the holder of all intellectual property rights resulting from its activity in the project. Scientific and technological entities were entitled to receive compensation equivalent to the market price from the companies participating in the project for intellectual property rights that resulted from their activity in the project. However, since this measure focused on individual projects, this issue was not directly related to the projects under analysis. Concerning the existence of suitable regulation allowing the beneficiary organisations to achieve economic benefits generated from the transfer of any type of knowledge or exploitation of intellectual property (**pre-condition #10**), direct beneficiaries interviewed on this issue said that in general, the teaching career in higher education did not value joint activities with businesses. Institutional policies in HEIs regarding the participation of professors/researchers in knowledge transfer activities varied from one to the other, but in general, it was considered that university staff was not sufficiently motivated from the point of view of financial return, since a part of the income they considered to be excessively high had to be shared with the universities. Other types of compensation were also considered insufficient. Internal technology transfer structures were deemed to be at incipient stages of development. Interviewees from Research and Technology Organisations (RTOs), which are entities more oriented towards applied and experimental research, expressed a different opinion, considering that their organisations motivated researchers for technology transfer activities satisfactorily. Overall, this precondition is therefore considered to have occurred only to some extent.

Verification of supporting factors

All identified supporting factors that have been considered to back the measure took place and positively influenced the level of achievement of intended results.

It was considered relevant to allow the measure to achieve the intended effect, the alignment with other similar measures implemented in the previous ERDF cycle (supporting factor #1). In the literature review and interviews with programme

managers, it was verified that support measures for RTD entities in the period 2007-2013 meant a line of continuity in relation to the ERDF programming cycle 2000-2006, despite being now implemented under an OP focused on economic development.

It was also considered that the measure would be more effective if there were other complementary measures that were part of a broader policy mix to support RTD entities within the National Strategic Reference Framework (NSRF) 2007-2013 (**supporting factor #2**). Indeed, as best described above in Section 2.3. and Section 3.1. there was a range of instruments that supported the entities of the scientific and technological system throughout this period, not only within the COMPETE OP (for example, the Support System to Research and Technological Development (SI RTD) in Axis 1 that promoted the relationship of NSTS entities with businesses), but also outside the OP (including, for example, the support available under regional operational programmes, or the Human Potential Operational Programme (POPH) that promoted scientific employment).

Beneficiaries' previous experience in applying and managing research grants, given their implication on national funding programmes (**supporting factor #3**), was also considered to help the effectiveness of the measure. Actually, there is some evidence that this being a relevant measure to support the research carried out by leading scientific and technological entities in convergence regions, and considering that the measure comes in line with similar instruments available in the previous ERDF cycle, many of the supported entities should already have experience in applying for this type of funding. A survey carried out in 2012 to the coordinators of projects funded under the SAESCTN instrument concluded that 61% of respondents had already projects funded in the previous 2000-2006 cycle (Mateus & Associados et al., 2013)

The continuous growth and development of the national scientific and technological system were another of the supporting factors considered (**supporting factor #4**). Over the 2000-2010 period, the Portuguese R&I system benefitted from relevant developments regarding its scientific and technological base. For the first time, R&D expenditure was above 1% of GDP, reaching 1.6% in 2010 (it was 0.73% in 2000). Over that decade, the country registered one of the highest rates of growth in scientific production in Europe, including aspects such as R&D expenditure, tertiary education, R&D personnel, and scientific publications. This positive trajectory began to happen many years before and had an important boost within the previous EU support cycle (2000-2006). There is, therefore, evidence that this factor took place and positively influenced the measure under assessment.

In the previous ERDF 2000-2006 cycle, some countrywide initiatives took place to connect scientific and business communities through the creation of technology transfer offices (OTIC network) and offices to support industrial property protection (GAPI network) located in higher education institutions, research and technological centres, business associations etc. These initiatives and networks had a positive effect in bringing scientific and business communities closer together and contributed to a better economic and social use of R&D results in the following ERDF cycle 2007-2013. However, as reported by the interviewees, that was a period when the support structures for the protection of intellectual property rights and technology transfer were still in the process of consolidation, especially in higher education institutions, so it is considered that the existence of mechanisms to support knowledge transfer (**supporting factor # 5**) took place to some extent.

It was also considered that continuous public investment in science, technology and innovation, including in the following ERDF cycle, would positively benefit the measured effectiveness (**supporting factor #6**). In the COMPETE OP, Axis 1 - Knowledge and Technological Development, under which the "RTD individual projects" measure was

allocated, ERDF funding was reinforced over three reprogramming exercises from €500m (OP beginning) to €642m (last reprogramming in 2015). The usual percentage of ERDF contribution to RTD individual projects also increased from 70% (OP beginning) to 85% (after 2012), which decreased the national co-funding effort. After all reprogramming actions, Axis 1 reinforced its relevance in OP total budget by increasing from 16% (initial programming) to 20% (last reprogramming of 2015). Furthermore, the financial envelope for Science, Technology and Innovation actions was also increased in the following ERDF cycle (2014-2020). It can, therefore, be concluded that this supporting factor has, in fact, occurred.

Verification of risks and threats

All potential risks and threats considered for this measure have materialised in some way, conditioning the intended results to some extent.

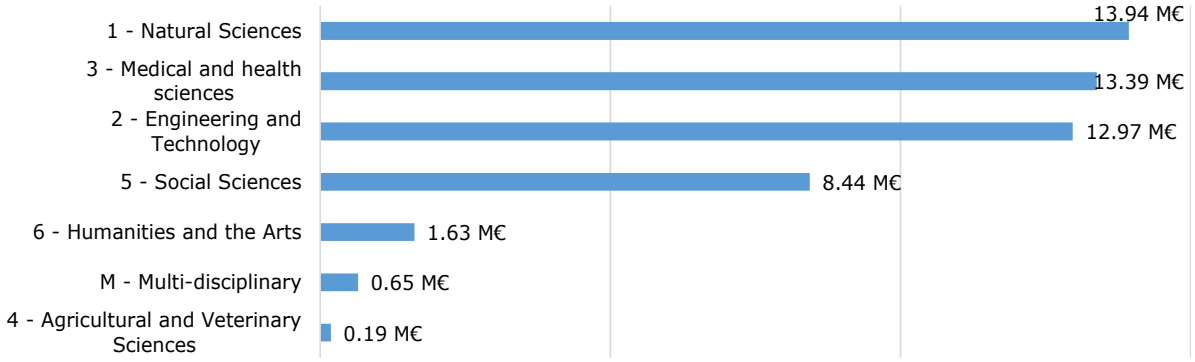
Inherent risks to the implementation of RTD projects (trying out new, untested ideas, including risks related to time, costs, resources, technology etc.) may have threatened the effectiveness of the projects supported by the measure (**risk #1**). Although the materialisation of these risks may have happened differently at the level of each project, anecdotal evidence collected from interviews - both with project beneficiaries and OP managers - suggests that in general, there were no significant deviations between goals and results achieved (although with identified exceptions), and when differences occurred in a relevant way, achieved results were usually higher than estimated.

It was also considered that reduced links of supported entities to the business community and society at large might have hindered the economic and social valorisation of project results (**risk #2**). The fact that these were individual projects run by scientific entities and their objectives were mainly related to the production of new relevant knowledge may have hindered the valorisation of results. Although the 2007-2013 ERDF cycle encouraged collaboration between RTD actors and industry (including, for instance, specific measures to support business innovation in which scientific and technological entities took part), until this period, there was in general relatively little tradition of science-business collaboration. This risk is therefore considered to have materialised, moreover because, at that time, many R&D institutions (namely HEIs and RTOs) had internal structures for interfacing with businesses performing incipiently.

One of the risks that may have affected the measure vis-à-vis knowledge transfer was the possibility of project results not being appealing for the industry to exploit them economically (**risk #3**). As already discussed in this report, strategic individual projects were mainly aimed at supporting scientific and technological development activities of the funded entities, so knowledge transfer would not be a priority. However, the projects did generate results with market potential, and concrete examples of transferred results were identified.

The scientific areas that received most ERDF funding under the measure were Natural Sciences, Medical and Health Sciences, and Engineering and Technology, fields that are usually prone to translational knowledge activities.

Figure 23. Typologies of fields of science in the context of RTD strategic individual projects



Source: CSIL elaboration based on Task 1 DB Projects and Beneficiaries

It is considered anyway that there was a high probability this risk has materialised, mainly because these activities were not a priority for the projects, due to scarce connections to companies of many HEI and some RTOs, and also due to mismatches between the results produced and the needs of the business fabric.

3.3.3. General assessment

RTD strategic individual projects led by entities of the scientific and technological system have, in general, been effective in reaching their intended activities, outputs and outcomes.

By concentrating a considerable level of resources in a restricted group of research entities, this measure generated results far superior to the averages of other measures, having contributed in an effective and visible way to a number of observable effects in the target regions, ranging from the upgrade of scientific skills, increase in scientific and technological capacities of research centres and internationalisation of scientific activities, to the growth of the scientific system and (although to a much lesser extent) enhancement of the respective innovation systems.

Intended outputs of the instrument – grants delivered to beneficiaries and projects effectively implemented - were generally achieved as expected, benefiting from the existence of necessary pre-conditions (e.g. applicants' resources and capacity), supporting factors (e.g. broader policy mix to support entities of NSTS), and non-occurrence of influential risks that could significantly endanger the measured effectiveness. The activities of the policy instrument (i.e. calls for proposals to support strategic individual projects developed in areas of public interest led by entities of the scientific and technological system) was the main cause leading to observed outputs.

Supported projects generated a significant amount of scientific deliverables – immediate outcomes - including 42,711 publications (100% of the projects produced publications; an average of 464.3 publications/project); 42,265 communications (100% of the projects generated communications; an average of 459.4 communications/project); 1,429 prototypes and pilot plants (45% of the projects led to a prototype and pilot plant, an average of 35 prototypes/pilot plant per project) and 290 patents (50% of the projects led to patent applications).

The results stated above suggest that the measure contributed to generate new knowledge (mainly fundamental and applied), new and enhanced scientific skills in the supported research groups, and intellectual property rights, being one of the causes leading to these immediate outcomes.

The strengthening of scientific capacity was often referred to in interviews with project beneficiaries as one of the most relevant effects of the projects for the respective research groups. Projects provided R&D centres with more human resources, new equipment (in some cases, large equipment) and acquisition of essential materials and services, ensuring enhanced conditions for beneficiaries to develop their main research lines. The development of new scientific knowledge and skills by the supported entities under the previous immediate outcomes is one of the causes that led to this effect.

Another expected intermediate outcome – knowledge transfer to the market – seemed to have taken place to some extent. Information collected in the interviews confirmed that some projects generated knowledge that was later used economically and socially, namely through licensing agreements, creation of university spin-off companies, know-how transfer agreements, contracts for technology services, joint doctoral theses with companies, research contracts with companies, and new funded RTD projects with firms, among others. Public disclosure of project results led other entities (e.g. research groups and companies) to use them for scientific and commercial purposes. A number of pre-conditions that have taken place only to some extent contributed to the relatively limited performance of this outcome (e.g. potential of project results for economic/social valorisation), as well as the non-occurrence of certain supporting factors (e.g. sound mechanisms for technology transfer).

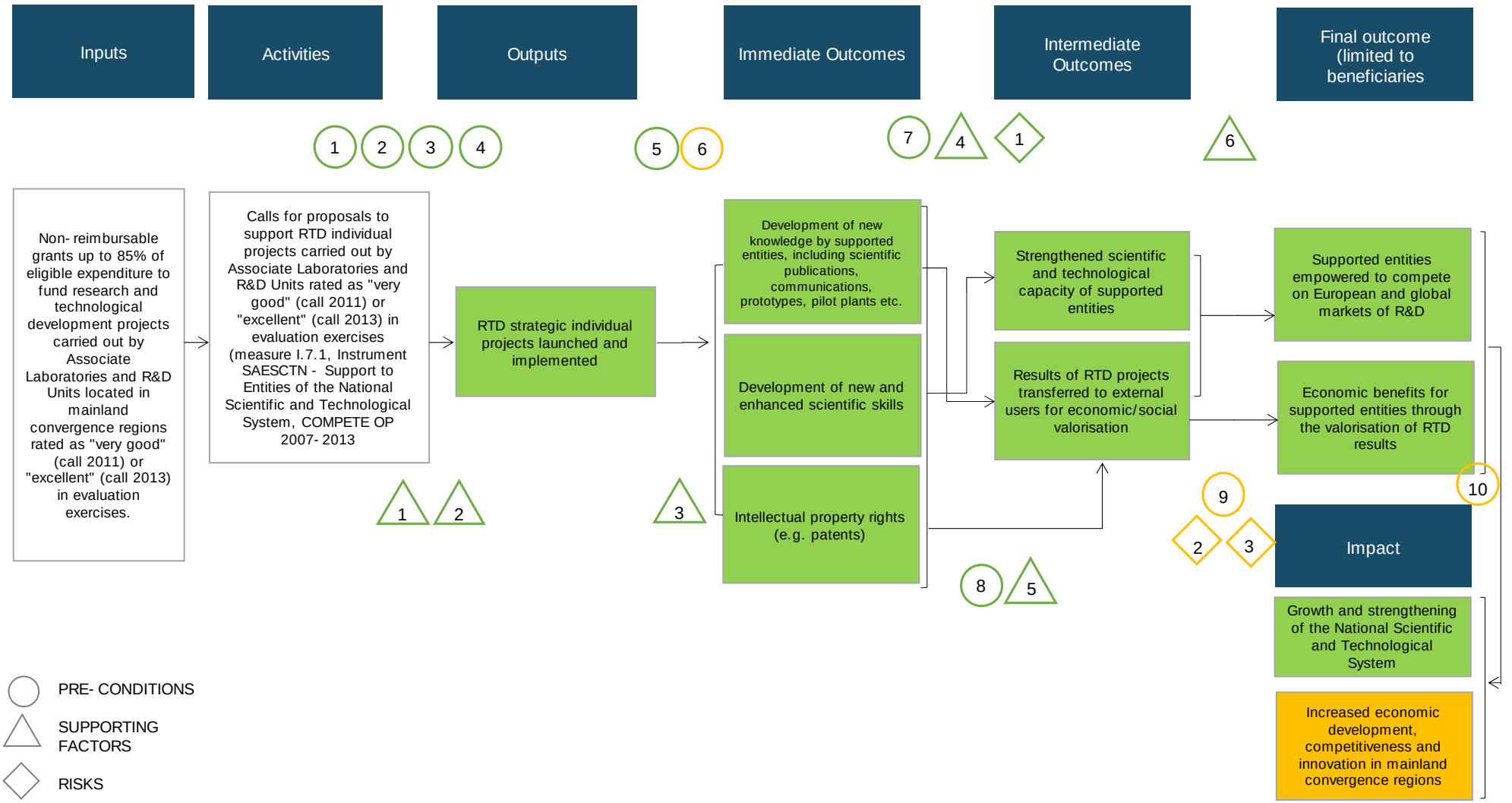
Expected final outcomes regarding the empowerment of supported entities to compete on the European and global markets of R&D were identified. The measure contributed to increasing international visibility of supported research groups, namely through published papers in international journals, communications at international events, and integration of national entities in international consortia. The reinforcement of scientific and technological capacity and the knowledge transfer to external users (intermediate outcomes) mentioned in the previous paragraph were among the causes enabling such final outcomes on the strengthening of the international profile of national entities.

Regarding final outcomes on economic benefits for supported entities through the valorisation of RTD results, technology transfer activities were identified that led to some financial return for HEIs and RTOs, including licensing agreements, provision of technological services, and establishment of research contracts with companies. Such outcomes were produced only to some extent and are also an effect of the previous intermediate outcome on the transfer of RTD results to the market. The industrial sector capacity to launch innovations based on the produced RTD results was a pre-condition that seems to have taken place only to some extent, not favouring this outcome.

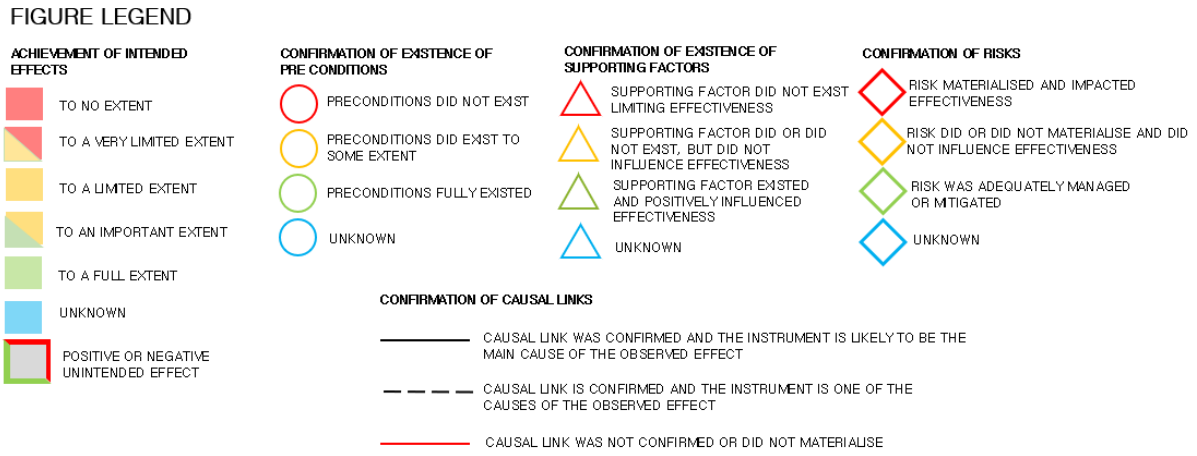
Notwithstanding the fact that some of the intended outcomes have been achieved to a limited extent (i.e. particularly those relating to the valorisation of RTD results), there is clear evidence that the measure contributed to the growth and strengthening of the national scientific and technological system (final impact). The short, medium- and long-term results generated by the strategic projects contributed to the increase of critical mass and quality of the system.

The impact of the measure on competitiveness and innovation in the convergence regions was also considered as a possible long-term result. According to the information obtained from the interviewees, the projects funded under the measure generated some effects in terms of economic valorisation, such as licensing agreements, spin-off companies, technological services, and research contracts. These would have been the main ways through which the projects contributed directly to increase innovation in the target regions.

Figure 24. Representation of the results of the contribution analysis for RTD strategic individual projects



Source: Evaluation team on the basis of primary and secondary data collected



3.4. Policy Instrument: International cooperation RTD projects (individual projects)

3.4.1. Theory of change of the policy instrument

The RTD strategy and the policy framework laid on three main pillars. This instrument addressed the pillar of internationalisation. The integration of Portuguese institutions in international networks was understood as the corollary of capacity building and a key element on the stairways of research excellence, as well as of institutional growth.

International cooperation RTD projects were designed to boost international cooperation, aiming to establish an effective link to tap into top knowledge reservoirs but also to induce cultural transformation through institutional learning and sharing. In this regard, the Portuguese government signed contracts of collaboration with some of the most reputed institutions in the world, namely the European Organisation for Nuclear Research (CERN), Massachusetts Institute of Technology (MIT), Harvard Medical School, Carnegie Mellon University or the University of Texas at Austin. The purpose of these partnerships was to take advantage of catching-up opportunities and stimulating institutional improvement derived from the exchange of experiences on how these institutions operated and managed science and technology.

This policy instrument hence envisaged the creation of links between Portuguese institutions and vanguard research units, providing favourable access to knowledge frontiers but also opportunities for learning on individual and organisational levels.

Through non-reimbursable grants (**inputs**) to some of the most outstanding research units in Portugal, it was awarded financial support to devise projects within the framework of those partnerships, aimed at collaborative R&D activities (**activities**). These projects pursued mostly fundamental science topics, and their duration was variable but usually up to 24 months. Grants (**outputs**) were provided on the basis of a competitive call for proposals, open to public or private research organisations and enterprises with R&D activity, focussed on pre-determined strategic areas and involving a team of experts from a high-level international partner institution (Harvard, MIT, Carnegie Mellon, Texas Austin, CERN). Although the participation of firms was technically feasible, this did not occur considering the topics addressed. On average, the amount of funding granted to approved projects was just above €80,000, which indicates a tendency for relatively small scale RTD activities.

Table 9. Financial scale of international cooperation RTD projects

Total ERDF contribution	Min ERDF contribution	Max ERDF contribution	Average ERDF contribution
4,114,724.83 €	3,981.15 €	463,622.03 €	83,973.98 €

Source: CSIL elaboration based on Task 1 DB Projects and Beneficiaries

However, during this period of analysis and considering that approved projects overwhelmingly corresponded to the partnership with CERN, we observed a strong institutional concentration of funding, both thematic and institutional. The Laboratory of Instrumentation and Experimental Particle Physics (LIP) and the Department of Physics - University of Coimbra represented 93% of the funding approved. This aspect made it possible to obtain synergies and a larger scale of RTD operations even though each individual project was of a small size.

Table 10. Institutions where ERDF contribution was concentrated in the context of international cooperation RTD projects

Institution	Type of direct beneficiary	ERDF contribution (EUR)	ERDF contribution as % of the total ERDF contribution policy instr.
LIP - Laboratory of Instrumentation and Experimental Particle Physics	RTO	3,264,516.06	79.34%
Development Association of the Department of Physics - University of Coimbra	RTO	571,870.08	13.90%
University of Aveiro	HEI	146,996.91	3.57%
University of Porto	HEI	118,711.16	2.89%
University of Minho	HEI	12,630.62	0.31%
Total ERDF contribution to top 10 institutions		**4,114,724.83**	**100.00%**
Total ERDF contribution to the policy instrument		**4,114,724.83**	

Source: CSIL elaboration based on Task 1 DB Projects and Beneficiaries

Delays in implementation and the financial crisis that hit very hard the RTD system contributed to a residual number of projects being developed within the framework of the collaboration agreements with other partners.

The ToC underlying the international cooperation RTD projects' policy instrument implies that this support scheme sought to stimulate a direct output consisting of collaborative projects being developed with Harvard, MIT, Carnegie Mellon, Texas Austin and CERN, taking advantage of the complimentary support schemes that were deployed to modernise infrastructure, increase the number of researchers and boost internal capacity. With the approval of these projects, a set of immediate correlated outcomes were intended.

- Firstly, the policy instrument aimed at establishing a pipeline for knowledge transfer from these vanguard institutes (**immediate outcome #1**), establishing a strategic tap that could leverage the national innovation system.
- Secondly, another immediate outcome resulted in the creation of the first links (**immediate outcome #2**). With the kick-off, contact points were established to manage the partnerships and to conduct the research activities. This allowed for two types of linkages: one on organisation management and the other on the R&D activity itself.
- Thirdly, considering the closedness of some of the Portuguese institutions, these instruments intended to be a stimulus to opening research units to international

networks and also to change its organisation (**immediate outcome #3**), in order to take stock on the best practices in terms of R&D management.

Following immediate outcomes, intermediate outcomes corresponded to the second stage of results. In particular, the development of the different projects was expected to have a direct outcome on scientific publications and advanced training (**intermediate outcome #1**), the creation of relational capital, which transforms the initial links into solid connections (**intermediate outcome #2**) and observable changes within Portuguese organisations, specifically in terms of process management and also organisational structure (**intermediate outcome #3**).

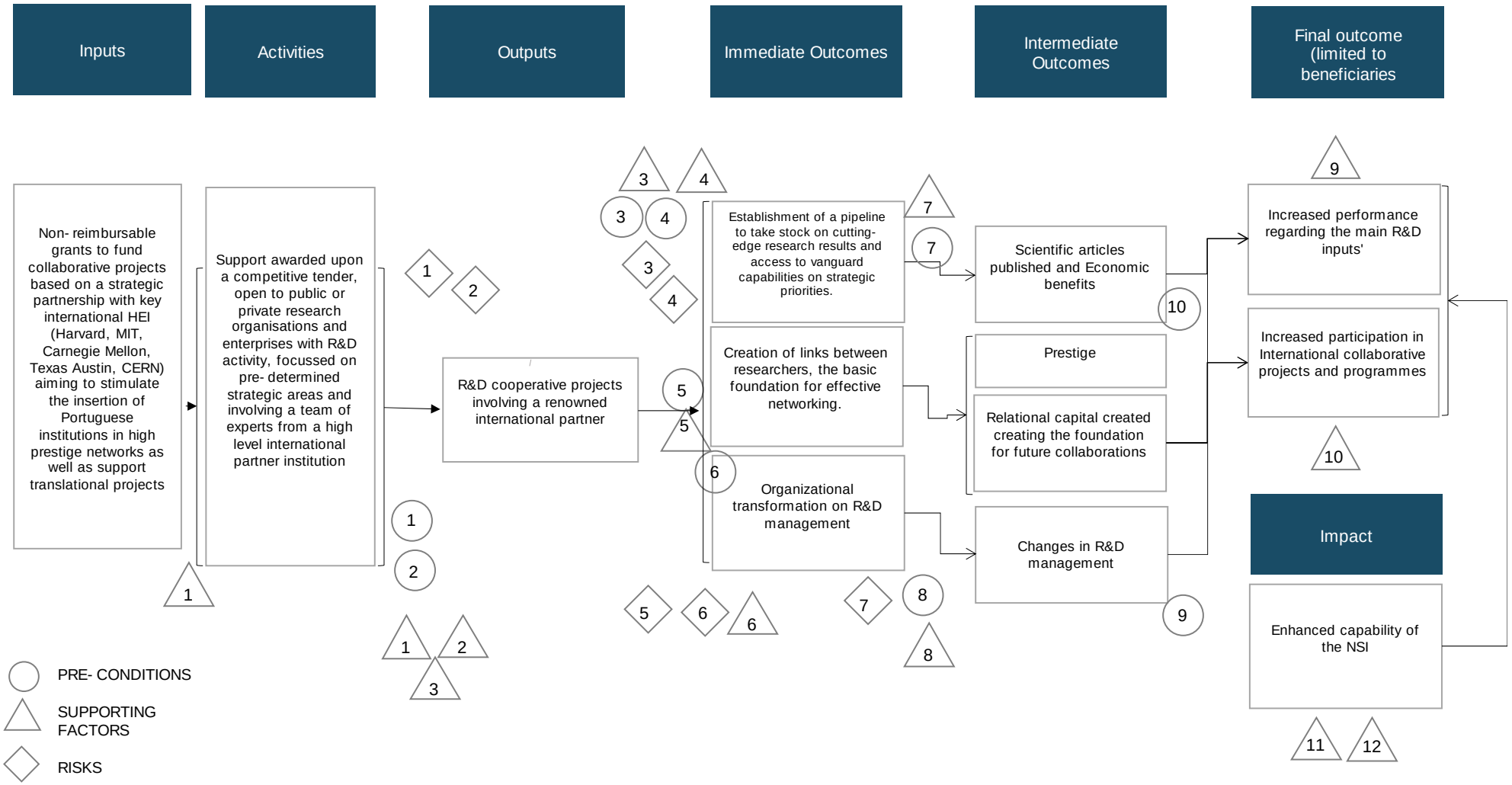
Final outcomes aimed at establishing the conditions for a more open national innovation system, with a greater propensity to integrate international networks of R&D (**final outcome #2**) and, simultaneously, taking stock on the experience of those leading institutions to improve the performance in terms of R&D inputs (**final outcome #1**).

The impact envisaged was the result of a multidimensional transformation process to improve the national innovation system, fomenting growth and the internal capacity of research institutions.

The original programme documentation provided a starting point for the development of a Theory of Change for the RTD international cooperation policy instrument. However, in order to build a complete ToC, the evaluation team had to recur to a number of additional sources, including literature review carried out as part of this evaluation, interviews with programme managers and beneficiaries, as well as our own knowledge and insight of the programme and local contextual factors. This has led us to develop a ToC as depicted in the following figure, with the intention of illustrating the intended effects of the policy instrument, the underpinning pre-conditions, contributing factors and potential risks and threats, and the causal pathways across the results chain.

The ToC figure below uses solid arrows to illustrate the causal pathways between the different levels of instrument intended effects. The nature of these causal links has been analysed and defined as part of the contribution analysis, the results of which are presented in later sections of this case study. It is worth mentioning that this instrument responded to a goal of transformational nature. The envisaged targets were concentrated on building organisational capacity in Portuguese research institutions and inducing cultural transformation favourable to a greater propensity to the internationalisation of RTD activities. Thus, unlike in other policy tools, no quantitative targets were defined in terms of outputs nor outcomes. The importance of stimulating internationalisation was perceived as an absolute priority in itself, explaining why there was no thematical focus underlying the international partnerships established. The goal was the partnership itself and the demonstration effect resulting from it.

Figure 25. ToC for international cooperation RTD projects



Source: Evaluation team on the basis of primary and secondary data collected

Pre-conditions

1. R&D Institutions have built-in capacity and scale to undergo an internationalization process.
2. Firms and non-profit are sensible to the transformational challenge on the NSI, namely, in terms of introducing new methodologies that boost scientific outcomes and economic impacts.
3. The international partners have a stock of research results that are willing to share, are aligned with the strategic priorities and adjusted to the absorptive capacity of Portugal
4. The beneficiaries have research units and firms with internal capabilities and adequate scale to promote an effective link.
5. Common research interests and stimulus to an active participation
6. Internal regulations and reward system must stimulate international collaborations and links to firms.
7. Research results from International partners are absorbable by local HEI, research units and firms
8. Effective transformation occurs in institutions and regulations
9. Macroeconomic Stability
10. Strategic Stability

Supporting factors

1. QREN launched parallel programmes to induce capacity building and the scaling-up of Research capabilities;
2. National policies focusses on producing PhDs, fuelling, research institutions and firms
3. The beneficiaries have the necessary own resources and capacities in terms of organisation, management, human resources and infrastructure to ensure the collaborative project implementation in a timely manner
4. Previous experience in project management and international collaborations
5. The development of the NSI and the significant accumulation of human capital in research institutions and firms provide a more suited ecosystem.
6. Shortage of public financing induced a greater focus on funded international collaborations
7. Synergies and complementarities with other instruments deployed for capacity building
8. Undergoing renewal of research institutions with new human capital adding greater flexibility
9. Strategic reference Framework targeting R&D+i
10. Increased awareness and support to stimulate the Portuguese participation in international networks of R&D
11. Continuous stimulus to international partnerships
12. Time consistency of innovation policies

Risks and threats

1. The generous national funding schemes generate a crowding-out effect on collaborative projects and perpetuate a standalone trend
2. Resistance to change
3. Project size relatively small may reflect pulverization rather than concentration
4. Inherent risks of experimental development and applied research projects (i.e. research project risks)
5. Distorted incentives for scholars, favouring publications rather than collaborative collaborations targeting innovation
6. Precarity of HEI research jobs leading to disruptions in teams
7. Status-quo: regulatory inertia and opposition to changes in the reward system on research

3.4.2. Contribution analysis

Verification of intended intervention implementation

The implementation of the policy instrument occurred as planned, using specific calls for projects in partnership and aligned with the programme's scope. These calls foresaw non-reimbursable grants to research institutions that applied to develop R&D projects within the framework of these international partnering agreements.

However, we observed a relatively low level of approved projects and the concentration of those on a single partnership. This was due to implementation delays which hampered the number of projects and the array of topics approved. In fact, the launching of this policy instrument faced significant delays, which may have accounted for the heavily skewed distribution of approved projects in favour of the cooperation agreement with CERN.

The collaboration with CERN was a more mature partnership that was easier to operationalise. The implementation of the other partnerships, apart from initial delays, was aggravated by the international financial crisis of 2008, hitting Portugal in 2009 and leading to the need for a financial assistance programme supervised by the International Monetary Fund, with consequential changes in government. These changes led to a change in priorities to "survival mode" and also to a disruption in the policies for Science and Technology, favouring applied science. Additionally, as it results from the interviews, the differences in background experience with cooperation and in terms of institutional openness affected the propensity and readiness for international cooperation.

According to the interviewees and document analysis, the implementation of these activities was smooth and did not require a re-design throughout the programming period.

Nevertheless, there were some remarks regarding the bureaucratical burden. Also, even though eligible beneficiaries included a vast spectre of actors, only scientific organisations applied. The consortiums created did not include firms.

A wide array of projects was approved. However, a significant concentration of projects was visible around the partnership with CERN, which implies that, to some extent, during the reference period, the implementation was asymmetric.

There were no major issues identified with regard to the implementation of the activities or calls. However, some possible improvements were identified. One of the negative aspects highlighted in the interviews relates to the length of each project, considered too short (maximum two years), limiting the ability to develop PhD programmes. An additional aspect that could be improved relates to transaction costs, which implied a very lengthy process between the submission of proposals and contract signature (exceeding one year in some cases). Some of the stakeholders mentioned the importance to devise a long-term agenda that could roll-over projects and fund them with sequential instruments. In other words, with the end of the project, the collaboration was abruptly discontinued until the following project was approved. Sequentially, at that stage of the national innovation system, it was relevant to consolidate institutional activities and, in particular, these partnerships until they were not subsidy dependent.

Throughout the reference period, there were no significant changes in the policy instrument.

Achievement of intended and unintended effects at the level of the expected threshold

This policy instrument was of a special nature. The intention underlying its deployment was not of a quantitative nature but of a qualitative nature. Hence, the objectives defined were qualitative, and no thresholds nor targets were identified. This implies that an assessment on the achievement of effects must be based on interviewees' opinion, on

existing evaluation reports and on proxies that may demonstrate the evolution of variables causally related to the envisaged quantitative targets.

As can be seen in the figure presenting the results of the contribution analysis, an important share of expected outputs and immediate outcomes were achieved to a partial or full extent. In particular, if we look at the set of immediate outcomes, the evidence collected suggests that the projects supported led to the establishment of a pipeline with the international vanguard institutes. The projects served to immediately create an organised and structured model of cooperation and effectively establish cooperation between the Portuguese and the international partner, facilitating knowledge transaction. The duration in time of these effects was partially achieved due to brain drain and also the discontinuation of these contracts. Also, the pulverisation of projects and their short length implied some constraints on the immediate outcomes derived from the projects.

Box 3. Examples of projects supported under the international cooperation RTD projects instrument

Faculty of Medicine of the University of Porto (FMUP)

Alport syndrome is a genetic disease characterised for leading to progressive loss of renal and hearing function. As part of the collaboration with Harvard Medical School, the project "Alport's Syndrome: Study clinical and molecular analysis of Portuguese families " was to identify mutations that cause Alport syndrome in Portuguese families and characterise the natural history of the disease in this population.

INESC TEC

The project Breadcrumbs was implemented by INESC TEC and the University of Texas at Austin. The project was based on the use of Social Web tools, which collected the tags created by the readers, organised these fragments and created a model of the semantic organisation of these opinions. The objective of "Breadcrumbs" was to capitalise on the participation of the general public in the production of news, creating bridges between online news and the Social Web.

Source: interviews with direct beneficiaries

Regarding the intended creation of links, points of contact were established between institutions. Furthermore, based on the alignment of research topics, researchers established roadmaps that fostered the creation of relationship capital and hence, establishing effective networks.

Considering the state of development of some of the Portuguese research units, these projects provided a learning opportunity to adapt their organisation and opportunities to learn how the most advanced research units manage their organisation, how they operate and how to manage partnerships. Some interviewees mentioned a positive impact, and some institutions created a dedicated staff to manage the partnership. This dedicated staff also looked for other collaboration opportunities improving the participation in international networks (e.g. including leading to a greater propensity to apply for grants at the FP).

A set of additional unintended effects was achieved, namely the employment of new researchers and a small increase in R&D investment.

In terms of intermediate outcomes, the following were intended: (i.a) promote an increase in quantity and quality of scientific articles, (i.b) economic benefits obtained from the transferring of research results to firms, (ii) changes in R&D management within an organisation, and (iii) relational capital created establishing the foundation for future collaborations.

Regarding (i.a) and (i.b), projects have reported positive impacts on scientific publications as well as some PhDs graduates and, especially, MSc. It was expectable that international partners of this quality would lead to science of excellence. However, economic benefits were not demonstrated since most projects followed a fundamental

science approach with no clear link to economic valorisation. Furthermore, no firms participated in the projects. Evidence demonstrates that a positive impact occurred but to a much lesser extent than envisaged due to the lack of a strategic agenda to maximise the return on these projects.

Concerning the intended effects on organisational changes, the progress reported on immediate outcomes led to the reaction of organisation structures dedicated to project management and knowledge management, but also to the definition of procedures for managing these collaborations from a more professional model. In relation to (iii), the links created between points of contact evolved through time, leading to true relational capital, which was crucial to the sustainability of the envisaged outcomes and impacts.

Among unintended effects but as probable collateral, the policy instrument paved the way for Portuguese organisations to increase their interest and participation in these programmes. Furthermore, this contributed to raising the prestige of Portuguese research units, making them more attractive to other international partners, and also having positive effects on the career of young researchers, namely regarding research opportunities and international job opportunities.

From a longer-term perspective, two intended outcomes were expected: (a) Increased performance regarding the main R&D inputs' and (b) Increased participation in international collaborative projects and programmes. In what relates to (a), the direct outcome related to scientific benefits was moderate, with particularly relevant outcomes in physics. The size of the projects also did not contribute heavily to a change in capacity. However, concerning (b) and even though causality is not direct, these projects have had a direct effect on stimulating openness and greater participation, which contributed to more and better participation in FP7 and H2020.

Table 11. Comparing the participation of ERDF beneficiaries benefitting from the international cooperation RTD projects instrument in FP7 vs H2020 projects

	ERDF recipients of internationalisation of research benefitting also from FP	Number of FP projects	Total FP contribution
FP7	3	131	38,452,194.61 €
H2020	3	144	57,956,806.95 €

CSIL elaboration based on Task 1 DB Beneficiaries and Cordis data

Finally, in terms of impact, our ToC presents an intended causal pathway leading to the enhancing of the National Innovation System. In this aspect, indicators show that the NIS improved significantly, with strong research outputs (PhD graduates, publications, citations). We also observed a continuous growth in GERD and BERD, as well as increased internationalisation (greater participation in collaborative projects). In spite of having a direct connection to the impact, the policy instrument's contribution was small.

Verification of assumed pre-conditions

The analysis on the preconditions demonstrates that most of them were verified to a partial or a full extent.

The readiness level for cooperation and the institutional stance on accepting and implementing change were two key pre-conditions for the envisaged change. In other words, these re-conditions implied that fruitfulness of this policy instrument was dependent upon R&D institutions having built-in capacity and scale to undergo an internationalisation process (**pre-condition #1**) and firms and non-profit being sensible to the transformational challenge on the NIS (**pre-condition #2**).

To ensure capacity building, both the COMPETE OP and regional OPs launched simultaneous calls aiming to improve the research facilities and promote an increase in their scale of operation, hence boosting the internal capacity for absorption of knowledge, as well as providing the means for a fruitful collaboration with institutions which laid on the forefront of research. The OP COMPETE's Axis 1 encompassed a wide set of instruments aiming to provide direct support to R&D activities and institutional research capacity building. The array of policy instruments included measures dedicated to supporting the development of science and technology transfer programmes, which created a wave of significant technology push, leveraging the simultaneous allocation of national funding. Furthermore, important support came from the regional OPs, which allocated an important share of ERDF resources to the creation or the consolidation of central nodes in the regional innovation system, hence further accelerating the creation of R&D capacity, as well as introducing a new instrument dedicated to long term research programmes (36 to 48 months length) which contributed to the stabilisation of research teams and more predictability in the funding system. Finally, the stressing of cooperation with the deployment of these mechanisms, alongside an unfavourable financial context, created the additional stimulus for the R&D institutions to participate in these programmes and, specifically, in the programmes involving international collaboration.

Other synergies among instruments were derived from the Operational Programme Human Potential, which offered support for the development of researchers and R&D personnel. Not only this was fundamental to retain human capital in universities, but it also contributed to the integration of international research networks.

Considering that the policy instrument being analysed focussed on R&D, the degree of participation of firms was limited. It is also worth noticing that cluster policy, which surprisingly was somehow discontinued, also played a key role in bringing stakeholders together and actively participating in European level networks.

In what concerns the instrument design, some remarks are in order. For instance, targets were not clearly defined, especially in terms of envisaged outcomes and impacts. Furthermore, considering the state of development of the National Innovation System, it was not clear if there was a thematic rationale considering economic impacts in the long run and the sustainability of outcomes in the research institutions. The time extent of the projects was considered too short for the purpose of upgrading Portuguese institutions and connecting them effectively to central nodes of research and innovation in the world (e.g. the maximum length of two years limited the implementation of joint collaborative research that could lead to PhDs). Furthermore, although a possible involvement of firms was foreseen, that rarely occurred.

The OP managers used the following criteria to confirm eligibility of project applications and carry out project selection:

- Scientific merit and degree of novelty;
- Scientific merit of the research team;
- Overall reasonability;
- Contribution to the capacity building of the National Innovation System;
- Economic potential.

The process demonstrated transparency and compliance with best practices. However, the excessive bureaucratical burden was identified, implying a very long time between the submission of applications and the signature of contracts.

A large accumulation of projects linked to physics compares with a small number of projects focussing on other topics such and Health and Life Sciences. A disproportion is

also clear in terms of the international institutions with an overwhelming prevalence of CERN related projects in this policy instrument and considering the time frame of this analysis.

Most projects were basic science (TRL1 and TRL2), so the expectable impacts are mostly on capacity building, organisational transformation and establishment of networks to support a boost in the internationalisation of the National Innovation System.

In terms of the pre-conditions associated with the immediate outcomes, those were mostly verified. Contractual arrangements between the Portuguese Government and the international partners were enforced. International partners, especially in the US, followed a very professional management approach, which was also applied to each approved project. Interviews highlighted not only the quality of the researchers to which access was provided but also the high quality of the management process by the international partners', with dedicated teams monitoring the progress.

Within the development of the projects, a joint research agenda was operationalised, and milestones were defined. The close contact between both organisations led to the establishment of points of access that allowed the Portuguese institutions to access these international partners during the projects, but also afterwards. Nonetheless, the brain drain effect on the Portuguese partners, the inability to retain some of the responsible researchers and also the short duration of the projects limited a wider impact. The project beneficiaries confirmed that the support measure did not promote governance models or contractual arrangements, which are typically associated with science-industry technology transfer. The ability to execute the projects approved demonstrates that both **pre-condition #3** and **pre-condition #4** were met.

Regarding **pre-condition #5** referring to compatibility between research agendas and pre-condition #6 referring to changes in the reward system to induce greater participation by Portuguese researchers, the list of approved projects and also the result of the interviews demonstrate that it was possible to identify topics of mutual interest. The downfall relates mostly to the stimulus for participation where it is clear the concentration of projects around a small set of researchers and also the fact that no visible incentive has been created to foster a strong commitment. This is particularly relevant across topics, except for physics.

In relation to **pre-condition #6**, the professor career reward system suffered no changes, maintaining a bias that may reduce interest to participate in these projects if they are not expected to produce high-quality publications.

A set of preconditions to intermediate outcomes were considered related to the capacity to absorb and take stock by the Portuguese participants, as well as the ability to change their organisations (**pre-condition #8**). In what concerns the former, all interviewees responded that Portuguese institutions were able to participate in the project competently and absorb results. Besides that, (**pre-condition #7**) additional capacity was created, which led to new graduate students. In what concerns the latter, the establishment of dedicated offices for partnership management in most of the participating institutions was observed.

Pre-conditions 9 and 10 refer to stability. On the one hand, macroeconomic stability did not occur (**pre-condition #9**). The world was hit with a severe financial crisis that affected Portugal even more, leading to a financial assistance programme and a change of government. This also impacted the strategic stability (**pre-condition #10**) associated with science policy. One of the reasons for the fast transformation of the Portuguese innovation system was the coherence of science and technology policies. This was affected throughout this period.

Verification of supporting factors

Supporting factors also played an important role in the implementation of the instrument and the level of achievement of intended results. In the TOC, we identified a set of supporting factors that could have had an effect on the outcomes of the measure.

Evidence shows that undergoing support to the capacity building prior to these international projects was important to develop adequate institutional capacity for fruitful collaboration (**supporting factor #1**). From a design perspective, the alignment between the policy instrument and other OP COMPETE supported instruments, as well as with other ESIF OPs, was considerable. The OP COMPETE's Axis 1 encompassed a wide set of instruments aiming to provide direct support to R&D activities and institutional research capacity building (**supporting factor #2**). The array of policy instruments included direct support to infrastructures (under regional operational programmes), which contributed to the modernisation and upgrade of R&D facilities, accompanied by other instruments dedicated to supporting the development of science and technology transfer programmes, creating a wave of significant technology push and leveraging the simultaneous allocation of national funding (**supporting factor #3**). Furthermore, important support came from the regional OPs, which allocated an important share of ERDF resources to the creation or consolidation of central nodes in the regional innovation systems, hence further accelerating the creation of R&D capacity.

Other synergies among instruments were derived from the Operational Programme Human Potential (**supporting factor #7**), which offered support for the development of researchers and R&D personnel. Not only this was fundamental to retain human capital in universities (**supporting factor #8**), has also contributed to the integration in international research networks.

National (COMPETE OP) and regional (regional OPs) calls were launched to boost the internal capacities of research units, reinforcing the ability to connect and absorb knowledge from these international networks (**supporting factor #7**). Also, the reinforcement of scholarships for PhDs that preceded and was enlarged through this period provided new human capital to accompany the growth of these institutions. The financial crisis that occurred created an additional stimulus to the opening of institutions and induced a greater propensity to integrate the international consortia of R&D. However, no direct synergies were derived.

Among the projects approved, we observed the concentration around a small set of institutions with greater capacity and with some degree of experience in partnerships (**supporting factor #4**). In some cases, interviews have provided insights on the importance of these projects in reinforcing specific structures within the organisation to manage projects and partnerships in a more professional way.

Although the ecosystem appeared prepared (**supporting factor #5**), the selected topics and the research made do not appear to be aligned with the research interests of many Portuguese scientific organisations, as well as it is not clear whether such topics provided an opportunity for good competitive positioning, both from the point of view of science and from the point of view of the economy.

In what concerns **supporting factor #6**, the financial crisis had a severe impact on R&D funding which forced organisations to look for alternatives. Although this may not have been the most relevant aspect within the institutions that applied, it certainly contributed to a greater propensity to participate.

The strategic reference framework at national and regional levels was heavily in favour of investing in R&D (**supporting factor #9**). According to an interviewee, "R&D and innovation have grown in the social agenda, and with that, both firms and the state

invested more. The support for international cooperation and for capacity building is still producing results" (**supporting factor #10**).

The policy instrument and actions dedicated to stimulating international collaboration were reinforced throughout the period of analysis (**supporting factor #11**), but some discontinuity was observed (**supporting factor #12**). In addition, the existence of sustained support for collaborative R&D and the stimulus to internationalisation continued with very positive outcomes.

Verification of risks and threats

Although a set of risks having been identified, most of those were mitigated or did not affect as much as it was foreseen.

A major risk relates to the effects of a biased incentive system (**risk #5**). The professor and researcher career encompassed a set of evaluation criteria that mostly favoured teaching and publications. Activities such as cooperation projects or project management are devalued (**risk #5**). This justifies the lack of stimulus to participate, especially in more traditionally close institutions and among established professors, leading to heavy resistance to organisational change (**risk #2** and **risk #7**). Another major risk refers to the sustainability of the outcomes and, in the long run, of the impacts. Considering the precarity of research jobs (**risk #6**), the best researchers and the best PhDs were approached by other international institutions and left the Portuguese innovation system. Although this could afterwards facilitate networking, it turns out to be a major loss.

Other risks were identified, such as the possible crowding-out effect of other instruments (**risk #1**). The possible unintended negative effects were mitigated because of two factors: (i) national funding schemes, especially in regional OPs, increasingly considered international projects as part of the evaluation system, and (ii) the financial crisis reduced the national budget, forcing institutions to look for additional funding elsewhere.

Another reported risk refers to "the pulverisation of projects, and their short length implied some constraints on the outcomes" (**risk #3**). In fact, the approach of many small projects may be sub-optimal and reduce the scale of outcomes, also increasing the inherent risks to the project in itself (**risk #4**).

3.4.3. General assessment

The general assessment of the policy instrument comprises different levels of results.

In terms of activities, we have concluded that a direct effect was reached, with several calls being launched to support the operationalisation of these international partnerships. The instrument was able to attract institutions to participate, even though the external shock affected Portuguese financing and the stability of institutions.

In what concerns outputs, 49 projects (international cooperation RTD projects, typology individual projects, funded under the OP COMPETE as priority theme "#01 - R&TD activities in research centres") involving a Portuguese institution and an international institution were approved, with grants being committed to support the rollout of this collaboration. In terms of direct effect from the policy instrument, in this case, it is verified a strong connection.

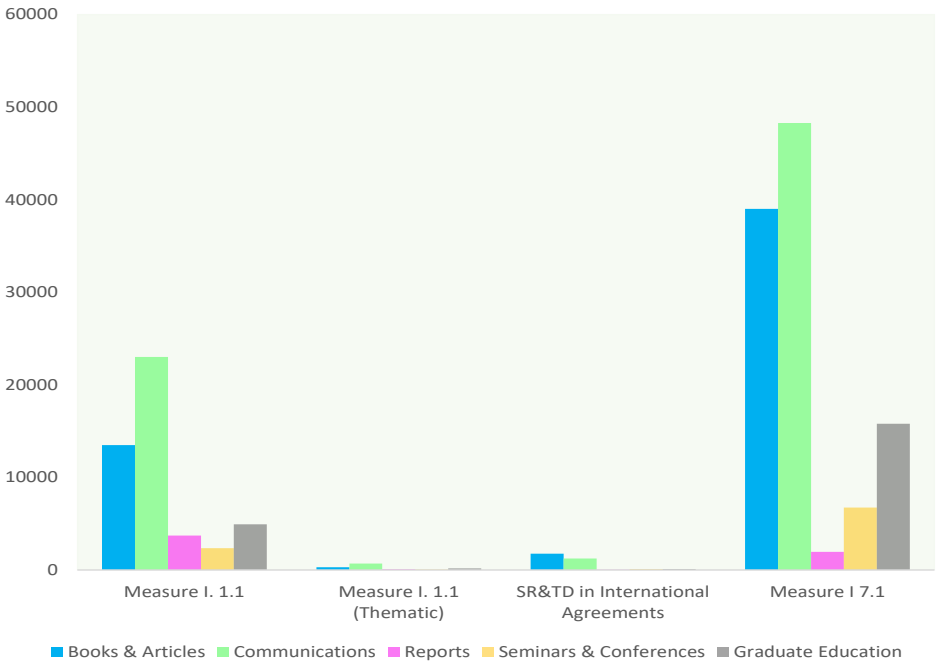
As expected from an isolated policy instrument, the direct causality between the instrument's effects and the outcomes erodes along time and with the breadth of the outcome.

Regarding immediate outcomes, these were associated with the kick-off of these projects and the effects resulting from it. In this sense, evidence from the interviews and reports suggest clear results concerning the creation of links. However, in terms of organisational

change and the establishment of a pipeline to tap into the knowledge of these partnerships, evidence is less compelling.

Achievements in terms of intermediate outcomes are asymmetric, namely regarding (i) Scientific articles published and economic benefits obtained from the transfer of research results to firms, (ii) Changes in R&D management within an organisation and (iii) Relational capital created establishing the foundation for future collaborations. In relation to (i), achievement is assessed as a medium due to some shortcomings. Interviewees identified the time frame of the project short to be compatible with PhD students, more propense to publications. On the other hand, in relation to (iii), some changes in the organisation were undertaken but resulting from a combining set of factors.

Figure 26. Scientific outputs from RTD projects



Source: Foundation for Science and Technology

Finally, regarding (ii), the achievement is assessed as strong. In fact, this has been one of the most positive outcomes mentioned by the interviewees.

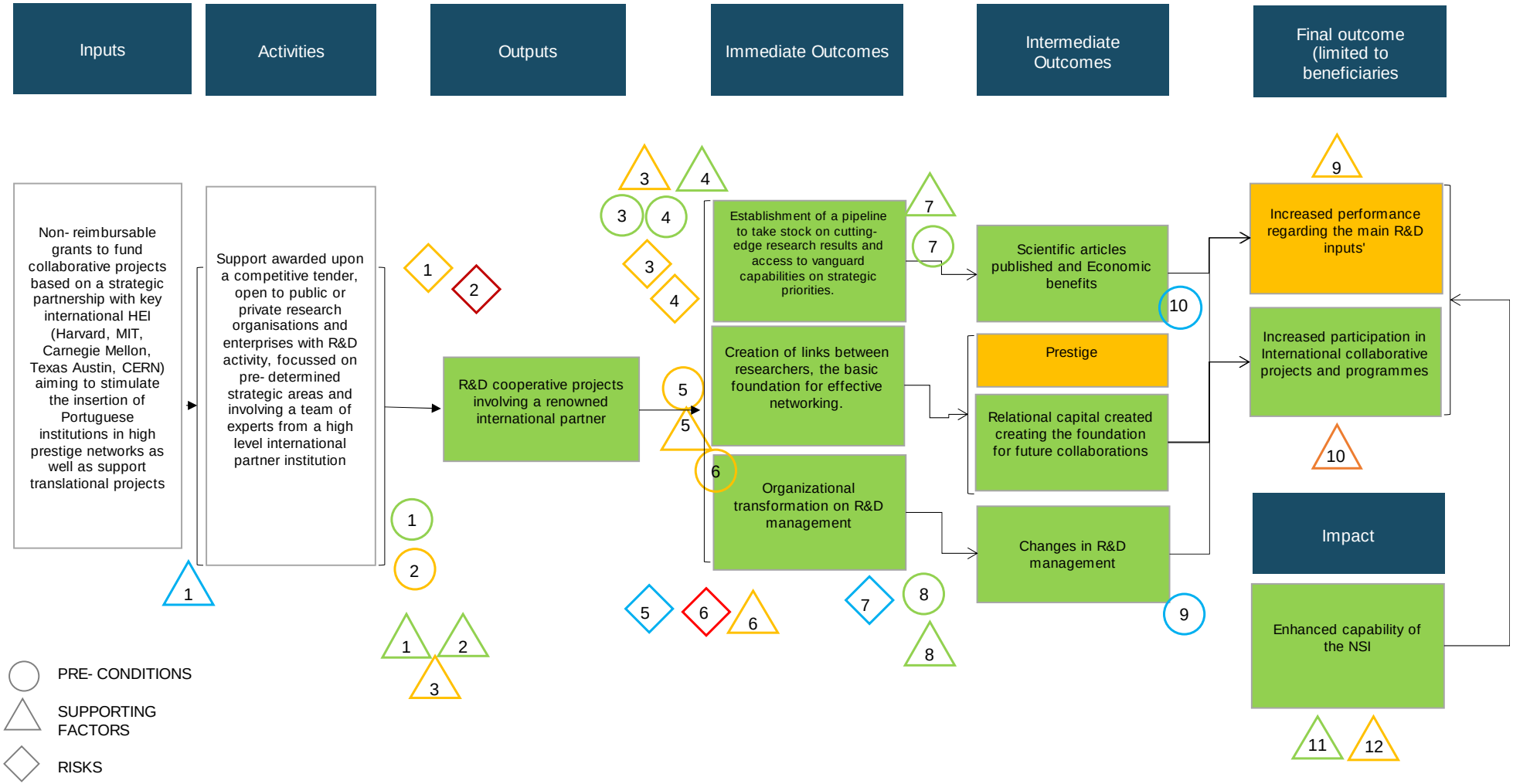
Considering final outcomes, the impact on the performance of the innovation system cannot be attributed to the policy instrument. Although the impacts have been positive, there is limited evidence that a major change occurred to support a productivity gain in the national innovation system. Nevertheless, in what concerns the increasing participation in international collaborative R&D projects, it is reasonable to assume that this instrument had a demonstrative effect and contribute to breaking some barriers, which facilitated a medium-level achievement in terms of openness to collaboration and greater participation in FP7 and H2020 (which has been observed).

The envisaged impact with the COMPETE OP was the enhancement of the national innovation system, supporting its consolidation and competitiveness. For that, a set of instruments must be combined to have a significant and broad structural effect. Evidence on this particular policy instrument does not support more than a weak achievement.

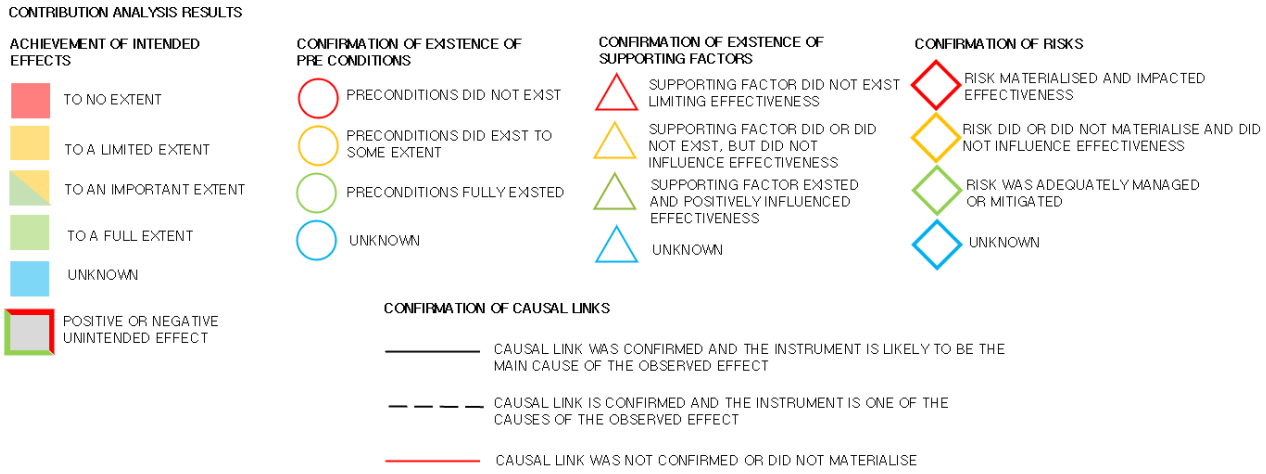
Overall, the policy instrument had a positive effect and contributed to a cultural transformation, which has impacted the success of Portuguese participation in FP7 and H2020. Furthermore, there is an unintended gain in terms of prestige that has been important to enter consortiums. Finally, it was demonstrated a strong additionality effect

of ERDF support, funding projects which would otherwise not be pursued. The summary of this analysis is expressed in the following figure.

Figure 27. Representation of the results of the contribution analysis for international cooperation RTD projects



Source: Evaluation team on the basis of primary and secondary data collected


CONTRIBUTION ANALYSIS RESULTS
ACHIEVEMENT OF INTENDED EFFECTS
TO NO EXTENT
TO A LIMITED EXTENT
TO AN IMPORTANT EXTENT
TO A FULL EXTENT
UNKNOWN
POSITIVE OR NEGATIVE UNINTENDED EFFECT
CONFIRMATION OF EXISTENCE OF PRE CONDITIONS
PRECONDITIONS DID NOT EXIST
PRECONDITIONS DID EXIST TO SOME EXTENT
PRECONDITIONS FULLY EXISTED
UNKNOWN
CONFIRMATION OF EXISTENCE OF SUPPORTING FACTORS
SUPPORTING FACTOR DID NOT EXIST LIMITING EFFECTIVENESS
SUPPORTING FACTOR DID OR DID NOT EXIST, BUT DID NOT INFLUENCE EFFECTIVENESS
SUPPORTING FACTOR EXISTED AND POSITIVELY INFLUENCED EFFECTIVENESS
UNKNOWN
CONFIRMATION OF RISKS
RISK MATERIALISED AND IMPACTED EFFECTIVENESS
RISK DID OR DID NOT MATERIALISE AND DID NOT INFLUENCE EFFECTIVENESS
RISK WAS ADEQUATELY MANAGED OR MITIGATED
UNKNOWN
CONFIRMATION OF CAUSAL LINKS
CAUSAL LINK WAS CONFIRMED AND THE INSTRUMENT IS LIKELY TO BE THE MAIN CAUSE OF THE OBSERVED EFFECT
CAUSAL LINK IS CONFIRMED AND THE INSTRUMENT IS ONE OF THE CAUSES OF THE OBSERVED EFFECT
CAUSAL LINK WAS NOT CONFIRMED OR DID NOT MATERIALISE

4. GENERAL FINDINGS AND LESSONS LEARNT

4.1. Key achievements of ERDF support in the Member State (i.e. effectiveness)

The 21st century exposed the Portuguese economy's fragilities and stressed the need to accelerate the pace of structural change. The increased awareness that competitiveness is founded on knowledge and that, in a cross-sectoral perspective, increasing the knowledge content of the goods and services produced was the key lever for a growth strategy of convergence to Europe. The National Strategic Reference Framework (NSRF) 2007-2013 was devised around this macro goal.

The diagnosis of the innovation system highlighted the progress underway in terms of human capital accumulation and the knowledge production sub-system's augmented capabilities. However, the economy was still in an early-stage process of painful structural change with massive destruction of jobs. The Portuguese strategy aimed at a considerable technological upgrade and consolidation of a competitive innovation system that could fuel the transformation and pave the way to the knowledge economy. However, the country's situation revealed fragilities in the knowledge production sub-system and the economy qualification and absorptive capacity. These fragilities were amplified by the divide between these two dimensions, and the organisational culture opposed to cooperation.

During the preparation of the NSRF OPs, a strong focus was placed on designing a comprehensive set of policy instruments to develop the scientific and technological system and connect it more effectively to the economy and society.

The main operational programme deployed to respond to these challenges (also supported by other thematic OPs and regional OPs) was the COMPETE OP, which presented a full range of instruments, such as the Support System to Entities of the National Scientific and Technological System (SAESCTN). Under SAESCTN, three measures were analysed in the context of this study, all addressing the entities of the scientific and technological system: RTD individual projects in all scientific fields, RTD strategic individual projects, and international cooperation RTD projects.

RTD individual projects led by scientific and technological entities intended to reinforce research and development activities, strengthening the scientific production and consolidating the NSTS. Overall, this measure provided crucial funding for research projects, having had relevant importance in contributing to the sustainability of supported R&D units in the 2007-2013 period. RTD individual projects financed under the measure gave rise all in all to 22 415 publications (99% of the projects produced publications - an average of 15.4 publications/project), a total of 1,673 prototypes and pilot plants were generated (27% of the projects supported by this measure led to a prototype or pilot plant, an average of 4.2 prototypes/pilot plant per project) and 128 patents (5% of the projects led to patent applications). The measure generated visible positive effects on the advancement of scientific knowledge developed by national RTD actors, increasing their scientific and technological capacity and empowering them for more ambitious RTD activities. Although some results have been identified for economic valorisation, the effects of these projects in this aspect were very limited.

RTD strategic individual projects involved the best-performing R&D organisations in the country to strengthen their capacity and make them competitive on a global scale. These were projects of an institutional nature, structuring the respective research groups' activities, and well embedded in long-term strategic research plans. RTD strategic projects (typology individual projects) generated 42,711 publications (100% of the projects produced publications; an average of 464.3 publications/project) and gave rise

to 1,429 prototypes and pilot plants (45% of the projects led to a prototype and pilot plant, an average of 35 prototypes/pilot plant per project), and 290 patents (50% of the projects led to patent applications). The measure reinforced the most outstanding Portuguese research groups' scientific and technological capacity, enabling them to act globally. The projects funded under the measure generated some effects in terms of economic valorisation (e.g. patent licensing agreements, spin-off companies, technological services, and research contracts), thus contributing to some extent to increase competitiveness and innovation in the target regions.

RTD international cooperation projects followed a different perspective. Throughout the COMPETE OP, a set of instruments were designed to provide tools to foment science push dynamics, technology pull dynamics and strengthen linkages within the national innovation system. Nevertheless, it had become clear that the evolution of the national innovation system and the stairways to excellence imposed its internationalisation. In other words, it was perceived as fundamental the ability to tap worldwide excellence science and take advantage of the Portuguese catching-up position. Hence, the COMPETE OP launched a set of calls that funded 49 projects within the framework of the international partnerships with CERN, MIT, Carnegie Mellon, Harvard Medical School and Texas Austin. The relevance of these projects also aimed to take stock of these institutions' R&D management expertise and hence induce organisational transformation in the Portuguese research units towards better management of partnerships and an easier linkage to the economy (two of the most severe shortcomings pointed to the national innovation system). Without specific targets defined, this policy instrument produced important qualitative outcomes, namely the creation of links and relational capital and, to a lesser extent, contributed to the opening of Portuguese institutions, which has had results in a significant increase in the participation in FP7 and H2020.

4.2. Relevance

The COMPETE OP provided the framework for deploying a comprehensive set of instruments intended to promote the development of the Portuguese national innovation system. The necessary balance between demand-pull dynamics and science push dynamics was achieved by combining instruments dedicated to strengthening capacity building both on research units and firms and through the introduction of cooperation inducing instruments to close the gap and mitigate the divide between science and economy.

The various typologies of projects supported under the OP Axis 1 – Knowledge and Technological Development contributed to addressing the main needs identified in the RTD field, as regards both RTD activities led by organisations of the scientific and technological system (SAESCTN support instrument) and led by businesses (SI RTD instrument). In particular, the funding of these projects had eventually positive medium- and long-term outcomes on key aspects such as strengthening the skills of scientific and technological institutions and their ability to better cooperate with economic actors; a significant increase in the number of company-led RTD projects (including consortia projects); increase in the number of collective research projects; expansion of demonstration actions and technology transfer to businesses; creation of RTD centres in companies; a slight increase in activities and number of stakeholders involved in industrial property protection; and higher participation of Portuguese organisations in the European Framework Programme for Research (particularly in the last years of the programme, i.e. from 2012 onwards).

For the important impact they generated, it is also relevant to mention the activities funded under the OP Axis 2 – Innovation and Renewal of the Business Model and Pattern

of Specialisation. Two support instruments were available mainly to the business community: 1) SME Qualification and Internationalisation Incentive System (SI SME Qualification) supporting actions to promote productivity, quality and internationalisation of SMEs; and 2) Innovation Incentive System (SI Innovation) to foster innovation and entrepreneurship through the launch of new goods and services; new production, organisational and marketing processes; new production lines; creation of start-up companies etc.

The policy instruments under analysis in this study followed a science push perspective aimed at reinforcing research capabilities and organisational capacity to develop excellence science and manage international cooperation. The study findings suggest that the instruments deployed were in line with the objectives, responding to the scientific and technological system's effective needs. The ERDF played a major role in sustaining and enlarging this system, having had a key intervention amidst the financial crisis in sustaining the results of previous investments and allowing to continue to finance research and technological development activities.

4.3. Efficiency

The evidence collected under the study, as well as the conclusions drawn in other assessment exercises, show that the ERDF investment in activities of COMPETE OP Axis 1, and in particular in the support mechanism for entities of the scientific and technological system (SAESCTN), was in general efficient and overall followed international good practices regarding the forms of available support.

The outputs, outcomes and impact identified in the study show that the ERDF support to the measures under assessment was sufficient to strengthen and enlarge the national science and research system, suggesting that the instruments mobilised by the OP induced the production of results with efficient use of resources.

Looking at the level of achievements and results attained in the two main mechanisms within Axis 1 of the OP – SAESCTN and SI RTD (Support System to Research and Technological Development led by businesses) – observed costs per unit result were different. In fact, in terms of scientific production results (e.g. scientific papers, pilot installations, patents), data analysis revealed that SAESCTNs projects performed better in the number of deliverables per million euros of funding. Although the projects supported by these two instruments may have resulted in similar scientific outcomes, their impact in valorisation was different since, in SI RTD, this potential was generally best achieved, as project results were usually closer to the market. It was also concluded that, in general, SAESCTN collaborative projects were also more efficient than individual projects per million euro (Mateus & Associados, 2018).

Although cases of projects approved without financial execution were identified (mainly during the first years of implementation of the OP), and in the first OP reprogramming action, approximately €140m was withdrawn from the SAECSTN instrument (the amount that would later be practically restored in all), the financial execution was at the end achieved according to what was initially estimated, allowing the use of the planned contribution from the ERDF.

4.4. Sustainability and replicability

Sustainability refers to the continuation or follow-up of the activities and results developed in the projects. In the context of RTD policy, this often includes the valorisation of results and outcomes. On the other hand, replicability is the potential for

applying the project results or elements such as methods and tools developed in other regions/countries or other activity areas.

The policy instruments included in this analysis were all directed to support scientific organisations. The first two instruments dealt with the building and expanding internal competences for research. In contrast, the third instrument intended to promote international collaboration and induce a more proactive stance to collaboration. Intended effects occurred to some extent and suggested being sustainable. Scientific and technological capacity building, development of new key competences, and organisational changes to better support project management and professionally addressing bridge-building with international partners have endured.

Lesser sustainability in what concerns effective knowledge transfer to the economy and consolidation of international partnerships was also identified. Regarding the former, linking to the economy and establishing dense cooperation patterns to fuel enterprise innovation produced feeble outcomes. In relation to the latter, the discontinuity in terms of funding schemes and the lack of sequential projects hampered the sustainability of effects, also in jeopardy due to the precarity of scientific jobs and the brain drain during the financial crisis.

In terms of replicability, these instruments have been replicated over time and in the setting of the current programming period. Moreover, the model to foster international partnerships has been replicated to new international collaborations (e.g. European Space Agency), as well as into new models (e.g. Atlantic International Research Centre (Air Centre)). The funding mechanisms can be easily transferred to different regions or countries, but in what concerns RTD advanced strategies and international collaborative R&D, policy coherence and consistency are required and the presence of advanced research centres knowledge-based businesses and entrepreneurial culture. It is most likely that only the more advanced regions will have the capacity to launch and sustain a policy instrument such as the RTD international cooperation projects in the long term.

4.5. Coherence

The quantitative measurement of the results and the visible effects on the target beneficiaries supports the conclusion that COMPETE ensured coherence in addressing the issues identified ex-ante in fundamental research, applied research, business R&D, technological services, and technology transfer and high-tech entrepreneurship. The set of instruments selected were also consistent with the objectives supporting the interventions, addressing failures and shortcomings within the national scientific and innovation systems, and creating the support mechanisms to induce change and transformation.

The territorial scope of the COMPETE operational programme was limited to mainland Portugal's convergence regions (i.e. NUTS II regions of Norte, Centro and Alentejo). In order to ensure the necessary articulation between the national and the regional operational programmes, all these operational programmes (i.e. OPs COMPETE, Norte, Centro and Alentejo) adopted a thematic structure which, although different from one programme to another, allowing the implementation of common support instruments and main typologies of projects in the RTD and innovation fields.

The following support instruments were available in all the above-mentioned OPs: **1)** Support to Entities of the National Scientific and Technological System (SAESCTN) to foster R&D actions in research and technological institutions. **2)** Research and Technological Development Incentive System (SI RTD) to encourage business R&D. **3)** Innovation Incentive System (SI Innovation) to promote business productive innovation and entrepreneurship. **4)** SME Qualification and Internationalisation Incentive System (SI

SME Qualification) to foster SME productivity by reinforcing competitiveness and increasing internationalisation. **5)** Collective Actions Support System (SIAC) to strengthen businesses' development (particularly SMEs) through joint actions for innovation, internationalisation and capacity building.

The sharing of competences between COMPETE and the regional programmes was based on the following main principles: actions that benefited from management closer to the beneficiaries or were to be implemented under a regional or local intervention logic were supported by regional OPs; actions that required critical thresholds, implied some kind of coordination or resulted from national strategies were funded by COMPETE. Furthermore, bearing in mind the need for coordination that had to be established between the national OP and the OPs of those three regions, particularly as regards the definition of responsibilities and tasks of each programme, a number of criteria were taken into account (non-exhaustive enumeration):

- regional OPs funded scientific and technological infrastructures, including business hosting infrastructures, as well as RTD projects led by small and micro companies;
- national COMPETE OP funded under Axis 1 RTD projects led by entities of the scientific and technological system (SAESCTN), RTD projects led by large and medium-sized companies (SI RTD), and actions to support the Portuguese participation in FP7 (in fact later supported under Axis 5);
- funding for business investment incentive systems under Axis 2 (SI Innovation and SI SME Qualification) was provided according to company size: medium and large companies' projects were supported by the national OP, while projects carried out by micro and small companies were funded by regional OPs.

There were synergies with other European objectives and strategies, for example, between the European Social Fund (ESF) and the national OP for Human Potential (POPH, as well as with Cohesion Policy (regional OPs). The application of complementarity between ESIF funds allowed the financing of advanced training (e.g. PhD), reinforcing the internal capabilities of scientific organisations and also human capital accumulation.

There were also elements of connection to the European framework programmes (FP) for research, despite the lack of specific coordination mechanisms. ERDF investments were in principle meant to enable the subsequent participation in FP actions, which has been confirmed by recent data on ERDF recipients' participation in research projects at the European level after the end of the 2007-2013 programming period.

4.6. EU added value

Overall, cohesion policy funds allocated to Portugal between 2007 and 2013 amounted to about €21.5b (€11.9b from ERDF), 24% of which for RTD, innovation and business support activities. The OP implementation took place in an extremely unfavourable context for the national economy caused by the international economic crisis and the need to consolidate public finances. The OP, together with the several regional operational programmes, was the main public instrument to enhance the competitiveness of the Portuguese economy, funding strategic dimensions such as research and technological development, innovation, internationalisation and entrepreneurship.

The OP supported more than 8,000 companies and 600 different organisations. It was estimated at the end of the programme that participating companies' turnover will have increased 52% and their exports 69% and that approximately 18,000 jobs were created, which highlights the relevant role that ERDF funding had to encourage competitive investment in the country while minimising the negative impacts of the adverse economic situation.

There is clear additionality resulting from the ERDF funding, and it is evident that the scale and pace of effects would have been produced at a much lower level and slower rhythm. The ERDF played a fundamental role in funding the capacity building of scientific organisations as well as firms, laying the foundations for the consolidation of national scientific and innovation systems. In parallel, the synergies with regional OPs reinforced convergence regions' scientific and technological systems, particularly in Norte and Centro.

The projects funded under the three policy instruments taken into account in the study and those carried out under international cooperation agreements established with renowned knowledge centres contributed to the prestige of the Portuguese institutions with relevant impact on the international collaboration patterns and intensity.

On an EU-wide level, the strengthening of the Portuguese innovative capabilities had an impact in increasing participation in EU projects, firstly by scientific actors, and later also by firms, enriching the European innovation ecosystem.

Annexes

ANNEX 1. OVERVIEW OF EVIDENCE COLLECTED ON EXPECTED EFFETS OF RTD PROJECTS LED BY ENTITIES OF THE SCIENTIFIC AND TECHNOLOGICAL SYSTEM (INDIVIDUAL PROJECTS)

Effect type	Expected effect	Targets defined by MA	Summary of evidence collected	Level of achievement of threshold
Outputs	RTD individual projects launched and implemented	No	Through interviews with the OP Managing Authority and the Intermediate Body (i.e. Foundation for Science and Technology, FCT), evidence was gathered that grant delivery activities were carried out as planned from an operational standpoint. Data provided by FCT show that a rather high level of grant applications was received, and the percentage of projects approved for funding was relatively low (typically under 15%).	TO A FULL EXTENT
Immediate outcomes	Development of new knowledge (basic and applied) by the supported entities	Yes	For these results (immediate outcomes), thresholds were established by FCT, namely for indicators such as the number of papers and books, communications, seminars and conferences, advanced training (e.g. Master and PhD theses), computational applications, pilot plants, prototypes and patents. Goals were established for each call for proposals taking these indicators into account. From data provided by FCT, it can be concluded that in all calls, achieved results have almost always exceeded the goals established for all indicators.	TO A FULL EXTENT
	Development of new and enhanced scientific skills	No	Interviews with programme managers and direct beneficiaries provided anecdotal evidence on the positive effects of the projects on the development of new and enhanced scientific skills of the participating research groups (including advanced scientific training for postgraduate researchers (e.g. Master and PhD theses)).	TO A FULL EXTENT
	Generation of intellectual property rights	No	Supported projects generated some intellectual property rights (e.g. number of patent applications, according to data provided by FCT).	TO A LIMITED EXTENT
Intermediate outcomes	Strengthened scientific and technological capacity	No	The strengthening of scientific capacity was often referred to in interviews with project beneficiaries as one of the most relevant effects of the projects	TO AN IMPORTANT EXTENT

Effect type	Expected effect	Targets defined by MA	Summary of evidence collected	Level of achievement of threshold
	of supported entities		for the respective research groups. Projects provided R&D centres with valuable resources (e.g. human resources and equipment), and their results established a basis from which new knowledge could be developed in the following years.	
	Project results transferred to external users for economic and social valorisation	No	In general, it seems that the priority of these projects was not technology transfer. Information collected in the interviews confirmed, however, that some projects generated knowledge that was later used economically and socially, namely through research contracts, consulting services, technology transfer agreements, and patent licensing (although rarely). Public disclosure of project results led other entities (e.g. research groups and companies) to use them for scientific and commercial purposes.	TO A LIMITED EXTENT
Final outcomes	Empowered supported entities to participate in more ambitious RTD projects	No	Interviewees said that the reinforcement of their capacity allowed them to access more ambitious RTD projects in the following years. In the framework of a survey carried out in 2018 with RTD actors funded under the SAESCTN mechanism, 89% of respondents said there was an increase in their capacity for more complex RTD activities in the future.	TO AN IMPORTANT EXTENT
	Strengthened international profile of supported entities	No	Most interviewees stated that the implementation of projects and dissemination of results increased the visibility of the respective research groups and facilitated access to international research consortia. The participation of Portuguese RTD entities in FP7 increased considerably in the period 2007-2013. Undoubtedly, many of these entities were the ones that implemented projects funded by the measure. In the survey mentioned in the paragraph above, 79% of RTD actors funded under the SAESCTN mechanism considered that their projects facilitated the entry or reinforced their presence in international research networks.	TO AN IMPORTANT EXTENT

Effect type	Expected effect	Targets defined by MA	Summary of evidence collected	Level of achievement of threshold
	Economic benefits for supported entities through RTD results in the exploitation	No	Evidence collected from the interviews suggests that only a small minority of projects have enabled respective R&D centres to increase their revenues through commercial activities. Such benefits over the following years were obtained not so much from immediate exploitation of project results (e.g. industrial property licensing agreements) but more from activities such as research contracts established with companies, typically implemented under publicly funded projects for business innovation. In the survey mentioned in the previous paragraphs, 16% of SAESCTN beneficiaries said that the projects led to the establishment of intellectual property rights licensing contracts; 28% had more collaborative contracts with companies; 28% had more contracted research and services; 22% reported new initiatives to demonstrate developed technologies (e.g. pilot plants, demonstration projects). From what was possible to ascertain in the interviews carried out, such percentages would have been lower in the projects supported by the measure.	TO A LIMITED EXTENT
Impact	Growth and strengthening of the National Scientific and Technological System		The expected impact considered in this study regarding the growth and strengthening of the national scientific and technological system was achieved, and all the evidence suggests that the RTD individual projects in all scientific fields measure contributed to it, including interviews, data provided by the COMPETE Managing Authority, FCT, other evaluation reports, and official statistics.	TO A FULL EXTENT

ANNEX II. OVERVIEW OF EVIDENCE COLLECTED ON EXPECTED EFFETS OF RTD STRATEGIC PROJECTS DEVELOPED IN AREAS OF PUBLIC INTEREST LED BY ENTITIES OF THE SCIENTIFIC AND TECHNOLOGICAL SYSTEM (INDIVIDUAL PROJECTS)

Effect type	Expected effect	Targets defined by MA	Summary of evidence collected	Level of achievement of threshold
Outputs	RTD strategic projects launched and implemented	No	Evidence collected from the OP Managing Authority and the Intermediate Body (i.e. Foundation for Science and Technology) revealed that activities were carried out as planned from an operational viewpoint. This includes the operationalisation of the two calls, as well as the implementation of the projects that did not denote significant problems in terms of both technical and financial execution.	TO A FULL EXTENT
Immediate outcomes	Development of new knowledge by supported entities	Yes	Among other key figures, RTD strategic individual projects generated 42,711 publications, 42,265 communications, 1,429 prototypes and 290 patents. Through data provided by FCT, it was concluded that in the two launched calls; achieved results have almost always exceeded the goals established for all indicators.	TO A FULL EXTENT
	Development of new scientific skills	No	Interviews with direct beneficiaries provided evidence on the positive effects of the projects on the development of new and enhanced scientific skills of the participating research groups. This was indeed one of the effects stemming from the projects most valued by the interviewed beneficiaries. Furthermore, in the scope of the 106 projects funded by the measure (including collaborative projects), 15,805 theses (mainly PhD and Master theses) were carried out, and many researchers were recruited, so reinforcing the human capital of the research centres.	TO A FULL EXTENT
	Generation of intellectual property rights	No	Supported projects generated some intellectual property rights (e.g. number of patent applications, according to data provided by FCT). 290 patent applications were filed from strategic individual projects (about 50% of these projects generated industrial property rights).	TO AN IMPORTANT EXTENT

Effect type	Expected effect	Targets defined by MA	Summary of evidence collected	Level of achievement of threshold
Intermediate outcomes	Strengthened scientific and technological capacity of supported entities	No	Reinforcement of research teams with more human resources, provision of new equipment (in some cases large equipment) and acquisition of essential materials and services ensured the beneficiaries enhanced conditions to develop their main research lines (information collected from programme managers and beneficiaries).	TO A FULL EXTENT
	Project results transferred to external users for economic and social valorisation	No	Interviews carried out with beneficiaries revealed that knowledge transfer activities took place, such as licensing agreements, creation of university spin-off companies, know-how transfer agreements, contracts for technology services, joint doctoral theses with companies, research contracts with companies, and new RTD projects with firms (publicly funded), among others.	TO A LIMITED EXTENT
Final outcomes	Empowered supported entities to compete on the European and global markets of R&D	No	Anecdotal evidence was collected from project beneficiaries that strategic projects have contributed to increasing the international visibility of supported research groups, namely through the following activities: dissemination of research results in international journals and events; organisation of events with the participation of renowned foreign scientists; recruitment of foreign researchers; and missions abroad with a view to integration into international consortia. This helped beneficiary entities to strengthen international connections and participate more often in projects funded by FP7 and H2020. Moreover, in the survey mentioned above, 79% of SAESCTN beneficiaries considered that the projects facilitated their entry or reinforced their presence in international research networks.	TO AN IMPORTANT EXTENT
	Economic benefits for supported entities through the valorisation of RTD	No	Several activities of technology transfer were identified in the interviews, which have meant some financial return for the participating entities in this measure, including licensing agreements, creation of spin-off companies, provision of	TO A LIMITED EXTENT

Effect type	Expected effect	Targets defined by MA	Summary of evidence collected	Level of achievement of threshold
			technological services, and establishment of research contracts with companies. New RTD-funded projects with companies were also reported, both at national and European levels.	
Impact	Growth and strengthening of the National Scientific and Technological System	No	The scientific system strengthened and grew during and after the implementation of the COMPETE OP. In the 2007-2013 period, scientific production in the country had significant growth rates, in a convergence process with the EU average. The short, medium- and long-term results generated by the strategic projects contributed to the increase of critical mass and quality of the system.	TO AN IMPORTANT EXTENT
	Increased competitiveness and innovation in mainland convergence regions		According to the interviewees, the projects funded under the measure generated some effects in terms of economic valorisation (e.g. licensing agreements, spin-off companies, technological services, research contracts). These would have been the main ways the projects contributed directly to innovation and competitiveness in convergence regions.	TO A LIMITED EXTENT

ANNEX III. OVERVIEW OF EVIDENCE COLLECTED ON EXPECTED EFFECTS OF THE INTERNATIONAL COOPERATION RTD PROJECTS

Effect type	Expected effect	Targets defined by MA	Summary of evidence collected	Level of achievement of threshold
Outputs	R&D projects involving a renowned international partner	No	49 projects were approved within the scope of this analysis. These projects were reported as successfully implemented.	TO A FULL EXTENT
Immediate outcomes	Establishment of a pipeline to take stock on cutting-edge research results and access to vanguard capabilities on strategic priorities.	No	The objectives underlying this policy instrument led to envisaged qualitative outcomes, as targets were not defined. Based on the interviews, it was unanimously recognised that the selected international partners were at the cutting-edge of science, providing an excellent opportunity for knowledge transfer to the Portuguese partners. Regarding immediate outcomes, the project served to immediately create an organised and structured model of cooperation, effectively establishing cooperation between the Portuguese and the international partner, facilitating knowledge transaction. On a longer-term basis, part of these effects was lost due to brain drain and also discontinuation of the contracts.	TO A LIMITED EXTENT
	Creation of links between researchers, the basic foundation for effective networking.	No	Within the framework of the international collaboration agreements, points of contact were established between institutions. Furthermore, based on the alignment of research topics, researchers established roadmaps that fostered the creation of relationship capital and hence, establishing effective networks.	TO AN IMPORTANT EXTENT
	Organisational transformation on R&D management	No	The approval of collaborative projects created an immediate collateral outcome. Considering the state of development of some of the Portuguese research units, these projects provided a learning opportunity to adapt their organisation, as well as opportunities to learn how the most advanced research units managed their organisations and how they operated. Some interviewees mentioned a positive impact in some adjustments leading to	TO SOME EXTENT

Effect type	Expected effect	Targets defined by MA	Summary of evidence collected	Level of achievement of threshold
			better project management practices and also improvements in the participation in international networks (e.g. including greater propensity to apply for grants at the FP).	
Intermediate outcomes	Scientific articles published and Economic benefits obtained from the transferring of research results to firms	No	Projects reported positive impacts on scientific publications, as well as PhDs graduates and, especially, MScs.	TO SOME EXTENT
	Changes in R&D management within an organisation	No	Interviewees mentioned that some of the structures created to manage these partnerships led to organisation reconfiguration and the set-up of units dedicated to managing projects and partnerships, actively supporting researchers.	TO SOME EXTENT
	Relational capital created, establishing the foundation for future collaborations	No	According to the interviewees, the researchers directly involved in the partnerships on both sides established solid links, which led to subsequent collaborations beyond the projects initially approved.	TO AN IMPORTANT EXTENT
Final outcomes	Increased performance regarding main R&D inputs	No	The direct outcome related to scientific benefits was moderate, with particularly relevant outcomes in the area of physics. No direct economic benefits are foreseeable.	TO A LIMITED EXTENT
	Increased participation in international collaborative projects and programmes	No	Although causality is not direct, these projects have had a direct effect on stimulating openness and greater participation. That is visible in the data on collaboration and participation in FP7 and H2020.	TO SOME EXTENT
Impact	Enhanced capability of the NIS	NO	Indicators show that the NIS has improved significantly, with strong research outputs (PhD graduates, publications, citations). It was also observed continuous growth in GERD and BERD, as well as increased internationalisation.	TO A LIMITED EXTENT

ANNEX IV. INTERVIEW LIST

Stakeholder category	Organisation	Role in the organisation	Name
Managing Authority	COMPETE Operational Programme	Member of the Board of Directors	Alexandra Vilela
Managing Authority	COMPETE Operational Programme	Head of Monitoring and Evaluation – Technical Secretary	Teresa Tomé
Managing Authority	COMPETE Operational Programme	Head of Research and Development – Technical Secretariat	Margarida Pinto
Managing Authority	COMPETE Operational Programme	Research and Development – Technical Secretariat	Pedro Gonçalves
COMPETE OP Intermediate Body	Foundation for Science and Technology	Member of the Board of Directors	Maria Emília Moura
COMPETE OP Intermediate Body	Foundation for Science and Technology	Head of Department for R&D Units	Isabel Vitorino
COMPETE OP Intermediate Body	Foundation for Science and Technology	Head of Department for R&D Projects and Programmes	Pedro Leite
OP Intermediate Body	Foundation for Science and Technology	Head of Studies and Planning Division	Maria João Sequeira
OP Intermediate Body	Foundation for Science and Technology	Studies and Strategy Office	Isabel Reis
OP Intermediate Body	Foundation for Science and Technology	Advisor - Board of Directors	Susana Dias
Managing Authority	Norte Regional Operational Programme	Former Member of the Board of Directors	Henrique Capelas
National Coordination of ESIF Funds	AdC – Agency for Cohesion and Development	Former Director - Regional Policy Unit	António Ramos
Beneficiary – Measure I.7.1 – RTD Strategic Projects	Centre for Neuroscience and Cell Biology (CNC) Faculty of Medicine University of Coimbra	CNC Former Director Full Professor – University of Coimbra	Catarina Resende de Oliveira
Beneficiary – Measure I.7.1 – RTD Strategic	Centre for Neuroscience and Cell Biology (CNC)	Financial and Administrative Department	Sílvia Sousa

Stakeholder category	Organisation	Role in the organisation	Name
Projects	University of Coimbra		
Beneficiary – Measure I.7.1 – RTD Strategic Projects and Beneficiary – Measure I.1.1 – International Cooperation RTD Projects	LIP - Laboratory of Instrumentation and Experimental Particle Physics Department of Physics Instituto Superior Técnico University of Lisbon	LIP Director Full Professor – University of Lisbon	Mário Pimenta
Beneficiary – Measure I.7.1 – RTD Strategic Projects	LSRE-LCM - Laboratory of Separation and Reaction Engineering - Laboratory of Catalysis and Materials Department of Chemical Engineering University of Porto	Coordinator LSRE-LCM Associate Professor – University of Porto	Madalena Dias
Beneficiary – Measure I.7.1 – RTD Strategic Projects	MED - Mediterranean Institute for Agriculture, Environment and Development Department of Landscape, Environment and Planning University of Évora	MED Director Full Professor – University of Évora	Teresa Pinto Correia
Beneficiary – Measure I.7.1 – RTD Strategic Projects	CESAM - Centre for Environmental and Marine Studies Department of Biology University of Aveiro	CESAM Scientific Coordinator	Ana Isabel Lillebø
Beneficiary – Measure I.1.1 – RTD Projects in All Scientific Fields	Institute for Nanostructures, Nanomodelling and Nanofabrication (I3N) Physics Department University of Aveiro	I3N Researcher Associate Professor - University of Aveiro	Teresa Monteiro
Beneficiary – Measure I.1.1 – RTD Projects in All	INEGI - Institute of Science and Innovation in	Director Structures and Mechanical Systems -	Jorge Seabra

Stakeholder category	Organisation	Role in the organisation	Name
Scientific Fields	Mechanical and Industrial Engineering Department of Mechanical Engineering University of Porto	Transmissions and Vibrations - INEGI Director and Full Professor - Department of Mechanical Engineering - University of Porto	
Beneficiary – Measure I.1.1 – RTD Projects in All Scientific Fields	Department of Physics and Astronomy University of Porto	Director, Associate Professor	Mário João Monteiro
Beneficiary – Measure I.1.1 – RTD Projects in All Scientific Fields	Department of Physics and Astronomy University of Porto	Researcher, Assistant Professor	Nuno Santos
Beneficiary – Measure I.1.1 – RTD Projects in All Scientific Fields	INESC TEC - Institute for Systems and Computer Engineering, Technology and Science Department of Informatics Engineering University of Porto	INESC TEC Researcher Associate Professor - Department of Informatics Engineering University of Porto	António Augusto Sousa
Beneficiary – Measure I.1.1 – RTD Projects in All Scientific Fields	INESC TEC - Institute for Systems and Computer Engineering, Technology and Science Department of Engineering University of Trás-os-Montes and Alto Douro (UTAD)	INESC TEC Researcher Assistant Professor - UTAD	Maximino Bessa
Beneficiary – Measure I.1.1 – RTD Projects in All Scientific Fields	MED - Mediterranean Institute for Agriculture, Environment and Development University of Évora	Researcher	Hélia Cardoso
Beneficiary – Measure I.1.1 – RTD Projects in All Scientific Fields	Institute for Sustainability and Innovation in Structural Engineering (ISISE) Department of Civil	ISISE Researcher Full Professor - University of Minho	Joaquim Barros

Stakeholder category	Organisation	Role in the organisation	Name
	Engineering University of Minho		
Beneficiary – Measure I.1.1 – RTD Projects in All Scientific Fields	Research Centre in Sports Sciences, Health Sciences and Human Development (CIDESD) School of Sports and Leisure Polytechnic Institute of Viana do Castelo (IPVC)	CIDESD Researcher Director and Assistant Professor - School of Sports and Leisure, IPVC	Pedro Bezerra
Beneficiary – Measure I.1.1 – International Cooperation RTD Projects	Faculty of Medicine University of Porto	Director	Altamiro Pereira
Beneficiary – Measure I.1.1 – International Cooperation RTD Projects	Faculty of Medicine University of Porto	Projects' manager	Isabel Pereira
Beneficiary – Measure I.1.1 – International Cooperation RTD Projects	Department of Physics University of Coimbra	Researcher	Pedro Costa
Beneficiary – Measure I.1.1 – International Cooperation RTD Projects	Department of Physics University of Coimbra	Director	Constança Providência
Beneficiary – Measure I.1.1 – International Cooperation RTD Projects	University of Coimbra	Project Manager	Nuno Gomes
Beneficiary – Measure I.1.1 – International Cooperation RTD Projects	INESC TEC - Institute for Systems and Computer Engineering, Technology and Science	CEO	José Mendonça
Beneficiary – Measure I.1.1 – International Cooperation RTD Projects	INESC TEC - Institute for Systems and Computer Engineering, Technology and Science	Director	José Caldeira

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