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

Czech Republic

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February 2021

EUROPEAN COMMISSION
Directorate-General for Regional and Urban Policy
Directorate B — Policy
Unit B.2 — Evaluation and European Semester
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2021 EN

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Manuscript completed in February 2021

1st edition

Luxembourg: Publications Office of the European Union, 2021

ISBN 978-92-76-45982-8
doi: 10.2776/536460

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LIST OF ABBREVIATIONS

BN	Billion
CA	Contribution Analysis
CS	Case study
CZK	Czech Crown
DG REGIO	Directorate-General for Regional and Urban Policy
DG COMP	Directorate-General for Competition
EC	European Commission
EIR	Electronic information resources
ELI	Extreme Light Infrastructure
ERA	European Research Area
ERDF	European Regional Development Fund
ESF	European Social Fund
ESIF	European Structural and Investment Funds
ESFRI	the European Strategy Forum on Research Infrastructures
EU	European Union
FP6	6th Framework Programme
FP7	7th Framework Programme
GDP	Gross Domestic Product
GERD	Gross Expenditure on Research and Development
H2020	Horizon 2020
HEIs	Higher Education Institutions
HiLASE	High-tech Laser Research Centre
HR	Human Resources
ICT	Information and Communication Technologies
IoP	Institute of Physics of the Czech Academy of Sciences
ISPROFIN	Information System for Programme Financing
M	Million
MA	Managing Authority
MEYS	Ministry of Education, Youth and Sports
MS(s)	Member State(s)
NO	Number
NDP	National Development Plan
NSRF	National Strategic Reference Framework
OP	Operational Programme
OP EC	Operational Programme Education for Competitiveness

OP EI	Operational Programme Enterprise and Innovation
OP PA	Operational Programme Prague Adaptability
OP PC	Operational Programme Prague – Competitiveness
OP RDI	Operational Programme Research and Development for Innovations
PA	Priority Axis
PALS	Prague Asterix Laser System
PI	Policy Instrument
R&D	Research and Development
RDI	Research, Development and Innovation
RIS3	Regional Innovation Smart Specialization Strategies
RTD	Research and Technological Development
RTOs	Research and Technology Organizations
STAR	Science, Technology Advanced Region
SUSEN	Sustainable Energy (major project)
ToC(s)	Theory of Change(s)

EXECUTIVE SUMMARY

BACKGROUND AND GOAL OF THE CASE STUDY

This study is one of seven case studies (CS) developed within the third task of the ex-post 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. It focuses on the Czech Republic, a Member State of the European Union since 2004, for which the programming period 2007-2013 was the first full-fledged period. The allocated amount of EUR 26.7 billion for the Cohesion policy opened an unprecedented opportunity for many thematic areas. For the realisation of investments under the code of expenditure 01 and 02 (Research infrastructure and research activities), three ERDF operational programmes (OP) were prepared to mutually address the needs of the RTD of the country. The total ERDF contribution reached EUR 1.9 billion. From the financial point of view, the Operational Programme Research and Development for Innovations for the Czech Republic (OP RDI) was the most important and explicit policy instrument after many years of underinvestment and limited political priority to the RTD sphere. The OP RDI covered 88% of the ERDF contribution for R&D in the country and fell within the framework laid out for the Convergence Objective. The finally allocated budget of EUR 2.2 billion (of which EUR 1.8 billion by ERDF). The support was provided to regions throughout the Czech Republic outside the Capital City of Prague, which fell under the Regional Competitiveness and Employment Objective.

This case study investigates predominantly the example of three policy instruments, whether the ERDF policy mix for RTD achieved its intended objectives and responded to the country's policy challenges. It also looks at whether the selected interventions for RTD infrastructure and activities were effective and according to which mechanisms. The CS looked at the RTD policy mix funded by the ERDF from three distinct perspectives: (i) from the perspective of a Member state and all relevant ERDF-OPs supporting the RTD infrastructure sphere, (ii) from the level of the OP supporting the selected policy instruments for in-depth analysis in this evaluation, and (iii) from the perspective of three selected policy instruments (PI). The Czech CS examines more deeply the following policy instruments and major project, all supported by the OP RDI:

- **(PI1) Infrastructure investments for research-related education at public higher education institutions (HEIs)** within the Priority Axes 4 "Research-related teaching infrastructure in higher education" of the OP RDI. According to the Task 1 classification, they are 62 projects, representing 22% of the OP ERDF expenditure. The PI consisted of constructing new facilities or modernising the equipment in HEIs, used for both education and research purposes. These projects aimed to reinforce the pool of highly qualified human resources, which was perceived to be the key to the competitiveness of the Czech economy.
- **(PI2) ICT infrastructure investments** funded from the Priority Axes 3 "Commercialization and popularisation of R&D" of the OP RDI. This PI included 12 projects, representing 2.3% of the OP RDI expenditure. The projects included investments for e-infrastructure, computing grids and data digitisation, storage, access, ICT network systems, information infrastructure for R&D, investments in material and technical ensuring, and non-material needs (software, licenses, databases etc.).
- **(PI3) Major Project "ELI: Extreme Light Infrastructure"** (ELI) supported from the Priority Axes 1 "European Centres of Excellence". It accounted for 10.3% of the OP expenditure. It was a strategic investment in line with the OP's aim to support the concentration of the top RTD capacities (in terms of infrastructure, financial and human resources, themes) and establish a few top excellence flagships R&D centres in the Czech Republic.

The methodology has been based on a Contribution Analysis approach and the underlying development of Theories of Change (ToC) for selected policy instruments. This involved disentangling the complex causal relationships within different stages of implementation and these policy instruments' results to identify the contributions made by the ERDF to

improving RTD in specific regions and the Member States. This approach aimed to build and consequently verify the ToC in a specific region/MS and context, addressing the specific conditions influencing the policy rationale (further explored in the cross-case analysis), the interplay of different stakeholders, their expectations and observed effects as a result of the policy instruments.

The data collection for the CS was based on desk research and semi-structured interviews with 35 relevant stakeholders. Desk research covered data and information, especially from strategic and programming documents, evaluations, projects' application and reporting documentation, statistical data, and indicators from the monitoring system and other analytical studies. The CS also builds on the evidence available from a previous project task.

OVERVIEW OF KEY FINDINGS AND CONCLUSIONS

Analysis of the policy context at the national level

At the outset of the programming period 2007-2013, the Czech Republic lagged behind in many RTD characteristics compared to the EU averages. Only 3% of R&D sources originated abroad, illustrating insufficient engagement in international R&D cooperation and in the European Research Area (ERA) in particular. The system of public R&D lacked thematic concentration and was characterised by high fragmentation. This led to a lack of top-class R&D centres in a limited number of fields with excellent performance. There was a profound shortage of adequate RTD infrastructure, facilities, and material equipment across all the Czech Republic regions. Production of high-quality and internationally respected R&D results was below the average of developed countries (with positive exceptions in some fields). The ability to translate the results of basic research into the application was even lower. This was one of the consequences of dysfunctional R&D cooperation between private and public sectors and of insufficient use of venture capital and support of spin-offs. Hand in hand with the outlined constraints, the Czech Republic lacked adequate R&D human capacities (e.g. a share of the population with a university degree was substantially below the EU average), especially in technical and natural sciences.

The EU played a key role in fostering the country towards the focus on the RTD sector as a prerequisite for building a competitive economy. The Czech Republic had a series of national strategic documents related to the R&D policy till the EU accession. In the years after, however, they were to a large extent only formal, and their implementation faltered. In other words, there was no systemic, conceptualised and functional national RTD policy till the start of the 2007-2013 programming period. Thus, the country needed to establish the basic functional policy frameworks to ensure effective usage of the anticipated EU funds. The Reform of Research, Development and Innovation system introduced in 2008 was aimed to be the key strategic framework to transform the Czech RDI policy landscape. Furthermore, the National Policy of Research, Development and Innovations 2009-2015 was formulated, and all its main objectives were strongly aligned to the proposed ERDF RTD policy mix. The European Structural Funds (both ERDF and ESF) were expected to be the prime financial sources and drivers for implementing the National RDI Policy because the national financial sources were insufficient to cover anticipated profound changes in the R&D sector of the country.

Although there was a very strong interconnection between the national RTD strategies/policy and the ERDF support in terms of thematical orientation and identification of key bottlenecks and related priorities, at the operational level, a double-track system of coordination and management of these two strategic policy streams has existed. In addition, the institutional fragmentation in the management of the RDI area has played a rather negative role in the pursuit of the RTD policies in the Czech Republic. At the regional level, a systemic approach to the RTD support was a rare exception and started to evolve only at the end of the programming period 2007-2013. The policy frameworks anticipated the linkages between the ERDF support for RTD and other European programmes (i.e. FP7 and the successor programme H2020). Still, they did not widely materialise, as the direct mechanisms for maximising the potential synergies were

not set up. A relatively short time passed since the newly R&D infrastructures were accomplished and could have participated in these programmes.

As in many countries, the R&D capacities and production are not equally distributed in the Czech Republic. There is a strong dominance of the Capital City of Prague over other Czech regions. Prague has historically played a central role in the R&D sector and higher education and concentrated 2/3 of the R&D capacities. There were intensive debates on how to approach a trade-off between the principle of excellence in R&D and the principle of social and economic territorial cohesion to support lagging regions to catch-up. Nevertheless, eventually, the country had to accommodate the EU funding conditions for regional eligibility and could not have included the Prague region into the ERDF policy mix, even though the RTD investment needs were across the whole country. The eventual regional targeting led to some problems in funds absorption for the more limited lagging regions' capacities and, more importantly, to some negative systemic consequences for the entire RTD system. Although additional instruments funded by national and also EU sources for Prague were planned, due to the economic crisis and the instability of national governmental priorities and weak national strategic management of these additional funds, these were not realised.

The data analysis at the MS-level shows that the strongest budgetary allocation across all OPs went to category 02 expenditure (RTD infrastructure), counting to almost 89%[1] of ERDF support purely or in combination with the 01 expenditure category allocated for R&D infrastructure investments. The largest recipients of the RTD ERDF support were the public HEIs (almost 41% of the total analysed RTD ERDF support) concentrating on infrastructure investments for research/research and education that had to cope with the instability of the national system of financing. The second most important targets were the newly established centres of excellence and competence centres (29% of the total analysed RTD ERDF funding) implemented via infrastructure investments for research. In terms of science, almost 85% of the ERDF contribution was allocated to natural sciences, engineering, technology and medical and health sciences.

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

The ERDF RTD budget allocated to the country played an irreplaceable role in constituting the modern conditions for R&D in the Czech Republic. There is a wide consensus that the OP RDI has succeeded in its prime goal – to build, develop and modernised R&D infrastructure in the Czech Republic – and it has enabled to shift of the R&D infrastructural capacities in the country at a qualitatively different level, comparable to the European standards. Consequently, the necessary infrastructural conditions for the middle-to-long-term effects of the RTD support (i.e. the involvement in the international RDI arena, the cooperation between public research and business sectors, the development of a knowledge-based economy) were achieved by the analysed OP RDI. Nevertheless, the OP was less successful in ensuring adequate R&D human resources that could have fully exploited all established capacities, even though this was the domain of the complementary ESF OPs. Unfortunately, the OP investments were not accompanied by any reform of the R&D and higher education system that would have supported the investment efforts and contributed to the needed systemic changes (e.g. a concentration of R&D efforts to the limited number of excellent capacities).

The evaluation focused on the three different policy instruments (including one major project) and can provide additional details on the achievement of these instruments' intended effects. For all investigated PIs pay that the intended activities, outputs and short-term outcomes were mostly achieved. At the same time, on a more complex level,

[1] Projects funded under category 02 (RTD infrastructure) received almost 52% of ERDF funding while 37% of this budget was allocated to projects that fell into categories 01– RTD activities and 02 – RTD infrastructure at the same time. The rest (i.e. only 11.6% of the ERDF contribution) was implemented through projects falling only into category 01.

the provability of effects is lower, and these effects could have been verified only to a limited extent, if at all.

The evaluation proved that the policy instrument supporting infrastructure investments for research-related education at public higher education institutions succeeded to fulfil its prime aim to eliminate the abysmal difference in the quantity and particular quality of infrastructure for research-related education as compared to standards of developed countries and thus create favourable conditions for the education of human resources for R&D and research itself. It also ensured RTD infrastructural endowments for more peripheral regions. In conjunction with a range of complementary actions (funded from the different policy instruments of the Structural funds RTD policy mix or national sources), overall "quality of the environment" at supported universities was increased, and it is believed the quality of tertiary education was improved at least to some extent. Moreover, positive outcomes related to improvements in managerial, organisational and communication processes at HEIs were also detected. On the other hand, the intervention's intended outcome in terms of ensuring adequate human capacities for R&D has not been fully achieved (also at the level of the entire OP RDI). The reasons for that lie beyond the PI and relate to more systemic aspects of doctoral studies in the Czech Republic. The qualitative evidence suggests that the PI contributed at least to some extent to the maintenance of a certain level of post-graduates.

Consequently, the Czech Republic still crucially lacks sufficient human capital for research and innovations, even more in the context of the newly established R&D infrastructures. In the long-term perspective, the PI expected the infrastructure would contribute to the involvement of HEIs in the international RDI arena and for cooperation between universities and business sectors. As an important supporting factor for the materialisation of middle and long-term effects, the existence of a regional strategic approach to RDI development was proved. The profound achievement of these effects requires more time since the interventions were accomplished. The realisation of the PI1 brought about also a set of unintended negative effects related to a polarisation between the regional HEIs and Prague's HEIs due to the eligibility setting.

As far as the policy instrument of ICT infrastructure investments is concerned, all outlined outputs, i.e., the new or modernised information infrastructure for R&D and electronic information resources, were achieved. The monitoring indicators were even exceeded. The instrument has addressed the pronounced need for this kind of investments of the Czech R&D. All potential risks were seriously considered and well-managed. The new investments enabled the higher storage, computational and information capacities of R&D institutions and improved scientific information resources. These achievements contributed to a significant shift of conditions for conducting the R&D in the Czech Republic, eventually comparable with the European research organisations. The PI was of a marginal extent and too narrowly delimitated to significantly influence the integration of the Czech R&D institutions into the European Research Area or impact the cooperation of the R&D institutions. Nevertheless, the PI improved academia's situation; however, it can be hardly attributable only to this PI. This policy instrument has a supporting character for the R&D area, and the more complex effects can be attained only with the concurrence of other activities and causal links.

The evaluation proved that the main intended effects of the third instrument, the ELI major project, were achieved to a full or significant extent. This is also valid for target values of respective monitoring indicators, as– some of them were even exceeded. The main evident result was a considerable enlargement of research capacities in the Czech Republic with the unique quality and performance at the global level, which was a necessary precondition to the involvement of the Czech research institutions into the European network and collaboration with top research partners. The ELI infrastructure played a key role in this process, and synergies with other investments into the R&D in the locality of Dolní Břežany were an important enabling factor. The newly created research cluster concentrated a critical mass of fundamental and applied research activities. It thus helped facilitate the change of the whole local research ecosystem and attract excellent foreign researchers.

On the other hand, this newly set RDI ecosystem requires continuous support from the European, national and local levels. The ELI infrastructure's sustainability remains the main issue for the future. It is still early to measure the ELI's impact on the national RDI system, and the competitiveness of the Czech economy as this complex investment was fully accomplished only in the period 2014-2020. Such a complex project needs time to settle in the ecosystem and to develop its potential fully.

Drivers and barriers to success

There was an enormous delay in the start of the OP RDI (due to the belated and long-lasting preparation, including long negotiations with the EC, and the insufficient initial capacity of the Czech authorities) that negatively impacted the entire implementation and the pressure on withdrawing at the end of the period. The situation of the analysed PIs was even exacerbated by the significant financial and content demands of the supported R&D projects. Unfortunately, the political and managerial instability and the vibrant professional capacity of the Managing Authority during the programming period were identified as cumbersome factor for the implementation. The required rules were complicated, frequently with ambiguous interpretation and the administrative load for beneficiaries inappropriate. Limited experience on the beneficiaries' side was also a challenge; they had to go straight away to realise the complex projects without previous experience with the EU funds.

The R&D system requires more than others stability and predictability. However, the Czech Republic has suffered from the institutional fragmentation of responsibilities for the RDI management and strategic directing that induced the cumbersome decision-making processes and harmed the assumptions of stability and predictability. Moreover, the criteria for the national funding of research institutions and universities changed several times and affected the practical operation of supported projects, mainly in the period of compulsory sustainability. In addition, as an indirect implication of the economic crisis, the government did not increase the public R&D expenditure over the period as initially anticipated beyond the co-funding requirements and did not compensate the R&D investments for the region of Prague from national sources fully.

The whole OP RDI and the anticipated effects were strongly influenced by the only limited eligibility for the Prague R&D institutions being in a competitiveness region, despite it being central in the tertiary education system and in the Czechia R&D structure. The pronounced regional disparities in R&D capacities and production between the Prague region and the rest of the country were a challenge in implementing the OP, which aimed at supporting top-class RTD. The OP negotiations succeeded to agree with the EC on an exception for Prague only at the end of the programming period for one policy instrument.

Another barrier to success concerned the system of public procurements and state aid. Both areas suffered from similar key problems: unclear interpretation and legislation changes over the period, from the EU level (State Aid) and the national level (Act on public tendering). The situation was particularly problematic for the R&D sector since technologies develop fast, and months-lasting public tendering processes could allow the purchase of outdated products.

The OP RDI proved to be more effective, especially in regions with a critical size of the existing R&D capacity and the consensual support across diverse stakeholders in the form of regional innovation strategy.

Relevance

The present case study's findings suggest that the RTD ERDF support in the Czech Republic responded to the main identified challenges and needs of the Czech RTD system. Thematic relevance of the support from the OP RDI and all evaluated instruments has proved to be high as the ERDF support responded to the infrastructural R&D needs of the Czech Republic. All evaluated PIs achieved to full extent compliance with analytical findings prepared for the OP RDI and reflected actual trends in the R&D

sector. Consequently, the ERDF RTD investment strategy focused on infrastructural development (i.e. the 02-expenditure category). The main rationale behind the prioritisation of infrastructure investments was to create competitive conditions for conducting top international quality research and upgrading infrastructure at public higher education institutions to ensure increased quantity and quality of human resources for R&D.

The main thematic focus of the ERDF support was found to be in line with the national priorities as the intensive support was provided to engineering and technology and to natural and life sciences (in total, 85% of ERDF). More than one-third of the RTD ERDF funding was concentrated on a combination of applied/industrial research and experimental development. Activities focused on fundamental RTD, and a combination of fundamental and applied/industrial type of RTD also recorded a significant share (24.5%, resp. 24.6%).

There was a key issue regarding the regional targeting of the ERDF RTD support. In line with the eligibility rules, most of the ERDF sources were aimed at the convergence regions proved by the conducted analyses based on the location of project implementation (94.4% of the ERDF RTD funds targeted these regions). The analyses uncovered that the main recipient of the support was the NUTS2 Jihovýchod region. A part of this region (the South Moravian region) run the first regional innovation strategy in the country that was the underlying factor for the leading position in acquired ERDF RTD sources. On the other hand, Prague's competitiveness region received a marginal ERDF support (in total EUR 107.63 million) from a regional OP and from the agreed exception between the Managing Authority and the European Commission for the PI1 at the end of the programming period. While this is in line with the objective of the policy to tackle regional disparities, it proved to be a challenge for the entire RTD system of the country and in the implementation of the OP, in particular in the face of the more limited capacities of lagging regions in preparing good projects and ensuring timely funds absorption.

On the contrary, the OP's strategic objective to promote top-class RTD would have required to concentrate a higher share of funds in the capital region where higher and better capacities were present. Moreover, the R&D sector in Prague suffered from the same infrastructural deficit as the convergence regions. s For this reason, the relevance of the ERDF support was lower in terms of regional targeting and national needs.

Efficiency

The intention of policy-makers was that the OP RDI would have been a catalyst of fundamental changes in the Czech R&D system. The volume of financial support provided by the ERDF to support the RTD activities and infrastructure was sufficiently high to "move the needle" for the country's RDI system (the data analysis at the MS-level shows the RTD investments in the Czech Republic accounted for EUR 1.9 billion representing almost 14% of the total ERDF contribution to the country). With the ERDF support, the Czech Republic was given a unique opportunity to resolve its R&D infrastructural handicap from the past, to establish a limited number of R&D excellence centres, to develop their infrastructural and human capacities to mitigate high fragmentation of R&D and to produce top research outcomes competitive in the international arena and applicable in practice. The then existing national and regional policies supporting RTD were marginal compared to the ERDF RTD investments in 2007-2013.

The ERDF support was efficient to reach the perceptible difference in the overall level of quality of the national research infrastructure and higher education system predominantly in the convergence regions. Nevertheless, the anticipated concentration of funds from the OP RDI to limited R&D capacities has not been reached to the full extent. While concentration in the infrastructural investments into research-related education at universities was ensured and to a large extent also in the policy instrument of centres of excellence, the number of established regional research centres within the Priority Axis 2 is questioned, and some of them demonstrated already poorer quality and concerns for sustainability.

Sustainability

The sustainability of all analysed policy instruments depends dominantly on public resources. The sustainability of invested infrastructure within the first two policy instruments under assessment throughout compulsory sustainability was ensured with internal sources of the supported HEIs. However, some questions arise as concerns the sustainability of acquired technological competitiveness and thus related to needed sources for the gradual upgrade of the purchased research equipment. The HEIs would not be able to cover all sources required for the modernisation.

The sustainability of the large excellence R&D infrastructures newly developed thanks to the OP RDI remains the key issue for the future. The MA was aware of that, and therefore they emphasized, quality, international relevance, and connection to the European research network during the preparatory phase of projects. These new excellent international R&D infrastructures have created a strong commitment for public budgets, and the overwhelming majority of projects is not sustainable without public financing. That is relevant for all projects funded under the Priority Axis 1 of the OP RDI (not only the ELI project). In order to ensure compulsory sustainability, the national programmes of sustainability of newly created research centres have been opened and funded from the state budget. However, this is not a long-term sustainable solution. The management of these new R&D infrastructures will have to focus on diversification of funds for operation and further development. Especially in R&D, the technologies and equipment could become obsolete quite quickly. They will have to rapidly increase the volume of industry cooperation, set up their own spin-off companies and use other ways to get financial resources from private resources and commercial activities.

Coherence

The OP RDI explicitly conceived synergies with other ERDF and ESF OPs. These programmes were designed ex-ante to jointly address challenges identified for the RTD and innovation systems in the Czech Republic. Synergies were explicitly defined in the programming documents and reflected in the appraisal process favouring synergic projects. Therefore, most of the HEIs benefitting from the PI1 implemented either simultaneously or later (even in the 2014-2020 period) synergic actions supported by the ESF programmes. In addition, the complementarities with the projects funded from other sources were demonstrated at the interviewed HEIs. The analysed ELI major project, the largest single investment under the ERDF RTD policy mix, witnessed a strong complementarity with other supported projects, identified as one of the key enabling factors. Due to the co-location of projects, it has been created a core for the national innovation milieu in lasers.

The OP RDI anticipated explicitly to create synergies with FP7 and Horizon2020 in terms of possible external funding for successful research teams at the supported RTD centres (e.g. ELI project). The aim was to ensure that the supported research centres would have decreased public funding share favouring external (international) research grants and sources from contract research. No specific coordination mechanisms were explicitly in place during the implementation of the OP. Nevertheless, as a result of efforts to succeed in the international competition for research grants, specialised grant offices were established within most supported RTD centres and thus improved management of research fundraising. However, the translation of these efforts into increased success rate in these programmes has not been generally materialised yet.

EU added value

The evaluation confirmed that without the ERDF support, the infrastructure investments into the majority of institutions would have never been realised in this scale and time-space. Therefore, the role of ERDF funding was irreplaceable. Many supported projects of Centres of excellence (and a couple of regional competence research centres) significantly improved the added value of science and research capacities at the European level. They became an important part of the European network with high intensity of international research activities. Attracting new countries as observing partners of the ELI consortium and other cooperating institutions enabled to rapidly enhance the added value of EU research capacities in the worldwide competition. In addition, investments into the HEIs infrastructure enhanced international R&D

cooperation and production of top-ranked research results, as confirmed by interviewed universities.

The investments from the OP RDI overwhelmingly contributed to significantly improve the capacity and quality of research in the Czech Republic. There is a wide consensus that this would not have been possible without the ERDF financing on such a scale. It was necessary to upgrade the quality of R&D infrastructure and equipment to be competitive in Europe. Thanks to the massive investments in the R&D sector in the 2007-2013 period, the quality of newly built research infrastructure is comparable with Western countries in THE EU.

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 is to identify the effectiveness of RTD infrastructures and activities, their coherence with other policies, their efficiency, relevance, and EU added value. The evaluation covers 53 Operational Programmes (OPs) selected by the European Commission, covering a substantial amount of the RTD funding (€14.64 billion, or about 85% of the EU total for the relevant themes) provided during this programming period.

As part of the evaluation, a total of seven case studies (CS) have been carried out to illustrate the concrete effects of ERDF-supported RTD policy instruments. Case studies were designed to examine the use of funding for different policy instruments in the selected Member States and the specific context in which they were implemented, their rationale, their effectiveness and their long-term sustainability.

The CS evaluation research followed a methodology set and developed by the core team. The methodology has been based on a Contribution Analysis (CA) and the underlying development of Theories of Change (ToC) for selected policy instruments (PI). This involved disentangling the complex causal relationships within different stages of implementation and production of these policy instruments' results, in light of identifying the contributions made by the ERDF to improving RTD in specific regions and Member States (MS). The approach aimed was to build and consequently verify the ToC in a specific region/MS and context, addressing the specific conditions influencing the policy rationale (further explored in the cross-case analysis), the interplay of different stakeholders, their expectations and observed effects as a result of the policy instruments.

The CS had to look at the RTD policy mix funded from the ERDF from the three distinct perspectives: (i) from the perspective of a Member state and all relevant ERDF-OPs supporting RTD infrastructure sphere, (ii) from the level of OP supporting the selected policy instruments for in-depth analysis in this evaluation, and (iii) from the perspective of three selected policy instruments. The Czech CS examines the following policy instruments that all received funding under the OP Research and Development for Innovations for the programming period 2007-2013 (OP RDI):

- **Infrastructure investments for research-related teaching at public higher education institutions (HEIs)** within the Priority Axes 4 "Infrastructure for University education related to Research". According to Task 1 classification, they are 62 projects, representing 22% of the OP ERDF expenditure. The PI consisted of constructing new facilities or modernising the equipment in HEIs, used for both education and research purposes. These projects aimed to reinforce the pool of highly qualified human resources, which was perceived to be key to the competitiveness of the Czech economy.
- **ICT-based infrastructures** funded from the Priority Axes 3 "Commercialisation and popularisation of R&D". This PI included 12 projects, representing 2.3% of OP ERDF expenditure. Projects included investments for e-infrastructure, computing grids and data digitisation, storage, access, ICT network systems, information infrastructure for R&D, investments in material and technical ensuring, and non-material needs (software, licenses, databases etc.).
- **Major Project "ELI: Extreme Light Infrastructure"** (hereinafter ELI) supported from the Priority Axes 1 "European Centres of Excellence". It accounts for 10.3% of the OP expenditure. It was a strategic investment in line with the OP's aim to support the concentration of top RTD capacities (in terms of infrastructure, financial and human resources, themes) and to establish a few flagships of top excellence R&D centres in the Czech Republic.

The rationale for selecting these instruments reflected (i) the various parameters of cross-selection of policy instruments at the level of the entire evaluation study and possibilities for further analyses across the MSs and (ii) relative importance of

instruments in the context of the Czech Republic. The OP RDI concentrated 88% of ERDF funding for RTD infrastructure, and it included the key investment measures of the ERDF RTD policy mix in the Czech Republic. While the selected major project ELI represents absolutely a unique case of strategic investment in all means (financial, expert, thematic, complexity), the instrument of infrastructure investment for research-related education at public HEIs received a considerable level of ERDF funding. It includes a relatively homogenous group of projects enabling to reach a certain level of generalisation in the assessment. On the other hand, the policy instrument, including three strategic ICT infrastructure projects (plus nine other projects focused especially on electronic information resources), has been rather marginal in the context of the RTD policy mix as well as in financial terms. Moreover, this policy instrument was rather artificially delineated within one of the OP's priority axis for the purpose of evaluation that hindered an in-depth analysis. However, this PI was important in terms to build basic conditions from today's R&D perspective.

The CS is based predominantly on desk research, secondary data analysis and semi-structured interviews with relevant stakeholders. The main consulted documents included strategic and programming documents, project documentation (project applications, technical annexes, final implementation reports), statistical data, monitoring data and indicators from the central monitoring system provided by the National Coordination Authority, Ministry of Regional Development and by the Ministry of Industry and Trade in the course of competition of Task 1, and other relevant literature (e.g. evaluation studies, analytical documents of MAs etc.). Secondary data analysed by the evaluation leader for Task 1 were used mainly for the OPs level analysis. Monitoring indicators were taken into consideration, although available at the level of the entire programme and the most often not broken down into individual support measures. Nevertheless, some of the monitoring indicators for outputs and outcomes were available also at the project level.

In total, 35 interviewees contributed to the information basement for the elaboration of this CS. The interviews were realised both face-to-face and online[2] during September-October 2020 with representatives of policymakers, former and current programme managers, beneficiaries, relevant regional stakeholders, and individual experts in the R&D policy.

The analysis also 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 infrastructure and activities; see the First Intermediate Report for more details) and cluster analysis of European regions according to their R&D performance.

The CS also faced some methodological challenges related to the limits of monitoring data/indicators (i.e. mainly the discrepancy between the location of beneficiaries and the location of project realisation or location of effects[3]), limited availability of projects documentation, lack of indicators at the PI level.

Interviews, however, provided very useful insights and anecdotal evidence, complementing aggregated quantitative indicators, which were primarily available at the programme level.

The following chapters provide an overview of the RTD national policies and ERDF policy mix implemented in the country. Then, Chapter 3 is specifically devoted to analysing the national OP RDI and the policy instruments. Chapter 4 provides a general summary assessment.

[2] The form of interviews was influenced by the actual situation around the Covid-19 pandemic. Only one field visit was realized (for the ELI project – Dolní Břežany).

[3] One problem was that many R&D institutions had headquarters in Prague but their projects were realized in different convergence region.

2. ANALYSIS OF THE POLICY CONTEXT AT THE NATIONAL LEVEL

2.1. National RTD objectives and strategies

The Czech Republic joined the European Union in 2004, and the ERDF support in the programming period 2007-2013 thus represented the first full-fledged programming period for the 10 million inhabitants. Within the allocated amount of around EUR 26 billion for all themes and regions of Cohesion policy in the country, an unprecedented opportunity was also opened for the underdeveloped Czech R&D system. This represented the first systemic set of interventions addressing the research field after many years of underinvestment and limited political priority.

At the outset of the programming period, the Czech Republic lagged behind in many RTD characteristics compared to EU27 averages. Only 3% of R&D sources originated abroad, illustrating insufficient engagement in the international R&D cooperation, the ERA in particular. The system of public R&D lacked thematic concentration and led to high fragmentation. This led to a lack of top-class R&D centres in a number of fields. There was a profound shortage of adequate RTD infrastructure, facilities, and material equipment across all the Czech Republic regions. Production of high-quality and internationally respected R&D results was under the average of developed countries (with exceptions in some fields), and the ability to translate results of basic research into the application was even more insufficient.[4] This was one of the consequences of dysfunctional R&D cooperation between private and public sectors and insufficient use of venture capital and support of spin-offs. Hand in hand with outlined constraints, the Czech Republic lacked adequate R&D human capacities (e.g. a share of the population with a university degree was substantially below the EU average), especially in technical and natural sciences.

The Czech Republic had a series of national strategic documents related to R&D policies till the EU accession. However, they were, to a large extent, only formal, and their implementation faltered because the responsibilities for these policies as well as the basic policy frameworks were laid down by the respective legislative act only in 2002. In the context of the Lisbon Strategy, the National Reform Program 2005-2008 defined as one of the priorities "the creation of an environment stimulating research, development and innovation and specific measures in the R&D field" with the target to devote to public R&D support at least 1% of GDP in 2010. The very first specific priorities in the R&D area of the country were formulated in the National Research and Development Policy for the period 2004–2008 (i.e. human resources, international cooperation in R&D, regional aspects of R&D, use of R&D results in practice and evaluation of R&D). Simultaneously, the National Innovation Policy 2005-2010 provided a basic conceptualisation of the country's needs in terms of innovations (i.e. enhancement of R&D as the sources for innovations, creation of functional cooperation between the public and private sectors, ensuring of human resources for innovations and streamlining the performance of public administration in research, development and innovation). However, neither of these two policies were fully implemented. In other words, there was no systemic, conceptualised and functional national or regional RTD policy till the start of the 2007-2013 programming period.

Importantly, the Reform of Research, Development and Innovation system introduced in 2008 represented the key strategic framework to transform the Czech RDI policy landscape. The rationale for the Reform was (i) the low added value of the RDI for the Czech economy and society, (ii) the inefficient system of the R&D funding and its limits to effectively use the expected EU sources for RTD, (iii) high fragmentation of the Czech R&D system, absence of excellence and RTD priorities, and (iv) the lack of cooperation between research institutions and enterprises. The implementation of this Reform resulted, for example, in the establishment of the Technological Agency as a unified body

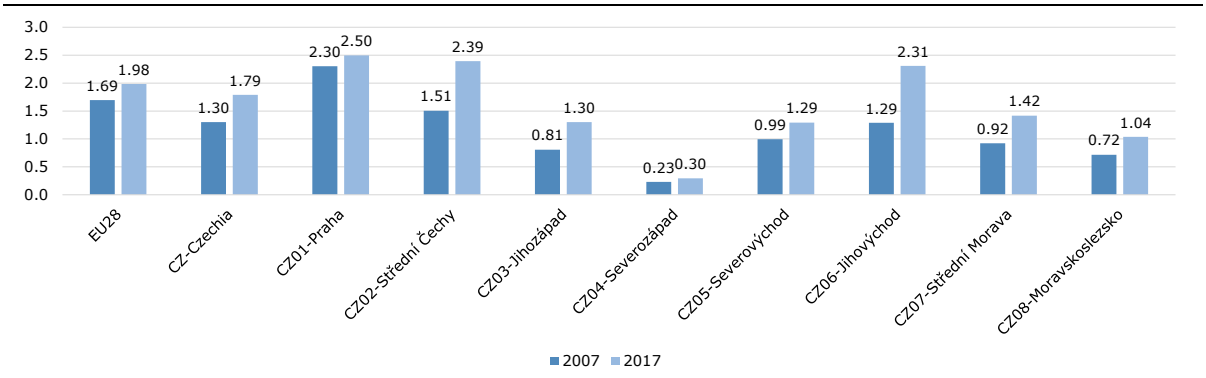
4 For example, the number of PTC patent applications over GDP was only 981 in 2007 while the EU-28 average was 3,879; according to the European Innovation Scoreboard, the Czech Republic reached the index value 0.34 in 2006 while the EU-25 average was 0.45 and the leading countries 0.73 (Sweden) and 0.69 (Switzerland).

for the provision of public support for applied research. In addition, the White Paper of Tertiary Education, also published in 2008, presented the objectives of planned principal reform of tertiary education in the Czech Republic, including the focus on the third role of higher education institutions (i.e. participation in economic development, cooperation with the industry and on technology transfers etc.).

The Czech strategic RDI frameworks suffered from the fragmentation undermined by the low strategic thinking in public administration and the fragmented R&D institutional landscape[5] in the country. The key authorities responsible for the management of the R&D sector were: the Ministry of Education, Youth and Sports (the central administrative authority for R&D, responsible for drawing up national strategies for R&D), the Research and Development Council (an expert and advisory body of the Government in the field of research and development), the Grant Agency of the Czech Republic (an organisational body of the state and administrator of public calls for R&D projects), the Technology Agency of the Czech Republic[6] and other central public administration authorities ensuring the preparation of specific R&D programmes. In addition, the Ministry of Industry and Trade has played a key role in orchestrating national efforts in innovation policies. Moreover, based on its competence in enhancing favourable socio-economic development, the regional administration of some regions started to develop their pioneering generation of regional innovation strategies.

As in many other countries, the R&D capacities and production were not equally distributed in the national territory, with a strong dominance of the Capital City of Prague over other Czech regions. As one of the regions with the highest GDP per capita in the EU, Prague has historically concentrated the large share of universities, R&D capacities, and of the national R&D budget. Between 2007 and 2017, the dominance of Prague significantly decreased in favour of Central Bohemia (CZ02 Střední Čechy) and Southeast (CZ06 Jihovýchod) in terms of total R&D expenditure over GDP. Although public R&D expenditure over GDP was still centralised in Prague in 2017, all other regions increased their share of the public R&D over GDP in 2017 compared to the situation in 2007. Moreover, an even more profound increase in the percentage of R&D expenditure over GDP was observed in the business sector (see the following figures).

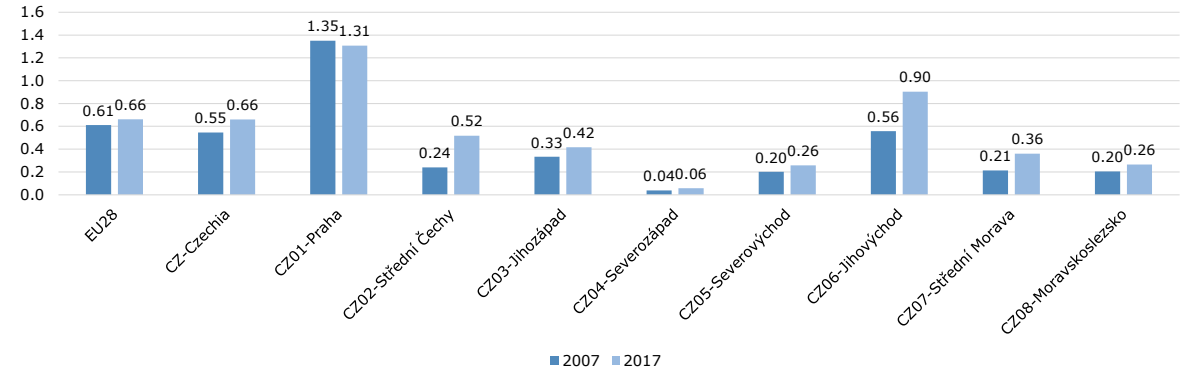
Total R&D expenditure over GDP – 2007 and 2017



Source: CSIL elaboration based on EUROSTAT data.
Note: Values are expressed in percentage of GDP.

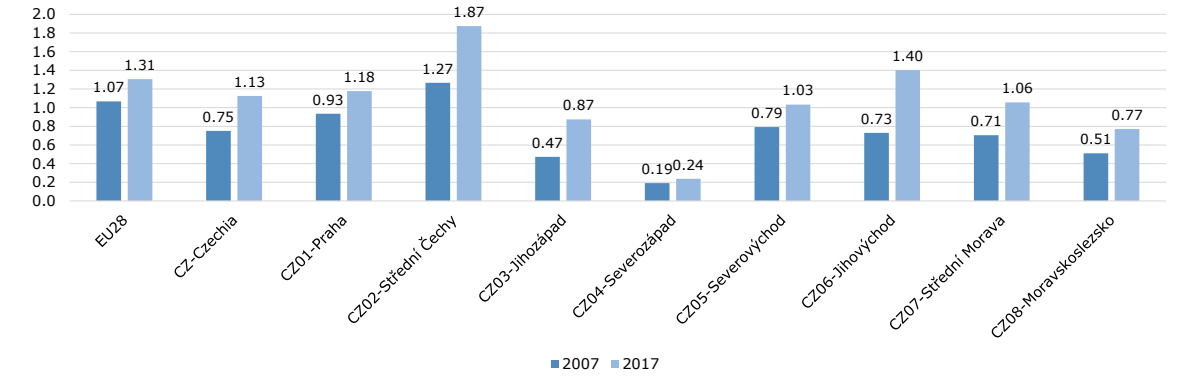
5 Act No. 130/2002 Coll on the Support of Research and Development from Public Funds.
6 Established in 2009; until then this state support had been fragmented among a large number of providers.

Public R&D expenditure over GDP – 2007 and 2017



Source: CSIL elaboration based on EUROSTAT data.
Note: Values are expressed in percentage of GDP.

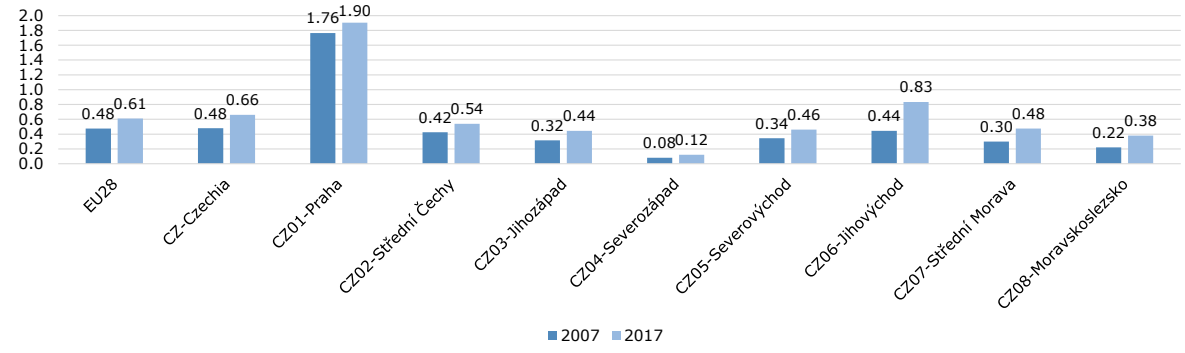
Business R&D expenditure over GDP – 2007 and 2017



Source: CSIL elaboration based on EUROSTAT data.
Note: Values are expressed in percentage of GDP.

In terms of R&D personnel over the total population, the relative dominance of Prague remained more or less stable between 2007-2017. Nevertheless, the highest growth in this characteristic was witnessed in the CZ06-Jihovýchod region that corresponds to a number of newly created R&D capacities in this region thanks to the ERDF support.

Total R&D personnel in percentage of total population – 2007 and 2017



Source: CSIL elaboration based on EUROSTAT data.
Note: Values are expressed in percentage of the total population.

The results of cluster analysis carried out within this evaluation suggest that even though ERDF investments were focused predominantly on less developed regions, they did not experience any significant leap in RTD performance between 2007-2017. In convergence regions, the performance remained stable over time (with the only exception of the most underdeveloped region of Northwest – CZ04) while considerably improving in Prague's competitiveness region (see Table 1). The explanations might be at least twofold: first, regional patterns in RDI witness long inertia (even across several generations), therefore it cannot be expected these patterns would be changed within ten years and that Prague

(CZ01) as a natural R&D centre of the country would stop its natural development trajectory. Second, the level of NUTS2 regions might be rather broad in the context of some Czech regions, and the evolution of RTD performance would be better uncovered from a more detailed regional perspective (i.e. NUTS3 level). Especially for the CZ07-Jihovýchod region, there are pronounced intra-regional disparities.

Table 1. Evolution of RTD performance in Czech Republic from 2007 to 2017 according to the results of the cluster analysis

	2007	2017	Evolution 07-17
CZ01-Praha	Moderate -	Moderate +	↑
CZ02-Střední Čechy	Moderate -	Moderate -	–
CZ03-Jihozápad	Moderate -	Moderate -	–
CZ04-Severozápad	Modest -	Modest +	↑
CZ05-Severovýchod	Moderate -	Moderate -	–
CZ06-Jihovýchod	Moderate -	Moderate -	–
CZ07-Střední Morava	Moderate -	Moderate -	–
CZ08-Moravskoslezsko	Moderate -	Moderate -	–

Clusters: Modest -; Modest +; Moderate -; Moderate +; Strong Business; Leaders.

Source: CSIL elaboration based on the results of the Cluster analysis performed under Task 1

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

2.2.1. Linkages between national RTD policies and ERDF support

Despite the existence of a range of national strategic documents related to the country's RDI sector, in the time of preparation for the 2007-2013 programming period, there was no comprehensive and functional strategic framework for RTD and innovation policy. Its preparation was mainly induced by the EU in the context of prospective support from the Cohesion Policy. As a result, the National Policy of Research, Development and Innovations 2009-2015 (the National RDI Policy) was formulated, and all its main objectives were strongly aligned to the proposed ERDF RTD policy mix in the National Strategic Reference Framework 2007-2013 and relevant ERDF RTD-oriented OPs (see section 2.3.2 for details). **The European Structural Funds** (both ERDF and ESF) were expected to be the prime financial sources and drivers for implementing **the National RDI Policy** because the national financial sources were insufficient to cover anticipated profound changes in the R&D sector of the country. One of the aims of the national policy, in general, was to fund large R&D infrastructures and to support the excellence of R&D, to improve cooperation between public and private sector and application of research results, to enhance the development of human capacities in R&D and to stimulate R&D international cooperation of Czech entities. Furthermore, the National RDI Policy encompassed the Priorities of Applied Research, Development and Innovation 2009-2011 and covered biological and ecological aspects of sustainable development, molecular biology and biotechnology, energy resources, materials research, competitive engineering, information society, security and defence, and priorities of development of Czech society. The ERDF RTD support was aimed to fund operations in line with these

thematic priorities. Also, this approach was accompanied by the Czech Roadmap for Large Research, Development and Innovation Infrastructures introduced in 2010 and regularly updated, directing the development of new R&D infrastructures of national and international importance in the Czech Republic funded predominantly from the ERDF support.

Although there was a very strong interconnection between the national RTD strategies/policy and the ERDF support in terms of thematical orientation and identification of key bottlenecks and related priorities, at the operational level, a double-track system of coordination and management of these two strategic policy streams has existed. Besides, the institutional fragmentation in the management of the RDI area has played a rather negative role in pursuing RTD policies in the Czech Republic.

As already stressed, the ERDF support into the R&D sector was the prime source for realising the national RDI strategic objectives and the entire strategy development process. The importance of support became even greater because the Czech economy was facing the economic crisis and its impacts since 2008. Before the crisis, the total R&D expenditure represented 1.55% of GDP in 2006, and a slow increase over the 2000-2006 period was attributable to the expenditure of the private sector. This trend was suspended by the crisis, and a slump in the R&D expenditure was evident in the business sector, particularly from large enterprises.[7] The public R&D expenditure had not experienced deviation as a consequence of the crisis.[8] However, the economic crisis impacted the overall planned strategy of public R&D expenditure seriously. While before the crisis, the government promised to increase support programmes for research and science investments by 8% annually to massively accelerate the development of the R&D sector; due to the economic crisis, the government reconsidered these plans, and the volume of national R&D public funds sustained at a steady level during 2007-2010. In the following years, the national R&D expenditure increased mainly due to co-funding of R&D projects supported by the Cohesion policy (e.g. in the period 2011-2015, the R&D expenditure from the state budget doubled in comparison to the level in 2007).

Moreover, the economic crisis influenced the availability of financial sources for newly created research centres' sustainability as the business sector reduced its demand for contract research. Due to other factors (e.g. the changed rules of State Aid, see more in section 3.1), the National Programmes for Sustainability had to be introduced to support the sustainability of the newly established large R&D infrastructures supported by the ERDF. These programmes, however, were funded entirely from the national budget for R&D. Consequently, the national public R&D finance dramatically decreased outside the framework of ERDF-supported projects (i.e. apart from co-funding and supporting sustainability), and for example, the initially planned investments into Prague's infrastructure from the national sources were no longer possible. As a result of creating several new R&D entities with the ERDF support in 2007-2013, the national finance competition from the state budget has even sharpened.

2.2.2. Linkages between regional RTD policies and ERDF support

At the beginning of the programming period 2007-2013, regional RTD policies were only at their outset. The only region that had a developed and accepted regional RTD policy was the South Moravian region. Some of the other regions were little by little preparing their first generation of regional innovation strategies, but an explicit manifestation of R&D policies into regional strategic planning occurred only during the preparation of the programming period 2014-2020.

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7 Ministry of Regional Development (2013): Analýza vlivu ekonomické krize na implementaci strukturálních fondů a fondu soudržnosti v České republice, http://www.eeip.cz/wp-content/uploads/2014/03/140515_Analyza_krize_SF.pdf (accessed 10.10. 2020).

8 CZSO (2016): Státní rozpočtové výdaje na výzkum a vývoj v ČR, https://www.czso.cz/documents/10180/46014864/21100117a.pdf/fa60c23c-24c8-494f-baeb-a8cb73e70311?version=1.2 (accessed 10.10. 2020).

In some regions, efforts were made to align regional innovation strategies and the analysed RTD policy mix funded by the Cohesion policy (see section 2.3.2 for details). For example, the South Moravian region took the opportunity to use ERDF investments of 2007-2013 as a catalyst for planned changes in the regional economy structure. In some other regions, the ERDF investments well fitted the newly elaborated regional development strategies (Olomoucký and Moravskoslezský regions).

2.2.3. Linkages between ERDF support for RTD and the European Research and Innovation Framework Programmes/Horizon 2020

The Czech Republic reported low attendance in the European Research and Innovation Framework Programmes (FP6, FP7) and overall low internationalisation of the Czech R&D system. The Czech Republic was ranked 21st among the EU-27 countries in the total number of registered projects that included Czech research teams at least as project partners. If ranked according to the absolute number of participations in the projects of the FP6, the Czech Republic was in 16th place. The average size of the allocation per Czech partner in the FP6 project was significantly lower than the average for EU-15 participants.[9] The position of the Czech Republic in FP7 did not improve significantly. The Czech Republic still lagged behind in the indicators of submitted proposals and the number of teams in FP7 (24th among the EU countries). The total number of registered projects increased slightly compared to the FP6; however, in financial terms, comparable countries in terms of population (e.g. Austria, Belgium, Portugal, Hungary) were still more successful. Consequently, the support from FP7 has played only a marginal role in the funding of the Czech R&D system[10]. The following main reasons for low participation of Czech teams were identified[11]: lower awareness of the possibilities and strategic importance of participation in FP among Czech R&D organisations as well as a lack of systematic support of R&D teams in this area, and a lack of key, internationally recognised and above-standard equipped R&D workplaces, which would regularly become sought-after partners in international R&D consortia.

Linkages between the ERDF support for RTD and Horizon 2020 (H2020) and Framework Programmes were explicitly considered. In particular, projects supported from the Priority Axis 1 "Centers of excellence" of the OP RDI were supposed to develop strong international partnerships with leaders of European research infrastructure and to ensure a substantial part of their future funding from the FP7 and Horizon2020 contribution. The R&D thematic priorities of the Czech Republic fully corresponded to the FP7's priorities that were one of the prerequisites of tighter interlinking of projects supported by the OP RDI and FP7.

Nevertheless, no specific coordination mechanisms were put in place during the implementation to interlink the ERDF support in the Czech Republic with FP7/H2020. Interestingly, as a result of efforts to succeed in the international competition for research grants, specialised grant offices were established within most supported RTD centres and thus improved management of research fundraising.

To illustrate the situation, from the total number of ERDF RTD beneficiaries, 34% participated in FP7 projects, and 40% participated in H2020 projects. In both programmes, the participation rate was higher for beneficiaries in the Prague area (40% vs 30%, resp. 48% vs 40%). Nevertheless, this evaluation cannot prove the connection between the degree of involvement of beneficiaries in these programmes and the support obtained from the ERDF. The ex-post evaluation of the R&D support in 2007-2013 (EACE 2018) suggests that "the overall success rate in 2014-2017 in H2020 calls for institutions

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[9] MŠMT (2008): Operační program Výzkum a vývoj pro inovace, p. 34, https://www.opvavpi.cz/cs/siroka-verejnost/zakladni-dokumenty-programu/operacni-program-vyzkum-a-vyvoj-pro-inovace/operacni-program-vyzkum-a-vyvoj-pro-inovace.html

[10] Úřad vlády České republiky (2013): Analýza stavu výzkumu, vývoje a inovací v České republice a jejich srovnání se zahraničním v roce 2012, p. 132, file:///C:/Users/Worker/Downloads/Analyza_VaVaI_2013.pdf (Accessed 28 October 2020).

[11] MŠMT (2008) *Ibid.*, p. 35.

that were beneficiaries of the OP RDI project was significantly higher (on average 15.1%) than for institutions without an OP RDI project (average 3.7%). Concerning the size of parent organisations, however, the higher success in the calls of the H2020 program cannot be attributed only to the centres established in the OP RDI. Nevertheless, this indicates at least that the interventions of the OP RDI managed to support institutions with higher scientific performance, which had the prerequisites for the establishment of a successful research centre. This hypothesis is also supported by the fact that universities with an OP RDI project applied to framework programs on average five times more often than universities where the OP RDI centres were not established, even before the support from the OP RDI" (pp. 24-25).

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

The National Coordination Authority at the Ministry of Regional Development was newly established as the main coordinating body for the 2007-2013 programming period, ensuring overall preparation and implementation of European Structural Funds in the Czech Republic. The Managing Authorities (MA) for the thematic (national, multi-regional) ERDF OPs were located at relevant ministries while the Regional Councils became the MAs of regional OPs. The Prague ERDF OP Prague-Competitiveness was entrusted to the Capital City of Prague.

The Operational Programme Research and Development for Innovations (OP RDI), analysed in this CS, was overseen by the Ministry of Education, Youth and Sports. No intermediate body was set up. This arrangement led to a simple implementation structure enabling direct contact between the MA and beneficiaries. For the Operational Programme Enterprise and Innovation (OP EI), the Ministry of Industry and Trade played the role of MA. This MA delegated certain activities (for example, receiving applications for support and organising calls for proposals, assessing formalities of the submitted project applications) to an intermediate body, more specifically to the CzechInvest – Business and Investment Development Agency. Both OPs were national programmes, and eligibility for the support was for entities settled in convergence regions (i.e. all regions without the capital of Prague). For certain measures, entities with headquarters in Prague were supported; however, the project's effects had to take place in convergence regions. The Operational Programme Prague – Competitiveness (OP PC) was designed for infrastructural investments in the competitiveness region.

A Coordinating Committee "Competitive Czech economy" was set up to ensure proper coordination mechanisms in managing and implementing the OP RDI and the OP EI, also supporting the RTD area. However, this platform did not prove effective, and the coordination (including synergies) was addressed mainly in practice at the level of particular calls and individual projects.

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

Almost EUR 26.7 billion (increased by EUR 237 million in connection with the Interinstitutional Agreement on the 2007-2013 financial framework and economic growth higher than forecasted for the Czech Republic) was allocated to the country to implement the Cohesion Policy. The ERDF allocation for the Convergence Objective and Regional Competitiveness and Employment Objective's realisation was EUR 13.7 billion.

RTD infrastructures and activities were supported through the following ERDF OPs:

- **2007CZ161PO012:** Operational Programme Research and Development for Innovations (OP RDI);
- **2007CZ161PO004:** Operational Programme Enterprise and Innovation (OP EI);
- **2007CZ162PO001:** Operational Programme Prague – Competitiveness (OP PC).

"Hard" investments and activities for the RTD area were complemented by support from ESF, specifically from these OPs:

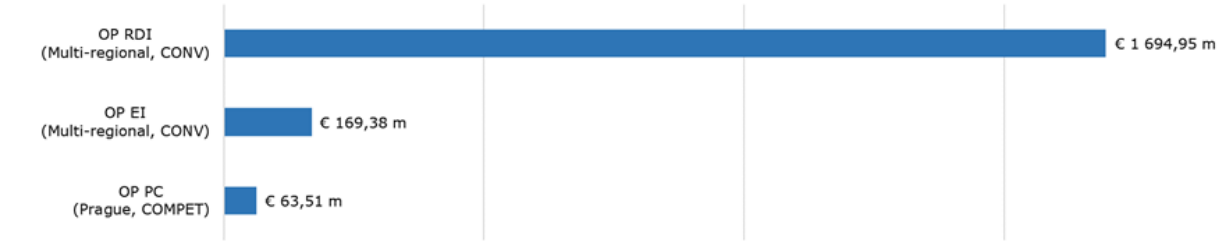
- 2007CZ05UPO002: Operational Programme Education for Competitiveness (OP EC);
- 2007CZ052PO001: Operational Programme Prague Adaptability (OP PA).

Together with the OP EI and OP EC, the OP RDI represented an interconnected system of interventions to ensure the long-term sustainable competitiveness of the Czech economy and target regions under the Convergence Objective. The OP PC and OP PA were aimed at supporting the territory of the Capital City of Prague.

Across all Czech ERDF operational programmes, a total of EUR 1.9 billion was invested in RTD-related infrastructures and activities. This amount ranked the Czech Republic, after Poland and Germany, among the countries that concentrated the highest amount of the ERDF contribution on RTD-related activities and infrastructures.

The following figure provides an overview of the distribution of the ERDF funding to RTD support by OPs. The highest amount of the ERDF contribution (88%) was delivered through the OP RDI, which is the subject of deeper analysis in this study.

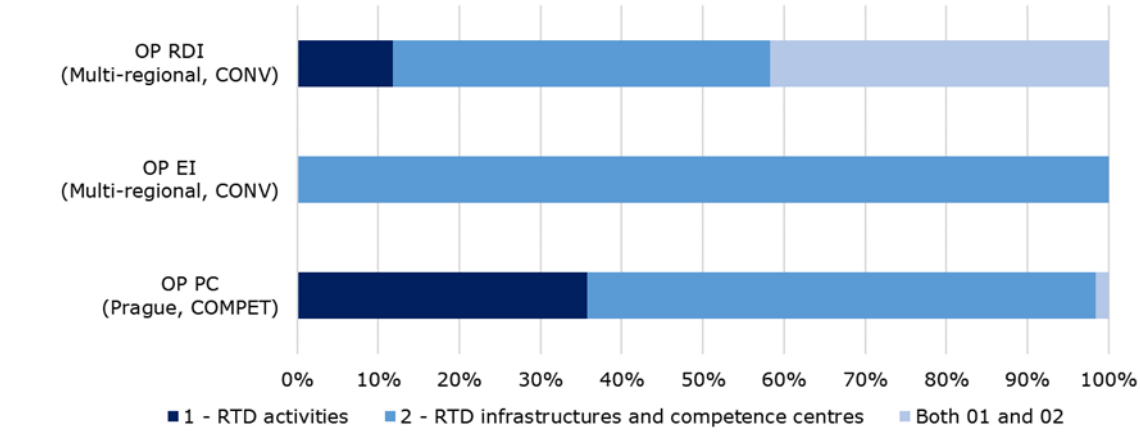
Distribution of ERDF funding for RTD in the Czech Republic by OPs



Source: Authors based on CSIL calculations.

The largest amount of the ERDF contribution was spent on projects funded under the category 02 – RTD infrastructure (almost 52% of ERDF funding), while 37% was allocated to projects that fell into categories 01– RTD activities and 02 – RTD infrastructure at the same time. The rest (i.e., only 11.6% of the ERDF contribution) was implemented through projects falling only into category 01. This distribution is determined by the allocation of funds within the OP RDI, which makes up 88% of the ERDF funding to the RTD support in the country. The RTD infrastructure preference is also evident in other OPs; for example, the OP EI did not allocate even any funding to category 01 – RTD activities.

Share of themes in ERDF funding for RTD in the Czech Republic by OP, % on total ERDF contribution to RTD themes



Source: Authors based on CSIL calculations.

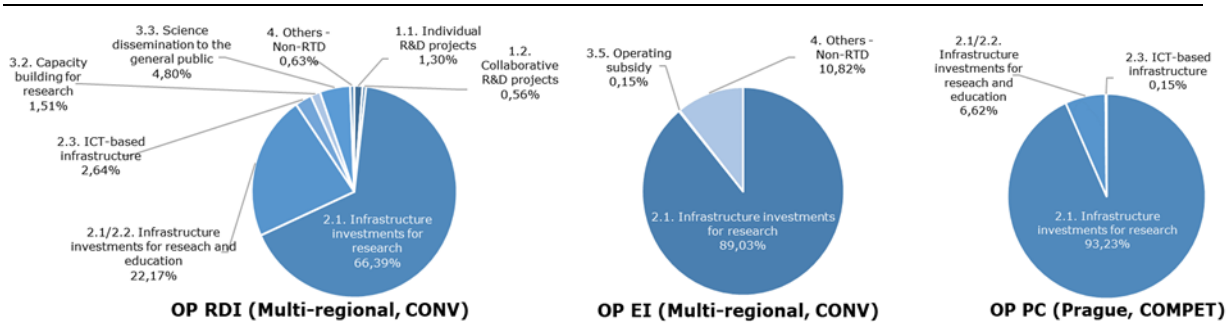
2.3.2. The ERDF RTD support policy mix: key instruments and rationale for selection

As previously mentioned, the ERDF RTD policy mix put a **strong emphasis on the RTD infrastructures** in the Czech Republic: the **infrastructure investments for research** account for the highest share of RTD interventions from the ERDF funding (almost 69.5%), followed by the **infrastructure investments for research and education** (19.8%)[12]. At the level of the OPs, nearly the same distribution applies for the OP RDI (66.6% for infrastructure investments for research, 22.3% for infrastructure investments for research and education). The RTD infrastructure's focus follows the hypothesis that an essential prerequisite for ensuring the continuous production of quality and relevant R&D results is achieving a sufficient critical size of research infrastructure and research teams. In the Czech Republic, however, the infrastructure for research (and subsequent production of cutting-edge knowledge, the consistent co-operation of the research and application spheres) and for education (and the subsequent production of the necessary quality and quantity of adequate human resources) was considerably underfinanced in the past and did not match the existing needs at the time. In addition, other (cross-cutting) policy instruments were implemented within this OP (the highest share for science dissemination to the general public – 4.8%).

The infrastructure investments for research played a dominant role in the OP EI RTD-related investments. They were intended to support cooperation between enterprises, scientific research and educational institutions at regional and national levels by creating technology parks, scientific-technological parks and clusters organisations.

The infrastructure investments for research also held a leading position within the OP PC ERDF funding to support RTD. It was complementary support to the OP RDI and OP EI in the territory of the Capital City of Prague. This support was focused on developing an innovative environment and partnership between the R&D and organisations of practical application.

Overview of ERDF funding by policy instrument in the Czech Republic



Source: Authors based on CSIL calculations.

The overall goal of the set of policy instruments was to create an environment stimulating research, development and innovation. This RTD support policy mix was the result of a combination of three main analytical inputs[13] and reflected the main R&D needs of the country.

The chosen set of policy instruments was created as a combination of bottom-up and top-down approaches. The RTD interventions were designed to support the supply of research and development activities, ensure the production of quality and relevant R&D results, and provide graduates with specialization relevant to the needs of the labour market. At the same time, the planned interventions should have strengthened the consistency of the supply with increasing demand on the side of the recipients of the R&D outputs and contributed to the successful transfer of knowledge to the application

[12] The case study applies a typology of RTD policy instruments developed for the purpose of the evaluation and presented in the First Intermediate Report (2020).

[13] (i) analysis of problematic areas in RTD, (ii) SWOT analysis prepared for the NSRF and particular OPs, (iii) analysis of the relationship between research, technology transfer, innovation and competitiveness.

sphere. In practice, however, based on the interviews with practitioners, the top-down approach eventually prevailed.

Within all RTD-focused ERDF OPs, the support in RTD was addressed through non-repayable aid (grants). Most RTD interventions were provided as a measure not constituting the State Aid[14] because most RTD activities were financed from the OP RDI providing support to non-profit public R&D organizations in particular (see for details section 3.1). However, the EU State Aid rules applied both to the OP EI (focused on the enterprises) and the OP PC (using the different State Aid schemes according to the beneficiary type).

The analysis of beneficiary types shows that **the largest recipients of the RTD ERDF were public higher education institutions** (HEIs, 40.6% of total analysed RTD ERDF support) concentrating on the infrastructure investments for research/ research and education. The second most important targets were centres of excellence and competence centres (29.1% RTD ERDF funding) implemented via the infrastructure investments for research.

However, there is a difference at the level of the OPs undermined by the setting of particular OPs. In convergence regions, the OP RDI addressed funds mainly to support HEIs and centres of excellence and competence centres, while the OP EI focused on supporting science and technology parks (88.3%). Concerning the specific characteristics of the Prague region, the OP PC allocated more than half of the RTD ERDF funding to the support of research and technology organizations (RTOs). Within the OP PC, approximately a quarter of RTD ERDF funding was directed to support of HEIs. Moreover, it is important to underline that the Czech Republic negotiated an exception for the OP RDI, thanks to which Prague public universities could have been supported by this OP at the end of the programming period.

Table 2. Overview of the ERDF funding by target beneficiary in the Czech Republic

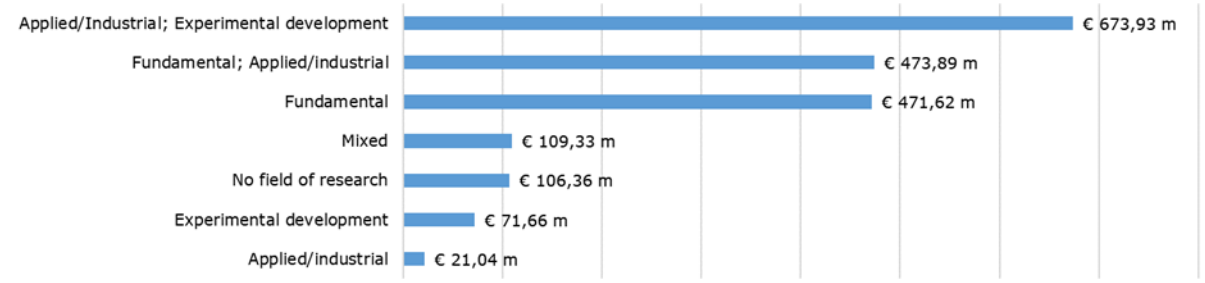
	OP RDI	OP EI	OP PC	Total
a. In higher education institution	€ 766,80 m		€ 16,13 m	€ 782,93 m
b. In Research and Technology Organisation	€ 180,51 m		€ 32,25 m	€ 212,75 m
c. In centres of excellence or competence centres	€ 559,34 m	€ 1,28 m		€ 560,62 m
f. In science and technology parks		€ 149,59 m		€ 149,59 m
g. In training centres	€ 4,93 m			€ 4,93 m
h. Others	€ 91,22 m		€ 15,14 m	€ 106,36 m
i. In enterprises		€ 0,19 m		€ 0,19 m
N/A	€ 92,15 m	€ 18,32 m		€ 110,47 m
Total	**€ 1 694,95 m**	**€ 169,38 m**	**€ 63,51 m**	**€ 1 927,84 m**

Source: Authors based on CSIL calculations.

More than **one-third of the RTD ERDF funding** was concentrated on a **combination of applied/industrial research and experimental development**. The activities focused on fundamental RTD, and a combination of fundamental and applied/industrial type of RTD also achieved a significant share (24.5%, resp. 24.6%). However, the distribution differs within the individual OPs. RTD funding within the OP RDI was almost evenly distributed between the three groups of RTD types mentioned above. Similarly, these three groups are significantly represented within the OP PC, although the combination of applied/industrial research and experimental development is the most important. Almost all RTD projects supported under the OP EI can be included in the group using applied/industrial research and experimental development.

[14] I.e. outside the Article 107, paragraph 1 of the Treaty on the Functioning of the European Union.

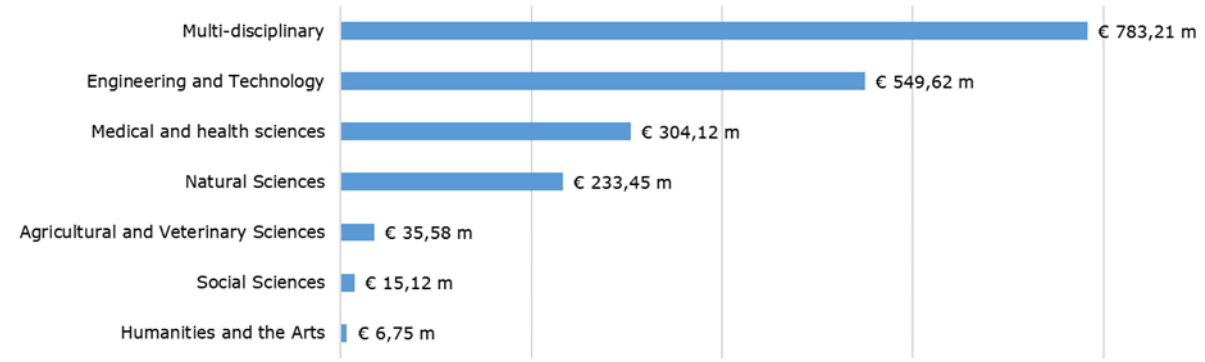
Overview of ERDF funding by type of RTD in the Czech Republic



Source: Authors based on CSIL calculations.

In terms of science, the Multidisciplinary field with EUR 783.2 million accounted for the largest share (40.1%) in the RTD funding. A significant part of the RTD ERDF funding also went to the Engineering and Technology (28.5%) and Medical and health sciences (15.8%). On the contrary, the smallest share of funds went to the Social Sciences (0.8%) and the Humanities and the Art (0.4%). In the convergence regions, through the OP RDI and OP EI, the ERDF funding was allocated primarily to the Multidisciplinary field and the Engineering and Technology. Within the OP PC, the Medical and health sciences precede these two categories. This thematic distribution was in line with the aimed ERDF policy mix to concentrate on the life sciences, technological and medical fields, and line with the national RTD policy and specified thematic priorities (see section 2).

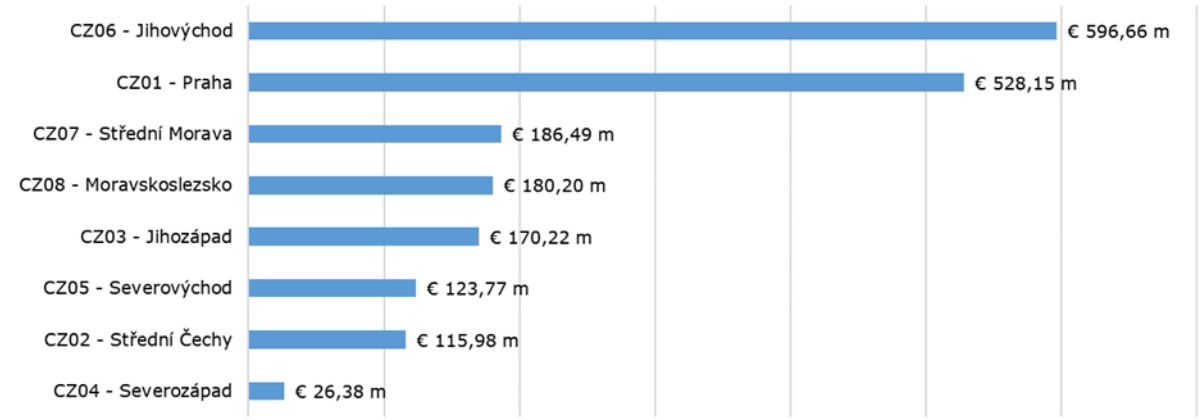
Overview of ERDF funding by field of science in the Czech Republic



Source: Authors based on CSIL calculations.

During the preparation of the relevant programming period, the support of the RTD infrastructures and activities was divided between the two OPs designed to support the convergence regions (i.e. the OP RTD and the OP EI) and one OP under the Competitiveness Objective intended to support activities in the Capital City of Prague (the OP PC). Initially, the dominant share of the ERDF funds under the codes 01 and 02 was allocated to the convergence regions, specifically for the Jihomoravský kraj (NUTS3 region; EUR 630 million) and the Středočeský kraj (NUTS3 region under CZ02; EUR 429 m). For Prague, only EUR 15.2 million belonging to these categories of expenditure were allocated under the OP PC. Nevertheless, the analysis of the geographical concentration of actual ERDF RTD expenditures **based on the location of the direct beneficiary** shows that the highest share of funds was concentrated in the Jihovýchod region (including Brno, the second-largest city in the Czech Republic) and Prague region (i.e. the competitiveness region) mainly due to the headquarters of two major projects beneficiaries.

Regional concentration of the RTD investments in the Czech Republic based on beneficiary's headquarters



Source: Authors based on CSIL calculations.

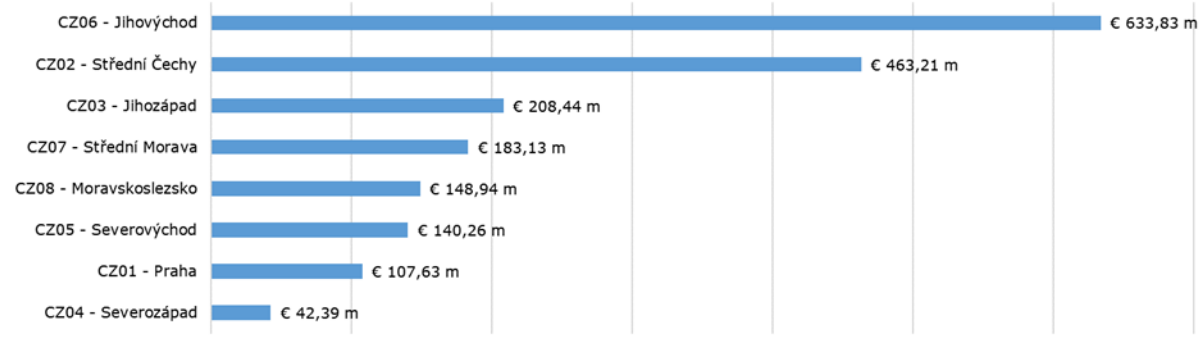
However, the picture of the **regional distribution of funds based on the beneficiary location** is distorted by the following main factors:

- When assessing the eligibility of project applications within the OP RDI and OP EI, the decisive factor within some calls was not the applicant's headquarter (beneficiary) but the place of project implementation.[15] Therefore, the beneficiary based in Prague could receive the ERDF contribution, although the project had to be implemented in an eligible region/regions (i.e. convergence region/s) to ensure the main territorial objective of the interventions.
- During the analysed period, the OP RDI was revised, and the support of infrastructure projects in Prague was enabled (under the Priority Axis 4). One of the main arguments was that the Prague region is an educational centre of super-regional importance with benefits for the whole country. Consequently, it was possible to support the Prague higher education institutions, the impact of which was on the regions included under the Convergence Objective.

Consequently, the picture of regional distribution of the RTD ERDF funds **based on the location of project implementation** is completely different. Only projects falling under the OP PC and projects for which an exception was negotiated within the OP RDI (under the PA 4, see above) were implemented in Prague's territory (EUR 107.63 million together, i.e. 5.6% of the total RTD allocation). Other projects (i.e. those having project applicants headquarter in Prague) were implemented in Convergence regions, which is fully in line with the purpose of the ERDF support. In addition, the comparison of both perspectives shows that the largest part (79.6%) of the ERDF allocation for RTD support entrusted to the beneficiaries based in Prague was implemented in the convergence regions.

[15] For example, in call no. 2.1 in Priority Axis 1 the headquarters of project applicants must had been in a convergence region (see https://www.opvavpi.cz/filemanager/files/file.php?file=31927) contrary to call no. 1.1 for which this requirement did not apply (see https://www.opvavpi.cz/filemanager/files/file.php?file=25642).

Regional concentration of RTD investments in the Czech Republic based on project location



Source: Authors based on CSIL calculations.

When it comes to the types of direct beneficiaries, the highest ERDF contribution received the HEIs (EUR 1035.3 million, 53.7% of the total ERDF contribution) and RTOs (EUR 490.2 m, 25.4 %). An in-depth analysis revealed that ten institutions got together 59% of the total RTD ERDF contribution in the Czech Republic.

This concentration of funds shows the initial efforts of the OP RDI to support a limited number of high-level research facilities. However, as evidenced by the previously carried out ex-post evaluation of R&D[16], this goal has not been achieved, and interventions have contributed to a significant increase in the number of research centres in the Czech Republic, which varies in terms of quality and brings problems in financial sustainability.

The available information and the evaluations carried out show that the selected policy mix and the emphasis on infrastructure investments have only partly led to the intended effects. The overall effects of the chosen policy mix are influenced by many external factors, e.g. by the system of rules for cooperation with the application sphere is missing, the R&D financing system in the Czech Republic is inappropriate.

A total of the new eight centres of excellence and new forty regional research centres were established (under the OP RDI, Priority Axes 1 and 2) and (as evidenced by *Ex-post evaluation of the programming period 2007 – 2013 in the field of research)* some of them manifested themselves on the European and international stage and are currently engaged in prestigious international projects. However, the sustainability of the centres' top position in infrastructure and equipment is threatened by the inability to generate enough funds for reinvestments. Cooperation with the private sector takes place mainly based on collaborative and contractual research. However, the commercialization of the results, i.e. their transfer into practice, is limited (partly caused, for example, by a possible conflict with the State Aid rules). Thanks to this infrastructure, students' access to the top equipment has increased, giving them unique opportunities not previously available. Some of the OP RDI centres increased the number of doctoral students or influenced university teaching.[17]

[16] EACE - Evaluation Advisory Central Europe (2018): Ex-post evaluation of the programming period 2007 – 2013 in the field of research and development.
[17] EACE - Evaluation Advisory Central Europe (2018): *Ibid.*

3. CONTRIBUTION ANALYSIS OF SELECTED POLICY INSTRUMENTS / MAJOR PROJECT

For the in-depth contribution analysis, two policy instruments and one major project, all financed from the OP RDI have been selected, namely:

- Research-related teaching infrastructure in higher education institutions, measure under "IV. Research-related teaching infrastructure in higher education" (Priority Axis 4);
- ICT-based infrastructures, measure under "III. Commercialization and popularization of R&D" (a minor part of Priority Axis 3);
- Major Project "ELI: Extreme Light Infrastructure" in measure "I.1 European Centres of Excellence" (Priority Axis 1).

The analysis of these policy instruments was conducted based on a CA approach, which in turn has been developed on the basis of a ToC defined for each policy instrument. The aim of this chapter is threefold:

- To present the OP under which the three policy instruments were funded;
- 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 effects 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 OP RDI, outlines the rationale of the OP and the policy instruments, and links to other measures and ambitions established by the programme. The subsequent sections (3.2,3.3,3.4) provide a comprehensive analysis of each of the selected policy instruments for Czechia. Each section includes the subsections outlined below.

- The first subsection presents the ToC of the policy instrument. The case study team developed theories of Change to conduct the contribution analysis. As such, Theories of Change are an ex-post reconstruction of the intended goals and purpose of the policy instrument and the causal package intended to generate such goals. However, it is worth mentioning that the ToCs presented in each chapter provide a snapshot of policy-makers intentions at a given point in time. ToCs generally adapt to the realities of specific territories and 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 and the final depiction of the ToC testing.
- The second subsection introduces the results of the contribution analysis. This section explains what happened when the policy instrument was implemented and why and how this happened. The contribution analysis was carried out by assessing the extent to which the different components identified in the ToC took place or to which there were conditions for the desired change and how they influenced the instrument's effectiveness. 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 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 their role in achieving the instruments' intended goals.
- The extent to which identified risks materialized, and whether these were effectively managed or mitigated, or limited the instrument's effectiveness.

- The combination of the results obtained for each of the previously described assessments led to establishing 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 materialized 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 that presents the overall contribution analysis results and the underlying explanation of this result.

3.1. Overview of the Operational Programme Research and Development for Innovations (OP RDI)

The OP RDI was one of the OPs aimed to contribute to the fulfilment of the Lisbon Strategy's objectives and balanced regional development of the Czech Republic. At the same time, it can be considered one of the key tools contributing to implementing the Reform of the research, development, and innovation system in the Czech Republic.

The OP RDI covered the RTD needs of the Czech Republic implicitly via the necessity to address the following problematic areas of R&D and innovation systems:

- (i) to tackle insufficient cooperation between public and private sectors in RTD and innovations by supporting mutual trust between both sectors, motivating for mutual cooperation, increasing mutual awareness in RTD sphere and communication, and importantly to support direct involvement of the application sphere in R&D activities of the public sector.
- (ii) to significantly improve capacity and material equipment of public R&D organisations that was obsolete and not corresponding to the need to perform high-quality research producing applicable research outputs. The Czech Republic needed to establish a limited number of R&D excellence centres and develop their infrastructural and human capacities to mitigate the high fragmentation of R&D capacities to produce top research outcomes competitive in the international arena. Also, public R&D organizations needed to urgently modernise equipment to deliver top research results, to ensure quality teaching of the new generation and cooperation conditions, especially in applied research. Moreover, higher education

institutions had to solve limited capacity for R&D activities related to teaching (e.g. equipping with modern devices, adequate software equipment, limited capacities of libraries), especially in more expensive fields (technical and scientific).

- (iii) the need to address the lack of qualified human resources (mainly specialized R&D employees, R&D managers), the adverse structure of current human R&D capacities (ageing human-resources R&D base, low engagement of woman in R&D), unfavourable remuneration of researchers in some regions/teams and shortage in universities graduates (including doctoral studies) with adequate practical skills and soft competences.
- (iv) there was a strong need to support internationalisation and international cooperation in R&D to improve a low level of internationalisation of the Czech R&D system, to increase foreign funding of R&D activities in the Czech Republic, to open the Czech R&D system towards international competition and to participate in the international division of R&D labour to a maximum extent.
- (v) there was an immediate need to address network failures, namely insufficient capacity and quality of services in technology transfer centres in research institutions and universities that resulted in insufficient contact and insufficient joint activities between these two spheres. Lack of incentives and insufficient motivation of public R&D institutions to cooperate with enterprises, together with the insufficient orientation to the application sphere's needs, resulting in low application relevance of R&D results and low expenditure efficiency and limited exchange and circulation of knowledge and new ideas.
- (vi) Furthermore, the OP RDI aimed to address institutional failures in terms of insufficient support for commercialization of R&D results, low level of awareness and experience with intellectual property protection, absence of a system of protection and use of intellectual property in most research organizations and universities. Insufficient awareness about R&D results and their use among academic and business entities and the general public also caused overall adverse impacts for the R&D sector (e.g. low interest of young generation in science, low prestige of scientists, rigid views across different R&D entities, low cooperation).

The OP RDI fell within the framework laid out for the Convergence Objective with the allocation of EUR 2.4 billion (of which EUR 2.1 billion from ERDF). During the programming period, this amount was adjusted, the final allocation reached EUR 2.2 billion (of which 1.8 billion from ERDF). Support was provided to regions throughout the Czech Republic outside the Capital City of Prague, which did not fall under the Convergence Objective. Projects implemented by beneficiaries from Prague's territory were supported only if their effects were demonstrably directed to the eligible regions of the Convergence Objective. Consequently, the OP had to consider pronounced regional disparities in R&D capacities and production between the Prague region and the rest of the country and adequately balance the need between the concentration on top-class RTD and the obligations to comply with eligibility rules. This trade-off has proved to be one of the key OP's challenges. As in most countries, Prague has played a central role in the R&D sector, and higher education and 2/3 of the R&D capacities of the country were concentrated there. Although the Czech Republic tried to negotiate with the EC support also for Prague from the OP RDI because of the unique position of the Czech R&D system from the very beginning of the OP’s design preparation, the OP negotiators succeeded to agree with the EC on an exception for Prague only at the end of programming period for one policy instrument.

The OP RDI was focused on strengthening the RDI potential of universities and research institutions and increasing their cooperation with the private sector. For this purpose, the OP RDI supported the supply of equipment of research institutes with modern technology, the construction of new research institutes, the creation of a system for the commercialization of R&D results and the increase of the capacity of tertiary education for R&D. The global objective of the OP RDI was to strengthen the research, development and innovation potential of the Czech Republic which shall contribute to economic growth, competitiveness and the creation of highly qualified workplaces. The global

objective was concretised through four specific objectives aligned to the particular priority axis of the OP.

The majority of the total allocation (EU funding and national resources together) of the OP RDI (EUR 1.4 million) was allocated to R&D infrastructure supported from the Priority Axis 1 "European Centres of Excellence" (EUR 686.4 million; 31.9% of the OP RDI allocated budget) and Priority Axis 2 "Regional R&D Centres" (EUR 751.8 million; 35.0% of the total allocation). The support was aimed at the creation and development of technology transfer centres from research organizations and investment projects aimed at popularization (e.g. science parks) in the Priority Axis 3 "Commercialization and popularization of R&D" (EUR 195.8 million; 9.1% of the allocated budget). The development of infrastructure for teaching at universities related to research and direct impact on the increase of human resources for R&D activities were supported under the Priority Axis 4 "Infrastructure for university education related to research" (EUR 444.8 million; 20.7% of the total allocation).

Synergies and complementarities

The OP RDI explicitly conceived synergies with the other two ERDF OPs (one thematic – OP EI, one regional – OP PC). Together with another thematic ESF-OP, these programmes were ex-ante designed to jointly address challenges identified for RTD and innovation systems in the Czech Republic. Consequently, a mix of mutually interlinked priority axes and OP's measures was proposed and implemented. The OP RDI supported public R&D organizations/academic sphere while the OP EI supported enterprises. The OP PC supported both segments, but in the Prague region, that was not eligible for the two listed OPs. The analysed OP covers all convergence regions that are the entire Czech Republic except for Prague's region demarked for the Objective Regional Competitiveness and Employment. Hence, the actions under 3.1. OP PC measures were envisaged to be complementary to all actions undertaken in national OP RDI, even though with much lower financial sources.

Further, an agreement between the analysed OP and the OP EI about synergic mechanisms outlined mutual complementarities, and two types of synergies were anticipated. First, horizontal synergies, expected by subsequent projects (projects were prepared at different times, projects submitted to the OP EI followed-up outputs funded from OP RDI), and simultaneously prepared projects. Second, vertical synergies emerging while projects from OP RDI were prepared in partnership with the application sphere. Examples of mechanisms ensuring synergies include a bonus for project proposals during the appraisal process that manifested synergies, the common project calls for the two OPs, institutional coordination via a joint implementing agency, informing applicants about the benefits of complementary actions from both OPs. However, in practice, synergies were rare and very difficult to be achieved due to the following reasons: (i) sectoral departmentalism of MAs (both at Czech and the EC side), (ii) huge delay with the launch of the OP RDI (due to some insufficiently resolved issues mistakes on both sides - Czech and the EC), (iii) changes in a regulatory framework for State Aid posed by the EC in 2013, (iv) absence of know-how to ensure interconnections between research organizations and companies.

The OP Education for Competitiveness (OP EC) was designed to complement infrastructural investments from the analysed OP by ESF-financed activities such as training, education and other "soft" activities in both research and educative sphere. The synergies/complementarities stemmed in support of the development of international relations and networks, establishment and support of top-quality research teams, development of networking partnerships between public and private sector/industry, improvement of the management of R&D organisations and universities. Further, training in technology transfer, intellectual property protection, and popularising research and networking were designed. In relation also to the national White Paper of Tertiary Education, the ESF OP aimed at upgrading of study programmes, study/research fellowships, the involvement of experts from industry and from abroad, development of cross-sectoral mobility, support of entrepreneurial spirit and the overall support of modernization of higher education to reflect the RTD challenges in human capacities.

The most important complementary aspect is perceived so-called "start-up grants" within the projects of PA 1 and 2 up to 20% of the entire ERDF project budget. These grants allowed to support the establishment of new research groups and operation of research teams (i.e. coverage of operating costs) without the necessity to apply for a complementarity ESF project with the uncertainty of funding.

State Aid rules

State Aid rules were one of the key challenges in the OP's implementation and one of the main barriers for the private sector's involvement and thus achievements of programme intentions for increased cooperation with the application sphere.

During the OP's preparation, there was no capacity at the MA and even in the country (e.g. via the Office for Protection of Competition of the Czech Republic) about ensuring compliance with the State Aid rules and understanding potential implications on the OP's implementation. The EC provided very little support in this regard. Eventually, the MA of OP RDI decided, based on the available knowledge and information, that the OP would have been implemented outside the state aid regime to avoid the notification process and benefit from a possibility to provide 100% grant support. This choice implied that only public research organizations without economic activity were enabled to be eligible beneficiaries.

During the OP's negotiations, DG REGIO stressed the importance to focus on cooperation between R&D centres and the private sector. To reflect this indication, the OP RDI required in the Priority Axis 1 and 2 that supported research centres of excellence and regional R&D centres would have ensured at least 30% of their income from contract research. The intended achievements of cooperation between the academic and private sectors were translated into projects' and OP's explicit targets. At the same time, however, DG COMP had been tightening the State Aid rules over the 2007-2013 period. Overall, there was a contradiction between the desired objectives of ERDF support in the R&D sector emphasized by DG REGIO and the interpretation of the State Aid rules for the R&D sector by DG COMPET, exacerbated by a strict interpretation of the State Aid rules by the Czech authorities in comparison to the other EU MSs. The situation was further complicated in 2013 when the EC amended the rules and decreased the limit for contract research at 20%, which had seriously disrupted a part of the OP's intervention logic and had devasting impacts for a number of research centres that had ambitions and potential to perform a higher share of contract research than those eventually requested by the amended compliance with State Aid in 2013.

Moreover, this change had brought about legal uncertainty for beneficiaries in particular in the Priority Axes 2 and 1 (and to a more limited extent also projects on R&D popularization under the Priority Axis 3, i.e. life science centres), undermining the sustainability of supported R&D centres and consequently negatively influenced the entire R&D environment and mutual trust. The final responsibility for compliance with the State Aid rules was transferred to beneficiaries (in the form of declarations of honour and amendments in project contracts). The unpleasant situation had to be solved *ex-post* extensively.

As concerns the policy instruments analysed in-depth, while for investments into research-related teaching infrastructure in higher education and ICT-based infrastructures, the State Aid rules had no serious consequences. For the major project ELI, the State Aid rules were of particular importance (see section 3.4).

Implementation

The implementation of the OP RDI was influenced by the substantial delay in the OP's preparation. During the investigated period, the MA experienced political and managerial instability and, consequently, high staff fluctuation leading to a low expert capacity of the OP's implementation structure in some periods of implementation. However, there is a wide consensus that the key OP setting of intervention logic and policy instruments was done when a highly-expert team operated at the MA.

In the 2007–2013 programming period, 20 calls for applications for support (in the form of non-reimbursable grants) in the total amount of EUR 2.34 billion were announced within the OP RDI. Before the decisive date of the end of the 2007-2013 programming period (i.e. December 31, 2015), 222 projects were successfully completed. The implementation of the OP supported over 6,000 jobs in the field of R&D (almost a third of them were women's jobs), there was an increase in the number of employees employed in the field of R&D. Furthermore, over 22,000 officially recognized R&D results (publications, patents, prototypes, etc.) were produced by the supported centres in the PAs 1 and 2. On the other hand, the growth in the number of doctoral graduates was insufficient when only 80% of the set target value was reached during the implementation of the OP RDI.

With regard to the material and financial importance of the OP RDI within the overall support of RTD in the Czech Republic[18], the main general conclusions stated in Chapter 2.3 pay also for this OP.

Thanks to the projects implemented under this OP, priority themes 01– RTD activities and 02 – RTD infrastructure reached, for example[19]:

- 4,158 new jobs – researchers were created (monitored within 48 projects of which 92% achieved the target value);
- 752,239.4 m^2 of capacity were reconstructed, extended or newly built (monitored within 106 projects of which 86% achieved their target value);
- 130 cooperation projects of application sphere with centres of excellence were realized (monitored within eight projects of which 88% achieved their target value);
- 1,123 cooperation projects of application sphere with regional R&D centres were realized (monitored within 59 projects of which 85% achieved their target value);
- 214,538 students benefited from new/reconstructed infrastructure (monitored within 62 projects, of which 50% achieved their target value).

Six Major Projects were implemented within the OP RDI under both 01 and 02 categories. The initial programme document listed an indicative overview of 12 potentially suitable major projects under Priority Axes 1 and 2. Based on a relatively strict and multi-stage project appraisal system and selection[20], six major projects were eventually granted support.

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[18] The OP RDI represents 88% of the ERDF funding to RTD support in the Czech Republic during the period in question.

[19] The values are valid for the end of sustainability period of particular project, the initial dataset was provided by the National Coordination Authority, Ministry of Regional Development. The target values were not set for particular policy instruments but for the entire OP. Here, only achieved values by projects under the codes 01 and 02 are included.

[20] The appraisal process was set up in the same way for Priority axes 1 and 2. Given the size and focus of the projects, it was a multi-stage appraisal system using domestic experts and foreign experts and three selection committees. Based on an overview of Projects appraisal and selection in the OP RDI (HOPE-E.S., divize EU Service 2010) the system had the following stages: 1) Check of formal requirements criteria – performed internally by the MA; 2) Checking of eligibility criteria – performed internally by the MA; 3) Assessment of application potential, financial sustainability and synergies with other operational programs – 3a) Assessment of project application with experts with experience from cooperation with the application sphere (individual assessments) – assessment of 3 external evaluators, 5 in the case of major projects (MP); 3b) Commission of experts with relevant experience from cooperation with the application sphere (so-called Consensus meeting) – 2 external evaluators; 3c) Construction-technical assessment (level 1) - 2 external evaluators; 3d) Applications panel – selection committee of external evaluators who had relevant experience in cooperation with the application sphere; 4) Evaluation of the overall quality of the project plan – 4a) Evaluation of the project application by expert evaluators / experts (individual assessments) –3 foreign external evaluators / experts, 5 in the case of the MP; 4b) Commission of expert evaluators (so-called Consensus meeting) – evaluation committee-foreign external evaluators/ experts 4c) Building technical assessment (level 2) – 2 external evaluators; 4d) Panel of experts (International panel) – selection committee-foreign external evaluators/experts; 5) Selection commission of the MA OP RDI; 6) Specification

All (except one project - SUSEN) represent centres of excellence. With their impact, equipment, unique structure and size should have contributed to the interconnection and greater integration of leading Czech R&D teams with international teams.

The implementation of these Major Projects followed one of the objectives of the OP RDI, namely the goal of creating a limited number of top centres ideally with a unique infrastructure and technologies (i.e. flagships of Czech R&D) and with high-quality R&D infrastructure capable of participating in international cooperation and creating knowledge usable in the application sphere. One of the major projects, ELI, is under scrutiny in Chapter 3.4. The interviewed stakeholders within this evaluation, more or less, agreed that the final number of six major projects is adequate. However, in conjunction with the other developed R&D infrastructures in the 2007-2013 period under the Priority Axis 2 have created enormous demands for financial sustainability for the future. The OP RDI anticipated explicitly that existing capacities in the regions had to be taken into account to avoid duplication and make the operation of the built capacity economically sustainable and that there could have been no fragmentation of funds into less significant small, unrelated projects. However, "the Ex-post impact evaluation of SF 2007-2013 spending into the R&D sector" (EACE 2018) found that these assumptions have not been fully met. One of the reasons for this situation is that the construction and modernization of the research infrastructure in the form of RDI centres were not followed by a certain inventory and consolidation of publicly funded R&D infrastructure to reach a limited number of top workplaces in the medium-term, where both instrumental and human capacities would be concentrated – i.e. critical mass in selected fields. Furthermore, a very significant volume of the total allocation, delayed withdrawing, all accompanied by political turbulence and frequent personnel changes in the management of the MEYS and the MA of the OP RDI, supplemented by regional pressure and originally unsuccessful projects, had a negative impact on the originally expected limited number of supported projects.

3.2. Policy instrument: Research-related teaching infrastructure at higher education institutions under the Operational Programme OP Research and Development for Innovations

3.2.1. Theory of Change of the policy instrument

As a part of the OP RDI policy mix, the assessed PI was a part of the Priority Axis 4 (hereinafter PA 4) that covered the infrastructure investments into research-related higher education to eliminate the negative heritage from the past when investments in RTD infrastructure were very limited. As a result, the infrastructure at higher education institutions (HEIs) was underfunded, not providing sufficient capacity and quality for students, academics and researchers, with outdated research equipment, and not in accordance with the modern education and research standards. Consequently, the infrastructure burdens at the institutions providing tertiary education prevented the Czech Republic from disposing of highly-educated and skilled human resources necessary to develop a knowledge-based economy. Simultaneously, the Czech system did not have adequate financial sources to upgrade the necessary infrastructure itself.

Therefore, the PA 4 (i.e. the policy instrument) focused predominantly on the support of:

- Newly built or reconstructed infrastructure for research-related education (buildings, lecture halls, classrooms, laboratories, offices for doctoral students);
- Modernization and improved quality of equipment for research-related education (instruments and lab equipment, highly specialized apparatuses, ICT

of parameters ("negotiations") -only for projects, for which the Selection Committee - MA recommended for this phase.

infrastructure, improvement of material and technical provision, new information technologies and systems, facilities for university libraries).[21]

The instrument targeted public HEIs predominantly in natural, technical and life-science fields, even though the support was also allowed for other fields (e.g. social sciences and humanities) that manifested the ability to produce highly qualified graduates with relevance to increase the competitiveness of the Czech economy. By all means, the applicant had to prove demand for its graduates and the insufficient state-of-art of the then infrastructure.

For the demographic trend and the expected decrease in the total number of higher education students in future (risk 5), the support was distributed selectively among the most prosperous research-oriented HEIs to avoid a blanket increase of HEIs capacities also at the universities of lower quality (pre-condition 7). The assessment of HEIs quality was based on the previous RDI results, the number of doctoral students/graduates, the state-of-art of doctoral study programmes and the level of cooperation with application sectors. The prominent emphasis was put on the HEIs' infrastructure enabling an interconnection of tertiary education and R&D leading to innovations. The Managing Authority (MA), the Ministry of Education, Youth and Sports (MEYS) used a procedure to calculate preliminary allocations of entire PA 4 among particular relevant HEIs to guarantee somehow that the capacities invested into the demanding project proposals would not have been lost. The preliminary pre-allocations were announced and reflected the previous quality of HEIs (the higher quality of HEI, the higher pre-allocation received). Thus, each HEI had to agree on investment priorities within its structure and submit a limited number maximum of five project proposals meeting the given quality criteria posed by the MA (pre-condition 1). As a result, this PI did not suffer from low-quality project proposals or low absorb capacity. Of course, the PI assumed that adequate capacity for the preparation and implementation of projects at the side of universities existed or could have been established (pre-condition 2).

Neither the MA nor the relevant ministry had in their possession a master investment plan for HEIs in Czechia or a systemic overview of the HEIs' needs. Thus, the investment prioritization in this segment was not driven by a top-down strategic approach. On the other hand, all supported projects had to be included in a long-term development plan of particular HEI, and thus, the prioritization took place at the university level. This approach was pushed by the MA, which issued "the Theses for support targeting"[22] specifying expected conditions for project proposals, namely:

- Investments in the educational infrastructure necessary for future researchers' education (especially PhD students) are more expensive than investments in the infrastructure needed for education at the bachelor's and master's level. For this reason, support under PA 4 focuses primarily on eliminating the infrastructure deficit in research-oriented schools and their bodies, or more precisely, to support projects that address the shortcomings of research-oriented faculties.
- It is impossible to anticipate further extensive growth of higher education institutions, especially about demographic trends and the existing share of the population in the relevant age category entering tertiary education.
- Requirements for a jump in capacity or a comprehensive modernization of tertiary education capacity will generally not be reflected.
- Further improvement of the educational infrastructure and material provision for research-related education should not be widespread but differentiated between and within universities. The differentiation should reflect individual universities' strategic intentions, not only the strategy of further investments but especially the long-term strategy of the further direction of research and educational activities of a particular university and its faculties.

[21] The support included also costs for preparation and management of projects.
[22] These Theses were included in the calls for project proposals.

In addition to the compulsory alignment of proposals with a long-term development plan, the projects had to be logically interlinked to the main premises of the White Paper of Tertiary Education in the Czech Republic (2009), namely to:

- Cooperation with practice, increasing of the relevance of education, employability of graduates (involvement of practicians into teaching, practical training, internships at employees, cooperation with users of R&D results, the interconnection of teaching students with research and innovation activities);
- Improvement of internal management of public HEIs (measures to professionalize managerial processes, the introduction of strategic planning principles, improvement in the management of cooperation with application sphere, enhancement of the third role of universities, engagement in regional development);
- International cooperation (involvement of lecturers from abroad, international internships of students and researchers, increase of international PhD candidates);
- Lifelong learning (offer of courses, increase in the number of graduates).

The project proposals were appraised for the extent to which they meet the above-listed premises that were considered as the long-term effects of the PI. However, it was also clear that supported projects alone could not provide those achievements. Still, a complex of interventions and actions was expected for the full materialization of these achievements (supporting factor 1, 2, 4, 5). In other words, the PI intended to achieve through the ERDF support for the newly built/reconstructed infrastructure of HEIs and for the modernization of equipment for research-related education the expected main effects of the instrument, i.e. to increase the capacity of tertiary education (i.e. to allow more (PhD) students to study at high-quality universities) and to create conditions for a qualitative change in tertiary education and teaching (by the profound improvement of conditions for research-related teaching and research itself). Students were expected to obtain improved skillsets enabling them to be engaged in R&D activities at university. The PI should have ensured the conditions for the increased number of PhD graduates. In the longer-term, these investments were anticipated to contribute to broader involvement of supported HEIs into the international R&D arena and to accelerated cooperation with the application sector. The ultimate objective was to ensure the increase in quantity and quality of RDI human resources as a fundamental pre-condition for the Czech economy's long-term competitiveness.

Due to the rules for regional eligibility of the support, the PI concentrated on HEIs located in convergence regions that allowed to follow the balanced development objective within Czechia (defined in the NSFR 2007-2013) and the increased attractiveness of regional universities. Although the Czech Republic endeavoured to include among the eligible regions also the region of Prague (i.e. a region under the Competitiveness Objective) because of its central position in the Czech R&D system (risk 2), an exception to support also the HEIs based in Prague was negotiated with the EC only in 2013 (pre-condition 4). Consequently, the first two round of calls for proposals (of EUR 366.3 million and EUR 48.1 million) targeted only the HEIs based in the convergence regions. The third round call opened in November 2013 focused on Prague and eventually included projects for EUR 54.4 million. The supported projects in Prague aimed to bring about spillover effects for the convergence regions as more than two-thirds of students of Prague HEIs came to study in Prague from convergence regions. The MA selected a round type of calls to stimulate applicants to prepare their proposals rather quickly.

All the support took the form of non-reimbursable grants, providing 85% funding from the ERDF and 15% of national co-financing for the convergence regions withdrawn as ex-post payments from the state budget. However, the national co-financing was taken from a bulk of institutional funding for a particular HEI and thus, consequently, from the own sources of universities.

The policy instrument's design foresaw strong complementary effects with the support provided from the OP Education for Competitiveness (OP EC, financed by the ESF) in terms of the increased quality and relevancy of tertiary education (supporting factor 1). Therefore, in the selection process, project applicants realizing a synergic project from

the complementary ESF OP to update study (doctoral) programmes and realize reform steps to interconnect education with research activities were favoured.

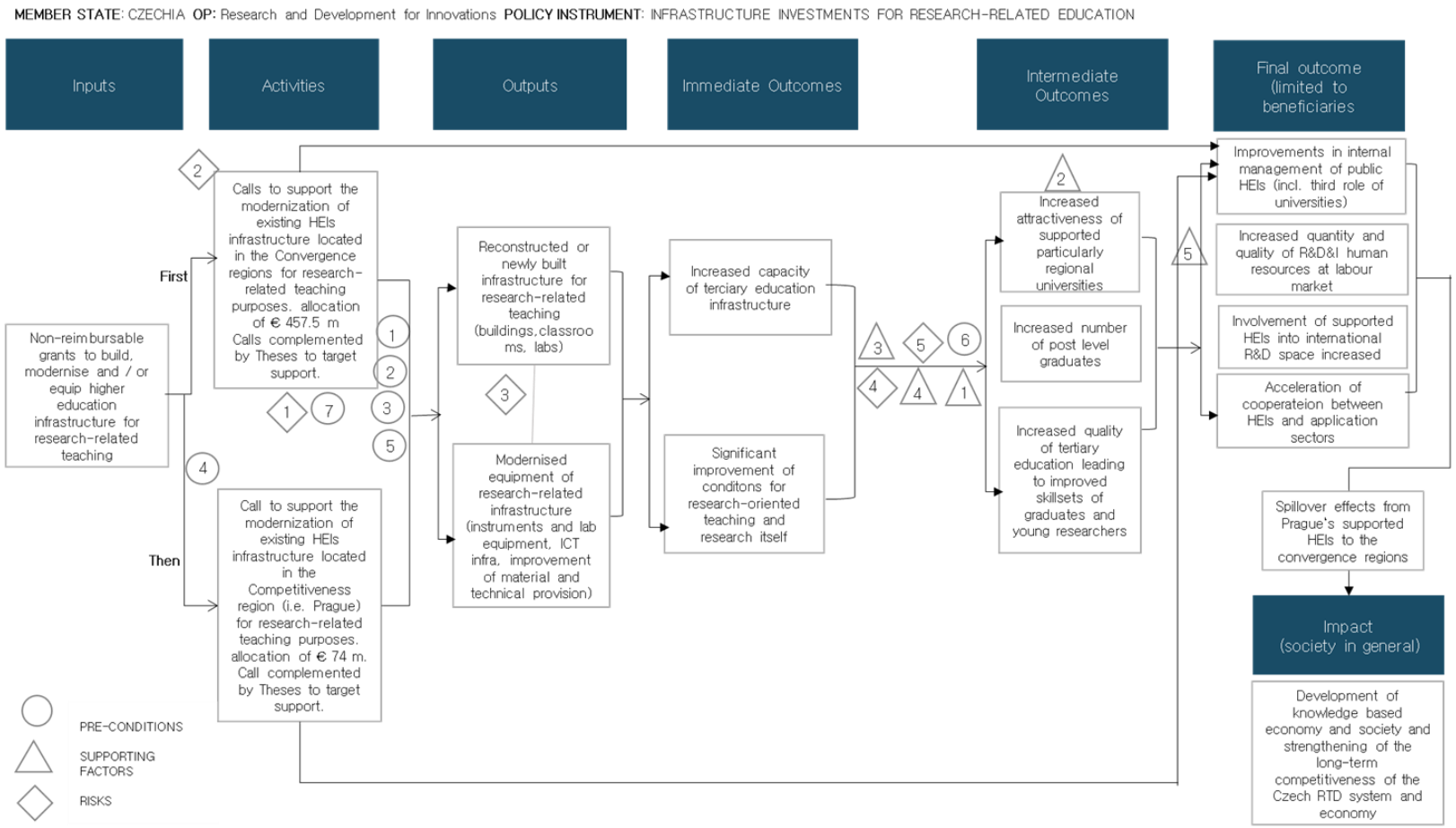
The instrument's design emphasised the energy demands of the newly built/modernized infrastructure. Project proposals that included energy savings solutions were substantially favoured during the appraisal process. This element was a rather novelty in the Czech environment at that time.

State Aid rules were very marginal in the design of this policy instrument due to the nature of investments.[23]

The following figure presents the ToC of the infrastructure investments for research-related education. It is meant to illustrate the intended results of the policy instrument and the underpinning linkages among them

[23] The only issue evolving in a later stage of project implementation/sustainability related to a possibility to locate in the new/modernized infrastructures canteens/buffets to ensure the refreshment for students/employees. Due to the State Aid rule this was not allowed.

Theory of change of Research-related teaching infrastructure at higher education institutions



Pre–conditions

1. Proper prioritization of investment needs of universities and preparation of high-quality projects that will be in line with the goal of support
2. Adequate capacity for the preparation and implementation of projects on the side of universities incl. public procurement procedures and organization of construction works
3. Stability of the adequately set rules and requirements for providing support
4. Additionally negotiated exception to support public universities in the competitiveness region (i.e. in Prague)
5. Sufficient expert capacity on the side of the Managing Authority to successfully organise and administrate the support
6. New/modernised infrastructure and modernised equipment is widely used by teachers and students and equipment is shared to the possible extent
7. Well-established framework rules for the allocation of support to individual HEIs by the MA in order to ensure high-quality and relevant project proposals

Supporting factors

1. Synergies with projects supported from the ESF-funded OPs at the ERDF-supported HEIs
2. Complementarities with projects supported from other European, national or regional sources
3. Sufficient size of the population is interested in post-graduate education
4. Complementary actions taken by the supported HEIs to maximize expected outcomes (support of internationalisation and mobility, engagement into international R&D arena, improvements in teaching quality)
5. Infrastructure investments are part of wider regional development (innovation) strategy

Risks and threats

1. Instability of the implementation structure and staff turnover at the MA of OP Research and Development for Innovations
2. Setting of allowed place of project implementation for the first calls (i.e. Czech Republic without Prague)
3. Uncertainty about the interpretation of public procurement rules, long-lasting and complex processes of related to public tenders
4. Beneficiary universities do not have the necessary staff and resources to manage and oversee the new/modernized equipment and conduct practical activities.
5. Unfavourable demographic development undermining a decline in number of students

Source: Own elaboration based on primary and secondary data collected.

3.2.2. Contribution analysis of Infrastructure investments into research-related education

Verification of intended intervention implementation

The PI was designed under time pressure, and the details of the support were prepared "at last minute", and thus there was practically no time-space for any significant changes at the level of PI over the programming period.

However, a noted change was an additionally negotiated exception for the **eligibility of HEIs from Prague** coming into force in September 2013. At least to some extent, this funding opportunity saturated the fact that in the OP's preparatory phase, planned investment funding for Prague HEIs from the state budget as compensation of non-eligibility for the ERDF support was not eventually realized.

The positive **spillover effects** of support for Prague`s HEIs for the convergence regions were anticipated to be realized through the number of university graduates who would bring benefits to these regions and also in the form of innovative technology and knowledge transfers that Prague-based universities implement in the cooperation with companies from the convergence regions. Graduates of Prague universities would have also been suitable candidates for work in scientific research centres, implemented with the different OP's priority axes' support. These centres were bound by the condition of employing at least 50% of new researchers. It was assumed that a significant part of these employees would have been found among graduates of Prague universities. The impact of implemented Prague projects on convergence regions was calculated[24] and set at 68% of the eligible project expenditures, of which 85% was from the ERDF and 15% from the national public resources. The remaining part of the project budget was covered by the national investment programme funding called ISPROFIN[25].

The shift of part of the ERDF funds from convergence regions to Prague was more or less well accepted by all stakeholders, especially because regional universities were saturated enough by the other ERDF sources.

Furthermore, the possibility to purchase equipment and instruments was enlarged during the period; in the first two calls, this activity was allowed only as additional. In addition, these activities were also enabled within the rules for the exploitation of savings in projects; however, issued with a delay that undermined in some cases a lower efficiency of used funds.

The PI support was based on **a mix of top-down** (the set requirements on research excellence and quality, necessary to prove research track record of particular HEI) **and of bottom-up approach** (concrete projects thought up from the "terrain").

Changes in projects took place quite often; however, they were related to the nature of projects – that of re/construction of real estate – which always brings about the necessity to adjust the project to actual circumstances (e.g. changes in the schedule of construction works or used construction materials). Furthermore, as will be discussed further below, most projects experienced savings, and new utilization of these was a subject of projects changes, too.

The overall implementation struggled with the instability of rules for public tendering (see more details below).

[24] The level of ERDF support was calculated based on a weighted average of the number of graduates (as of 31.12.2012) who came to study at public HEIs in Prague from the convergence regions. The weight was the total number of students of individual universities.

[25] ISPROFIN= information system of programming financing used to fund national investment projects requiring more than one year of funding and ensuring sources across the different fiscal years. Later on, the name was changed for EDS/SMVS.

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

The policy instrument covered **62 supported projects counting for EUR 375.7 million of ERDF contribution**[26] and the total project costs for EUR 442 million. The average duration of project was 3.5 years; however, for the last call targeting HEIs in Prague, the time for complete preparation and realization was short (2 years). At the beginning of the implementation, there were rather limited capacity and experience of beneficiaries in dealing with such large investment projects. The projects were of a significant financial scale in most cases; the median value of project was EUR 3 million of ERDF contribution, ten projects disposed with the ERDF budgets over EUR 10 million.

Table 3. Financial scale of RTD projects funded under the policy instrument

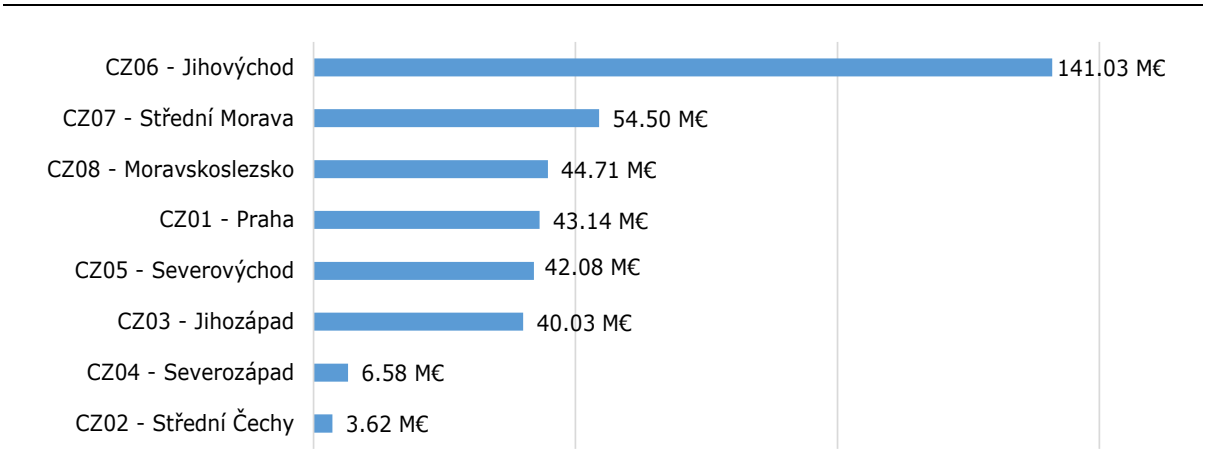
Total ERDF contribution	Min ERDF contribution	Max ERDF contribution	Average ERDF contribution
375,695,182 €	448,474 €	33,065,604 €	6,059,600 €

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

The ERDF funds **concentrated in convergence regions,** especially in the Jihovýchod region, with 37.5% of PI's funds. Ten institutions with the highest concentration of funds accumulated 78% ERDF budget for this PI (out of which three institutions from the Jihovýchod region gained 29% of ERDF sources), and it can be claimed that a certain level of concentration was achieved.

As anticipated by the MA, most ERDF contribution was used for projects in engineering and technology sectors, natural sciences and medical and health sciences (in total, 63.6%). Also, 27% of projects ERDF contribution was invested in multi-disciplinary projects in which the previously listed sectors dominated. All projects were implemented in public higher education institutions, apart from two projects implemented by the Ministry of Defence in training centres.

Regional concentration of RTD investments in the context of policy instrument 1 based on project location



Source: CSIL elaboration based on Task 1 DB Projects and Beneficiaries.
Note: Data are retrieved from the location of the projects receiving ERDF financing.

The expected outputs in terms of supported projects were substantially **exceeded** for this PI; the same pays for the output "area capacity designated to R&D teaching and

[26] For the purpose of in-depth analysis of this PI, beneficiaries of six projects from the different universities across the various regions of the country were interviewed. In total, the interviewed projects represent almost 25% of the ERDF contribution for this policy instrument.

activities" that was renovated or newly built (see Table 4). In some cases, projects funded a completely new building for a faculty whose capacities were scattered across the city or did not dispose of sufficient capacities (e.g. at universities in Brno, Ostrava, Liberec, Ústí nad Labem). All interviewees agreed that the **policy instrument enabled to upgrade research-related education infrastructure** and **to shift,** especially regional **public HEIs to a new qualitative level** (see also, e.g. Růžička, Voráček 2019). Similarly, substantial improvements in research-related teaching and research conditions were reached: supported projects purchased needed equipment and created a comfortable and respectable environment for teaching and studying related to research. These achievements were confirmed by all interviewees with knowledge of this PI. Rather than massively newly created capacities, the PI contributed to eliminating handicaps in the insufficient environment at selected HEIs. In many cases, old and inconvenient faculties were substituted by newly established infrastructure. Information from interviews also suggests that modernized infrastructure strengthened "the third role" of universities in some cases.

The main goal of the PI at the level of immediate outcomes was to **increase the capacity of tertiary education** infrastructure related to research. The goal was **fulfilled** to a full extent at the PI level; the monitoring indicators covering (PhD) students benefiting from the new/reconstructed infrastructure were exceeded more than twice (see Table 4). The reason behind this is attributable to a sufficient number of high-quality projects prepared for realization and the high budget for the PI (including considerable savings in construction parts of projects used for further improvements at particular HEIs) (Ministry of Education, Youth and Sports 2017). However, for some projects, meeting monitoring indicators related to (PhD) students benefiting from supported infrastructure was challenging because the original commitments did not reflect sufficiently (i) the anticipated negative demographic decline in the number of students and (ii) changes in students' interests in particular study fields. Consequently, the target values of selected projects, which provided adequate argumentation, had to be lowered. This was the case of about a half number of projects not achieving the initial targets (see Table 5). It is important to highlight that for half of the projects that did not achieve the targets, the difference between achieved and targeted values were only marginal. On the other hand, projects with achieved targets exceeded them in most cases significantly.

Table 4. Overview of relevant monitoring indicators at the level of policy instrument 1

Type	Monitoring indicator	Unit	Initial value	Target value (1st version of OP)	Target value (last version of OP)	Achieved value (as of 2017)
Output	Supported projects – R&D teaching-related infrastructure	number	0	20	20	62
	Reconstructed, expanded and newly built capacity	m^2	0	70,000	270,000	419,099
Outcome	Students benefiting from new/reconstructed infrastructure	number	0	50,000	100,000	213,481
Outcome	PhD students benefiting from new/reconstructed infrastructure	number	0	5,000	8,000	21,044

Source: MEYS (2017).
Note: The total number of realized projects in PA 4 was 65, but three projects were not included in the PI analysis.

Table 5. Projects funded by the policy instrument 1 by indicator and level of achievement

Indicator		Achieved	Not achieved	Total number of projects
Capacity of reconstructed, extended and newly built infrastructures (in m^2)		82%	18%	55
	Capacity of newly built infrastructures (in m^2)	95%	5%	19
	Capacity of expanded or renovated infrastructures (in m^2)	78%	23%	40
Number of students benefiting from new/reconstructed infrastructure		48%	52%	62
	Number of students benefiting from new/reconstructed infrastructure (doctoral candidates)	48%	52%	62

Source: CSIL elaboration based on monitoring data provided by the MA.

In quantitative terms, the intermediate **outcome of the increased number of post-level graduates** at supported universities was not fully met according to the respective monitoring indicator. The target was 1,700 PhD graduates, while the achieved value in 2017 was 1,387. All consulted interviewees agreed that apart from demographic development, the more fundamental reason for not reaching this outcome has been a low rate of PhD study completion[27] undermined by constantly unfavourable systemic conditions for doctoral study in the Czech Republic[28] and the opportunities to study abroad. Besides, the other newly R&D infrastructure created with the help of the OP RDI (in the PA1 and PA2) could have even more attracted potential talented PhD students (EACE 2018). On the other hand, the interviewees highlighted that without the infrastructural investments at HEIs, a decrease in PhD graduates would have been even more profound (see also EACE 2018). Unfortunately, the severe lack of adequately qualified human resources for RDI still has persisted (Ernst&Young 2020). Consequently, the expected final outcome has not been achieved, but the **PI has contributed to maintaining at least a certain level of PhD graduates**.

The qualitative data from interviewees confirmed that the ERDF investments, to the **full extent,** contributed to the **increased attractiveness of supported** (predominantly regional) **HEIs**. New infrastructure, modern equipment, and top-class instruments were the necessary conditions for attracting students, top lecturers, and researchers, both from abroad and other Czechia territories.[29] Afterwards, more natural contacts among academicians have been developed, and international/interdisciplinary cooperation could have emerged. For example, thanks to the numerous OPs investments (not only from this PI), the City of Brno became an antipole to the capital of Prague in terms of opportunities to gain high-quality tertiary education, especially in certain fields. Furthermore, the PI's investments helped transform the facelifts of HEIs dramatically in some regional university cities with positive effects spread to the local community (e.g. further upgrade of the physical environment of particular city parts).

[27] The rate of PhD study accomplishment rank between 43%-47% in 2010-2016 (Ernst&Young 2020).

[28] For example, non-competitive financial conditions, persisting rigidity of academic sector, poor prospects in academic career, desire of students to work on issues with practical application, systemic barriers in contractual research with applied sector as regards to State Aid rules.

[29] For example, in the South Moravian region, the share of international students increased since 2007 from 8,5% up to 20,4% in 2016. The share of domestic students with permanent place of living outside the South Moravian region studying at the three biggest universities in the region reached over 56% in 2016 that was one of the highest figures among the Czech universities (see Technology Centre of Czech Academy of Science at al 2018).

All qualitative evidence direct to a confirmation that improved infrastructure impacted "**quality of life at supported universities**". Implicitly, to a certain extent, the infrastructure investments might have positively influenced the mobility of students and researchers, the production of R&D results, the cooperation in prestigious research projects etc. However, these chaining effects can be only confirmed though anecdotal evidence or partial qualitative statements from interviews.

Similarly, the outcome of **increased quality of tertiary education and improved graduates' skillsets** can also be confirmed by only anecdotal evidence from the conducted interviews. All interviewed representatives of beneficiaries confirmed that that modernized infrastructure to the full extent enabled to increase the quality of education (e.g. increased capacity and improved instrumental equipment is widely used in practical training, students can work with high-quality equipment that is used in companies and eventually they are better prepared for the needs of the labour market, mostly PhD students are more involved in the realization of research projects). Other interviewees provided positive examples where the evaluated investment projects contributed to these qualitative change. Some interviewees also confirmed that students' final thesis's quality had been significantly increased thanks to the new equipment, and interesting research topics with practical relevance have occurred. Nevertheless, no systemic analysis of the state-of-art of graduates' competencies is at disposal for the supported HEIs.

The achievement of final outcomes thanks to the PI can be confirmed to only a limited extent as the number of interviewed beneficiaries and experts were scanty to deliver firm evidence, and relevant data-based analyses are not at disposal. Nevertheless, all beneficiaries stated the ERDF investments from this PI had brought technological upgrade that **created the competitive conditions** for the Czech HEIs **in the international R&D arena and the space for cooperation with the private sector**. For example, one of the supported interviewed universities indicated that modernized up-to-date equipment had deepened cooperation with the chemistry and technology companies through, e.g. (i) regular conferences at which graduates present their research to representatives of the application sector or (ii) excursions at new laboratories for alumni (usually employed in application sectors) and practical training fellowships. Moreover, this university is an excellent example of producing spillover effects from Prague as most cooperating companies are based in the convergence regions. Another supported HEI confirmed to increase its attractiveness and competitiveness for international research partners and programmes. The growth of projects receiving the Horizon2020 funding and other prestigious grant schemes was noted there. In conjunction with the other ERDF investments in the region, the supported faculty has reached a profound change of its climate and even a global effect for innovative research. Also, smaller beneficiaries verified that infrastructural projects undermined the chaining effects resulting in their increased involvement in R&D projects, however, rather of a national scale. However, this is in line with the PI's intention as infrastructure for excellent research was channelled through the different priority axes.

On the other hand, the final outcome, "Improvements in internal management of public HEIs (incl. third role of universities)", was confirmed at all interviewed supported universities. The most frequently mentioned elements of this outcome on the beneficiary side were:

- Development managerial, organizational and communication processes within the supported organizations and changes in process management of public tenders;
- Establishment/enlargement of professional project management teams at faculty/university levels;
- Acquirement of know-how of project thinking, know-how to prepare, realize and successfully accomplish large investment projects;
- Development of a strategic approach to prioritization of investment intentions at HEIs (e.g. via passportization of investment needs);
- Increased thinking about the energetic demands of university real estate at supported HEIs.

The implicitly awaited effect of influencing the management of public HEIs that was addressed through the calls' settings and "the Theses for support targeting" was at least partially met at the interviewed universities.

No contribution claim can be provided for the PI's impact on the development of a knowledge-based economy because this long-term effect has not been achieved yet.

As concerns **positive unintended effects,** with the evolution of specialised project teams at universities, these teams' informal platform was created to share experience and cooperate. Gradually, this platform ensured communication towards the MA of joint statements of supported HEIs. Interestingly, the platform has also been operating in the 2014-2020 period.

At a systemic level, the PI contributed to a changed approach at the MEYS to prioritise HEIs' investment intentions. Eventually, the systemic passportization of the HEIs' investment needs became an integral part of ministerial planning. Moreover, cooperation at the MEYS between the section of national investments and the section of European funds investments has been improved.

On the contrary, systemic recognized **unintended negative effect** was a slow down of development at Prague's HEIs and, in contrast, dynamic development of regional HEIs (see also EACE 2018). This situation negatively affected the national higher education system and the R&D system and had unpleasant consequences for R&D terrain (e.g. pull over R&D human capacities from Prague to regional facilities, uneven competition for talents). Further, Prague's organizations did not gain practically any experience with the engagement into the EU Structural funds support in comparison to the regional HEIs and thus, they were disadvantaged in the next period 2014-2020 in the national competition for EU sources as regional HEIs had their capacities to prepare and oversee such projects already fully established.

Verification of assumed pre-conditions

The most of pre-conditions were confirmed as materialized, namely "proper prioritization of investment needs of universities" (pre-condition 1) and "well-established framework rules for allocation of support to individual HEIs by the MA to ensure high-quality project proposals" (pre-condition 7). Thanks to these pre-conditions explicitly taking place via the setting of rules for PI's implementation (cf. Section 3.1), the PI did not suffer from low absorption capacity or low-quality projects. The applicants/beneficiaries either have had sufficient capacities or have them established to ensure the preparation and implementation of supported projects (pre-conditions 2). The supported HEIs were keen to successfully realized investments; they experienced a learning process, adjusted their procedures and flexibly responded to actual projects' needs. The materialization of this pre-condition was crucial for the successful accomplishment of the projects. Similarly, according to the interviewed stakeholders, the funded infrastructure/equipment in this PI is widely used/shared (pre-condition 6).

The most critical issue represented **the rules for public tendering and its interpretation** (pre-condition 3). The relevant national act was modified during the programming period twice, and beneficiaries were challenged to the instability of interpretation of adjusted rules from the side of the MA. This fact undermined the effectiveness of project management processes and the uncertainty and frustration of beneficiaries. The reason for that is reckoned to the low expert capacity at the MA side during the OP's implementation phase (also found by RegioPartner 2011). Even more, the rules for public tendering proved to be hardly applicable when unique instrumental equipment (e.g. produced only by one company in the world) was intended to purchase. To set the requirements and parameters for such particular tenders to be under the Act on Public Tendering was extremely demanding, requiring expert consultations and intensive communications with potential suppliers in all phases of tenders. In many cases, the challenges in realising public tenders prolonged the overall realization of projects; however, all of them were eventually finalized within the eligible period (Annual Implementation Report of the OP RDI 2014). All the interviewed representatives of

supported HEIs highlighted that pre-condition no 3 related to the rules' stability was not materialized.

Due to the political instability and high staff turnover (see details below in risks), the expert capacity at the MA of OP RDI (pre-condition no 5) was limited during the implementation, based on information obtained from the beneficiaries at top managerial positions. Furthermore, the project administration load posed by the MA on beneficiaries was perceived as inappropriate.

Verification of supporting factors

All identified supporting factors were confirmed as playing a role for the policy instrument. Moreover, several additional supporting factors that positively influenced the policy instruments were identified during the fieldwork.

Synergies with projects supported by the ESF-funded OPs (supporting factor no 1 in the ToC) were confirmed to a **full extent**. All interviewed organisations implemented simultaneously with the ERDF project also an ESF-funded intervention, the most often aimed at adapting doctoral study programmes. This finding was also proved by the evaluation of synergies of the OP RDI (Hope Group 2015), stating that the most synergic links were operationalised between this policy instrument and the policy measure "Higher education" under the OP EC (ESF-funded). However, this supporting factor occurred to be more vital in the following programming period when infrastructure projects were finished, and more effort could have been devoted to "soft" projects.

Similarly, **complementarities** with projects funded through the other sources (supporting factor no 2 in the ToC) was demonstrated at interviewed HEIs to a **full extent**. At some interviewed HEIs, regional research centres financed from the Priority Axis 2 of the OP RDI (at some HEIs even research centre of excellence by the Priority Axis 1) were established, and the evaluated infrastructure has been proved as a necessary component to educate the needed human resources for the new research facilities. Furthermore, a range of supported HEIs invested their resources to acquire additional instrumental and other equipment; in some cases, local authorities funded needed a complementary transport infrastructure to the new tertiary facilities (e.g. in Brno). Moreover, the policy instrument was complementary to the national programme financing of HEIs development (so-called ISPROFIN). In the 2014-2020 programming period, all interviewed HEIs implemented projects supported by both the ERDF and the ESF to complement the initial infrastructure investments by further components for their R&D activities and tertiary education (e.g. purchase of top instruments, support of internationalisation, mobility programmes to attract researchers with an international reputation to establish research teams). Nevertheless, the interviewees' findings suggest that both the complementarities and the synergies with projects from alternative fund sources were successful, particularly at larger more-experienced universities.

As discussed above, the anticipated supporting factor of sufficient demand for post-graduate education (supporting factor no 3) did not take place that negatively affected the expected results.

The supporting factor no 4 "Complementary actions taken by the supported HEIs" shown to be present in particular at larger well-established supported HEIs, and actions have included the internal grant programmes for PhD students, the cross-faculties cooperation, the increased support of international mobility or the enhanced support of cooperation with firms on students' final theses. On the other hand, at smaller regional supported universities, the investigated projects represented rather the initial key step of materialization of the new faculty and complementary actions had been belated.

The interconnection of investments with a regional development strategy (supporting factor no 5) and dedicated regional/local stakeholders proved to be a vital supporting factor that enabled multiplying the effects of invested sources not only within the investigated projects under this evaluation. Namely, the South Moravian region is highlighted to be the best example of doing so as the first region disposing of a coherent

regional innovation strategy in that time in the Czech Republic (confirmed by all relevant interviewees). For example, the three greatest universities in the region coordinated the preparation of project proposals (not only within this PI) to eliminate overlaps in the development of thematically similar oriented faculties and to jointly work on the development of regional innovation system (for more, please see Technology Centre of Czech Academy of Science et al. 2018).

As a factor that positively influenced the PI (and the entire OP), a highly qualified team at MA that led and finalized the OP's design process was stressed by the interviewees, although the further implementation was to a large extent cumbersome and affected by staff fluctuation and the low capacity of MA, thanks to **the thoughtful setting of the OP RDI within the given EU conditions**, the OP is perceived to be successful. Further, the then low demand at the construction market undermined the **tenders' considerable saving**s for the building parts of projects. Although the rules for the exploitation of savings endorsed by the MA were delayed, savings enabled the purchase of additional equipment for some projects. Moreover, the interviewed project managers of supported HEIs stated as an important factor **a supporting dedication of HEIs management** (see also the analysis of RegioPartner 2011).

Verification of risks and threats

The risks of **political instability and high staff turnover at the MA** (risk no 1) and **the uncertainty of interpretation of public procurements rules** (risk no 2) unfortunately materialised to a **full extent** (see also RegioPartner 2011) and negatively influenced the implementation of projects. The beneficiaries had to comply with enormous administrative load and burdens related to public tenders and the application of the relevant legislation. The application of rules for public tendering caused substantial delays in the majority of realized projects. Moreover, legislative changes in the associated act within the programming period implied that all construction-sites were practically stopped in 2013 for one year due to the different interpretation of rules related to "extra-works", almost always present in construction investments. Altogether, these burdens created an unfavourable environment between the MA and beneficiaries for a certain time and complicated the realization of projects.

Apart from one interviewee, all interviewees stressed that the ineligibility of Prague was a major challenge (risk 2) (see also EACE 2018) as **the targeting did not fully reflect the regional differentiation in the distribution of tertiary education capacities** (and in the RDI potential) in the Czech Republic. The negative impact on achieved effects has been materialized, particularly in the negative consequences for the entire R&D system and structure in the Czech Republic (e.g. formation of dualism between Prague and regions in the R&D area) (also confirmed in the evaluation of EACE 2018).

The threat of decline in the number of students due to the demographic development (risk no 5) materialized and to a larger extent than expected by the MA and beneficiaries. In addition, the other systemic issues related to the overall approach to doctoral study in the Czech Republic played a very important role (see the previous section). The interviewed supported universities did not confirm a lack of staff and resources capacities to oversee the new/modernized equipment (risks no 4).

The relevant interviewees agreed that a risky factor influencing strategic decisions on infrastructure investments from the entire OP was a double-track in decision-making within the responsible MEYS: first, there has been the management of national R&D policy and second, the management of EU Structural funds, and **the coordination** between these managerial segments was **dysfunctional** in the investigated programming period.

An external factor of the changed **system of HEIs financing** influenced the approach of HEIs to their development. Until 2010 the system was based predominantly on the number of students; hence, the beneficiaries committed to the increasing number of students with the supported infrastructure's help. However, the systemic change in funding and strategy of HEIs' development coming into force in 2011 undermined that

R&D results were more important in the coming years in the financing system. The pressure on the increase of student numbers was diminished. Consequently, the reality of projects was different, and the HEIs could not have mirrored the changed rules.

Finally, the Czech National Bank's currency intervention in 2013 at financial markets caused an increase of disposable funds in the OP due to the changed exchange rate EUR/CZK, and the MA had to solve the usage of additional resources quickly.

3.2.3. General assessment of the policy instrument

Overall, the ToC for the research-related infrastructure for HEIs was largely confirmed. The PI achieved its outputs and immediate outcomes, and in these cases, the PI was the main cause behind their materialization. Besides, some of the intermediate outcomes were achieved thanks to the PI and simultaneously thanks to a contribution of materialization of some supporting factors and pre-conditions. On the contrary, one of the desired intermediate outcomes was achieved only to a limited extent as some risks prevailed to play a more important role. The outcomes and impacts could not have been undoubtedly confirmed, as it was possible to collect only anecdotal evidence.

There is a wide consensus and evidence that **the policy instrument succeeded in fulfilling its prime intention** to eliminate the abysmal difference in the quantity and, in particular, quality of infrastructure for research-related education as compared to the standards of developed countries. In total, the policy instrument included 62 investment projects (more than three times more than anticipated) predominantly in the convergence regions with an amount of EUR 375.7 million. In combination with a range of complementary actions, the policy instrument made possible **the technological upgrade of higher education institutions** up to European and international standards. For some regional institutions, the support implied increased competitiveness within Czechia only. The majority of supported institutions acquired the high-standard new or upgraded capacities for research-related education and top-class research equipment; thus, the expected outputs were achieved to a full extent. There is no doubt that the intended outcome of the increased tertiary education capacity and the significant improvement of conditions for research-related teaching and research itself was achieved through the supported HEIs. Overall, "quality of life" at supported universities was increased. It is believed that jointly with other policy instruments and actions, the quality of tertiary education was improved at least to a significant extent alongside graduates' enhanced skillsets. The intended outcome of the **increased number of PhD graduates**, however, has **not** been **achieved**. Nevertheless, **the reasons for that lie beyond the scope of PI** (demographic decline, framework and conditions for PhD study in Czechia, the interest of young people in research career), and the qualitative evidence suggests that the PI contributed at least to some extent to maintain a certain level of post-graduate students.

The intervention's contribution to the long-term effect of increased quantity and quality human resource for R&D is less evident as **Czechia still crucially lacks sufficient human capital for research and innovation**. Nevertheless, collected evidence suggests that the instrument contributed to mitigating the decline of R&D human resources. Concerning the final outcomes, **only limited anecdotal evidence** on the contribution of PI to these was possible to collect, even though the infrastructure investments are considered the necessary prerequisites for the involvement of HEIs in the international RDI arena and the cooperation between universities and the application sector.

Although some statements from the interviewees indicated a partial materialization of anticipated **spillover effects** from the supported Prague's HEIs, this effect cannot be firmly confirmed within this evaluation's scope, and a self-contained study would be necessary to prove these.

The **PI's key limitation was** that **Prague's HEIs were not eligible for the support** being from a competitiveness region. However, Prague's HEIs was in a unique position in the tertiary education system/R&D structure of Czechia. The HEIs in Prague suffered

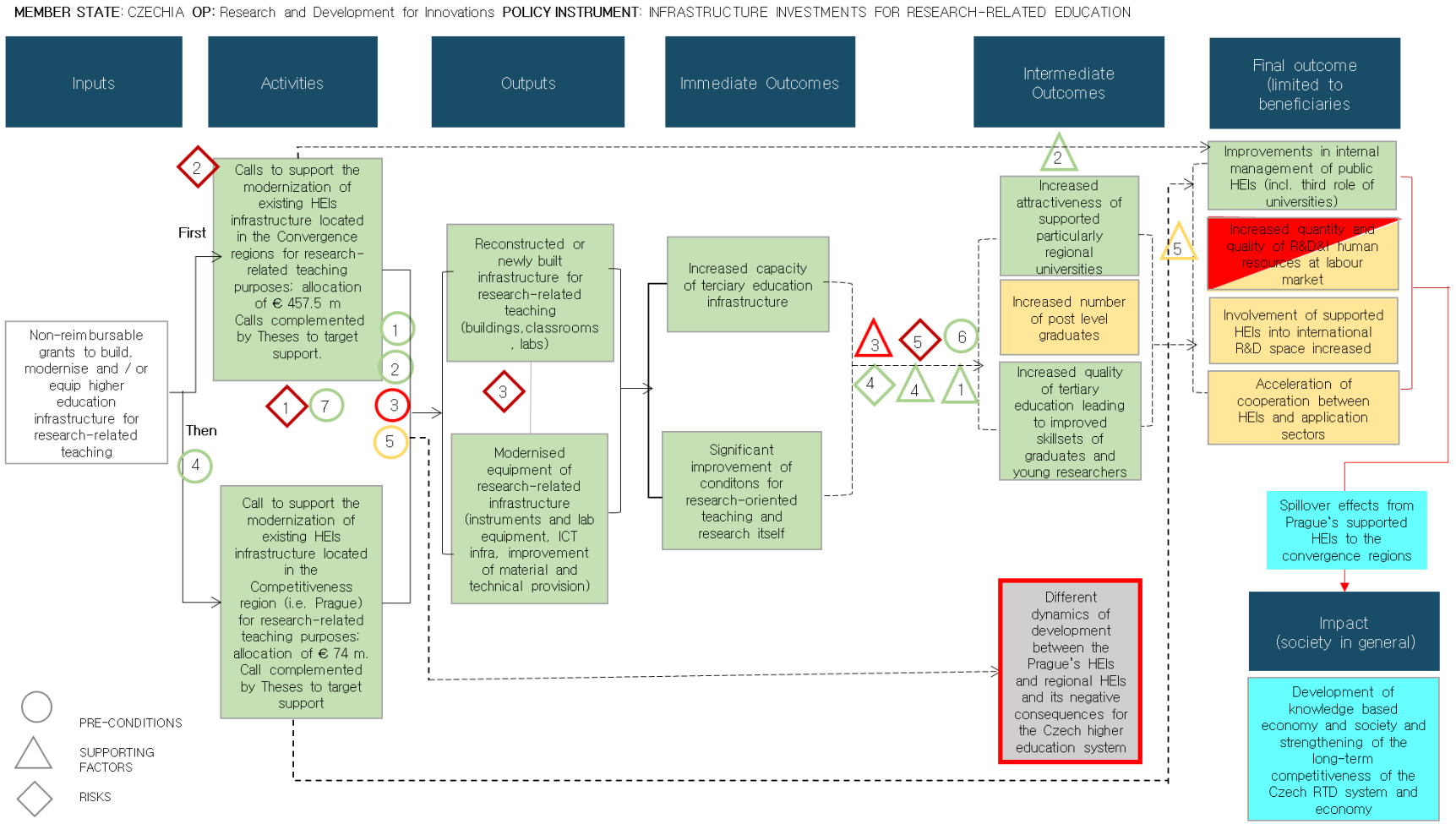
from severe infrastructural problems and institutions from lagging regions. Although at the end of the programming period, an exception for support in Prague was negotiated with the European Commission, the initial regional setting of support limited the instrument's potential to generate positive **impacts** and, on the contrary, brought about a series of negative systemic consequences. While the RDI capacities of HEIs located in lagging regions were dynamically developing, Prague's capacity and infrastructural deficit persisted in the absence of national funds compensating for the missed ERDF investments.

While the **focus on the territorial cohesion objective** of convergence regions may have undermined the PI's potential (and the OP as a whole) to support excellence in science, it, however, contributed to reducing the gap in Czech regions' scientific capacities.

It was confirmed that without the ERDF support, the evaluated investments into HEIs would have never been realized in this scale and time-space. A minimum of these investment projects and within much longer time period would have been supported from the national sources. Therefore, **the role of ERDF was irreplaceable**. The level of funding allocated to the PI was sufficient to "move the needle" regarding the key challenges faced by the HEIs. The nature and setting of PI "helped" in particular to high-ranked HEIs with the prepared investment project intentions. There was practically no further space for prospective ERDF sources for efficient spending unless Prague's HEIs could have been engaged in the support.

The policy instrument's main logic did not undergo any important changes apart from the above-outlined enlargement of eligible regions. Experienced changes related particularly to the associated legislation (the Act on Public Procurement) and methodological instructions, and they had to be dealt with in practice mainly by beneficiaries. However, **the instability of rules and their interpretation** brought inefficiency in the implementation and even distrust among beneficiaries and the MA. Moreover, the political instability and high staff turnover at the MA over the period negatively affected the implementation of PI.

The **sustainability** of invested infrastructure within the PI throughout compulsory sustainability was ensured with the internal sources of supported HEIs. However, questions arise as concerns the sustainability of acquired technological competitiveness and thus related to the needed sources for a gradual upgrade of the purchased equipment. The HEIs would not be able to cover all sources required for modernization.



Source: Own elaboration based on primary and secondary data collected.

3.3. Policy Instrument: ICT Infrastructure Investments under the Operational Programme Research and Development for Innovations

3.3.1. Theory of the policy instrument

The policy instrument ICT Infrastructure Investments was supported within the Priority Axis 3 Commercialization and popularization of R&D, measure 3.2 Promotion and awareness of R&D results. The overall aim was to create or improve conditions for producing quality scientific research results from the two points of view: 1) information infrastructure and 2) electronic information resources. Both these pathways were supposed to shift existing conditions for R&D to higher standards available for Czech researchers and thus create an environment for more effective R&D and better applicability of Czech science in the world (for a more detailed anticipated causal mechanism, please see the Theory of Change, figure 15).

Following these logical pathways, the ICT infrastructure investments were supported by two calls for projects. The call for projects for information infrastructure for R&D (No 2.3) was intended mainly to address information infrastructure for R&D, investments in material and technical ensuring, and software (hereinafter SW) and licenses, databases, etc. It was open between December 2009 and April 2010 with an allocation of EUR 29.6 million. Call for projects (No 4.3) to fund equipment of professional scientific and branch libraries was intended to address mainly acquisition of electronic information resources, licenses, renewal of HW, SW and networks, equipment of libraries and study rooms (furniture, security systems, special technologies), minor reconstructions and other related activities. It was open between August 2011 and January 2012 with an allocation of EUR 25.9 million. Only convergence regions were eligible in both cases.

Both calls for projects were underpinned by so-called theses, i.e. starting points for the respective topic, defining basic ideas, assumptions and conditions for the prospective support. The majority of these factors concern the implementation phases, i.e. the sphere of control of the Theory of Change (ToC), as the theses co-designed the environment for calls for projects and launching activities. Supporting effects and risks are presumed to be in the causal relationship between activities and outputs. This points to the realization phases of projects. Other factors were grouped around the sustainability topic. The call for projects No 4.3 assumed that "availability of scientific information sources is a basic prerequisite for the production of quality results by R&D institutions". […] It is also supposed that "failure to ensure or limit availability has a negative impact on Czech science and its involvement in European, or world research area and application sphere"[30]. The call for projects No 2.3 assumed that the research and development community is increasingly dependent on the ability to process and transfer large volumes of electronic data quickly. Appropriate infrastructure for R&D and its optimal functionality are necessary conditions for conducting research and development with significant results for developing human knowledge, for industrial innovation and economic development, for society's overall development[31].

Several preconditions were identified, common for the whole policy instrument. In general, these preconditions can be grouped into the following categories – managerial preconditions (e.g. absorption capacity, necessary resources and capacities in general at the side of the applicants, partners and the managing authority as well), thematic and technological preconditions (e.g. technology readiness and use of infrastructure), and context preconditions (i.e. stability of rules).

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[30] MŠMT (undated): Teze výzvy 4.3 – Vybavení odborných vědeckých a oborových knihoven, p. 1, https://www.opvavpi.cz/cs/siroka-verejnost/prehled-ukoncenych-vyzev/vyzvy-v-ramci-prioritni-osy-3/vyzva-cislo-4-3-vybaveni-odbornych-vedeckych-a-oborovych-knihoven-po-3-op-vavpi.html (accessed 20 October 2020).

[31] MŠMT (undated): Teze výzvy 2.3 – Vybavení odborných vědeckých a oborových knihoven, p. 1, https://www.opvavpi.cz/cs/siroka-verejnost/prehled-ukoncenych-vyzev/vyzvy-v-ramci-prioritni-osy-3/vyzva-cislo-2-3-informacni-infrastruktury-pro-vav-po-3-op-vavpi.html (accessed 20 October 2020).

Call for projects No 2.3 reflected insufficient capacity of information infrastructure from the point of view of the needs at that time and the expected increase of demand of newly established R&D capacities of Priority Axis 1 and 2. In this perspective, the call for proposals was thus complementary to these interventions. The call also reflected the limited possibility to join international computer networks, which influences international cooperation and integration to the European Research Area. According to the complex needs of the R&D institutions, the call for projects 4.3 focused on the insufficient availability of scientific information resources for a wider professional public. Even if some multidisciplinary databases used to be partially available and most disciplines used to have ensured basic key top-level information resources in general, especially regional R&D libraries operated in unsatisfactory conditions.

The eligibility of support was limited, especially to research organisations (Call for projects No 2.3), universities, public research institutions elaborating research and development, professional and scientific libraries (Call for projects No 4.3), exclusively in convergence regions.

The policy instrument's effects can be traced per each pathway (however, both pathways are mutually supporting). Both lines are interlinked at a more complex level (intermediate and final outcomes and impacts).

1) Information infrastructure

The first pathway focused on information infrastructure for R&D to strengthen and intensify the connection of a larger number of research and development organizations and their computing, storage and information capacities. Outputs of supported activities, i.e. new, modernized or developed repositories, optical network, network optical elements, storage capacities, SW, licenses or databases, should ensure higher storage, computational and information capacities of R&D institutions.

New systems were planned to be distributed and managed under a shared management that was considered more effective and rational. This should enable and require more intensive cooperation at the national level among R&D institutions and the international level in integrating the Czech R&D institutions into the European Research Area.

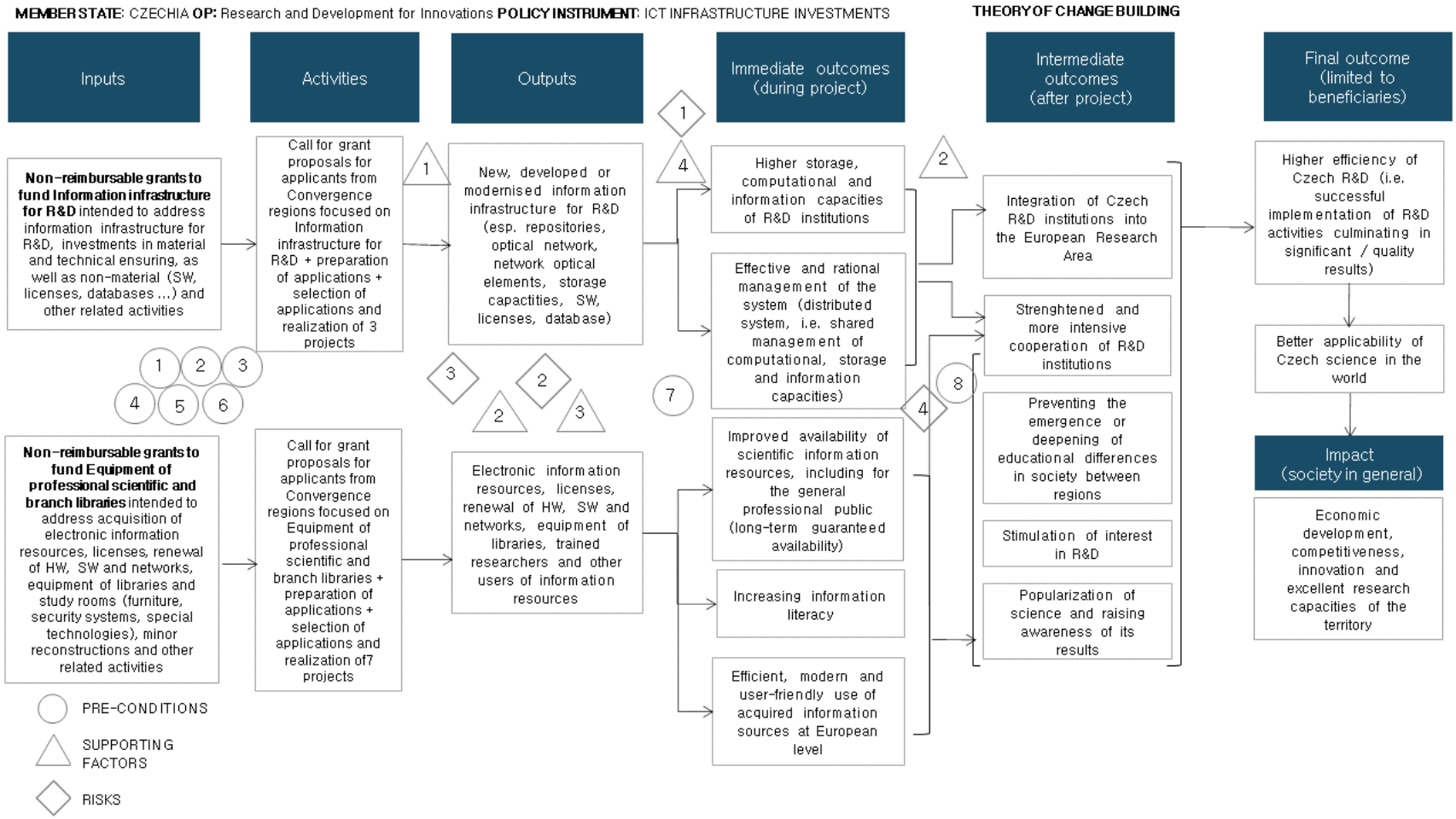
The planned measure was underpinned by the Roadmap for Large Research, Development and Innovation Infrastructures in the Czech Republic that has outlined Czech priorities and large infrastructure systems since 2010.

2) Electronic information resources

The second pathway concentrated on electronic information resources (hereinafter also EIR) for R&D institutions. The aim was to ensure these resources' availability, their effective use, and thus create conditions for producing quality scientific research results through investments in scientific information resources and related infrastructure. Among outputs, EIR or licenses are the most important; however, the support was also available to the renewal of HW, SW and networks, and marginally to libraries' equipment. These investments were accompanied by training for researchers and other users of information resources to be able to use new systems. Once all these outputs were installed and used, this should improve the availability of scientific information resources and create an efficient, modern and user-friendly R&D environment at the European level. The experience with new databases and discovery systems was expected to increase the information literacy of users.

Both pathways were intended to contribute to the strengthening of efficiency of Czech R&D (i.e. successful implementation of R&D activities culminating in significant / quality results) and to better applicability of the Czech science in the world. As the seat of majority of the Czech R&D institutions and universities, Prague was excluded might have been quite threatening. It would be difficult to imagine that Prague institutions would have worked with other (lower-level) systems than institutions from further (convergence) regions. Thus, the Czech Republic allocated national resources to support some complementary actions of ICT infrastructure to maximize the expected outcomes and logic interconnection of networks for the whole country.

The ICT infrastructure, as well as the EIR, require further investments to keep the attained level. It concerns new ICT technologies or the renewal of purchased licences. The interviewed beneficiaries seriously considered their financial capacity to sustain all outputs in the sustainability period before entering into projects.



Source: Own elaboration based on primary and secondary data collected.

PRE-CONDITIONS

1. Activities' design is based on best practice and good knowledge of needs, i.e. intervention is needed
2. Well estimated absorption capacity and well adjusted calls for proposals
3. Adequate technology readiness level
4. The applicants have the necessary resources and capacities in terms of organisation, management, human resources and infrastructure to carry out the project and foreseen activities (including ensured coordination of the procurement process)
5. Stability of the rules and requirements for providing support
6. Sufficient organizational, staff and expert capacity on the side of the Managing Authority to successfully administrate projects, stability of the implementation structure, smooths and timely procedures of funds distribution
7. The projects' partners have the necessary resources to ensure sustainability
8. Use of information infrastructure and information resources by wide range of users

Supporting factors

1. Existing strategy Roadmap for Large Research, Development and Innovation Infrastructures in the Czech Republic
2. Complementary actions of ICT infrastructure in Prague to maximize expected outcomes and logic interconnection of r
3. Public support for ICT infrastructure sustained over time
4. Increasing demand for ICT infrastructure

Risks and threats

1. Rapid technological, social, regulatory or economic changes may render some technological solutions irrelevant
2. Conditions of support excluding Prague institutions whích without complementary actions could have caused interconnection problems
3. Uncertainty, instability of the interpretation of rules, long-lasting and complex controls of tenders of public procurements process
4. Risks of unsustainability of projects' results

Source: Own elaboration based on primary and secondary data collected.

3.3.2. Contribution analysis of the policy instrument

Verification of intended intervention implementation

The logic of the policy instrument of the ICT Infrastructure Investments remained unchanged. It was supported by only two time-limited calls for projects, with the total allocated budget of EUR 55.5 m.

Within the call 2.3 Information Infrastructure for R&D, five projects were submitted in the total amount of EUR 40.8 million. Three out of five project applications for funding of EUR 31.7 million were supported. Under the call 4.3 Equipment of Specialized Research and Department Libraries, closed in 2012, 14 project applications were submitted. Ten projects were in the total amount of EUR 25 million[32].

Some beneficiaries described the whole appraisal process as very long. The length of the appraisal was determined not only by the process itself but also by capacity issues on the Managing Authority's side. In 2010, significant personal changes resulted in a new concept for the organisational structure of the OP RDI[33] that affected the call for proposal 2.3. Moreover, call 4.3 was affected by the concurrence of appraisal processes of two calls for proposals that placed high demands on project and financial managers[34].

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

The ICT Infrastructure Investments policy instrument covered one point of the indicative list of operations of measure 3.2. According to the Managing Authority, it was a relatively marginal part of the operational programme with a predominantly supporting character for the Priority Axes 1 and 2.

The allocated budget for projects selected for this policy instrument represents approximately 34% of the measure 3.2 Promotion and awareness of R&D results (part of Priority axis 3 Commercialization and popularization of R&D) budget. Given that allocation on this measure (the ERDF contribution) was EUR 127.6 million, the ERDF contribution for selected projects cut off only 2.3% of the OP budget. This perspective illustrates the possibility of assessing this policy instrument's effects at the OP level as these effects are rather incommensurable with other measures in financial terms and the potential use of monitoring indicators. The latter aspect is even more complicated because this policy instrument's projects are not uniform and grouped two distinctive categories of projects.

As it was already explained, this policy instrument's heterogeneity made us look at assessed projects as two logical pathways, separately according to calls for projects; however, a more complex level of the intervention logic is described together for both of them.

1) Information infrastructure

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[32] MŠMT (2013): Annual Report on the Operational Programme Research and Development for Innovations for 2012, 98 p., https://www.opvavpi.cz/cs/siroka-verejnost/zakladni-dokumenty-programu/vyrocni-zpravy-op-vavpi.html (accessed 24 October 2020).
MŠMT (2014): Annual Report on the Operational Programme Research and Development for Innovations for 2013, 117 p., https://www.opvavpi.cz/cs/siroka-verejnost/zakladni-dokumenty-programu/vyrocni-zpravy-op-vavpi.html (accessed 24 October 2020).
[33] MŠMT (2011) *Ibid.* (p. 35).
[34] MŠMT (2013): *Ibid* (p. 70).

At the level of measure 3.2 (see the following table for an overview of supported projects), two indicators were directly relevant for this group of projects and planned targets of both of them were exceeded. The number of supported projects - two projects were planned, three supported - and the number of entities using information infrastructure services for R&D – 65 entities were planned and 113 institutions achieved. These indicators, however, enable only a very limited view on the implementation of this group of projects.

Table 6. Breakdown of funded projects – Information infrastructure

Title of the project	Type of direct beneficiary	ERDF contribution (€)
Extension of the National R&D Information Infrastructure in Regions (eIGeR)	Consortium (science and/or industry)	17,501,077.41
CERIT Scientific Cloud	Higher education institution	4,249,516.21
VAVINET Information Infrastructure R & D centres	Higher education institution	2,295,912.76

Source: own elaboration based on Task 1 data.

Through the creation, development and modernization of information infrastructure for R&D, the overall aim of this call was to strengthen and intensify the connection of a larger number of R&D workplaces in the Czech Republic and research organizations and their computing, working and information capacities to contribute to their integration into the European Research Area[35]. The sum of more than EUR 24 million as the ERDF contribution for all three supported projects was directed at new, developed, or modernised ICT information infrastructure for R&D. This means supportive technical infrastructure for R&D institutions as repositories/storage capacities, optical network, network optical elements, SW, licenses or database. These outputs ensured a qualitative shift of existing or establishment of new services (storage capacities). The evidence gathered to support this claim is underpinned by existing reports, interviews with diverse stakeholders, and some indicators.

The Final report on the OP RDI summed up: "Through these projects, the backbone transmission network was strengthened, a cloud storage shared by R&D workers was created and high-quality computing capacity was created. […] the goal of the intervention, which was a significant strengthening of the information infrastructure for R&D in the Czech Republic, was met[36]".

Interviewees confirmed that these goals were met, too. The analysed project brought a profound shift in the quality of provided services, as capacities of the network had been insufficient, new demand for capacities from newly developed large infrastructure had been expected, and need for data storage was identified.

This supported project operated and developed the national e-infrastructure for science, research and education, which encompasses a computer network, computational grids, data storage and collaborative environment in a radical way. Thanks to it, the beneficiary could have offered a rich set of services to tens of connected organisations. That enabled a significant qualitative change in network area (important strengthening of the original capacity), an extension of the metacentre computing power, development of a network of data storages, strengthening the environment for cooperation, and web conferencing.

[35] https://www.opvavpi.cz/cs/siroka-verejnost/prehled-ukoncenych-vyzev/vyzvy-v-ramci-prioritni-osy-3/vyzva-cislo-2-3-informacni-infrastruktury-pro-vav-po-3-op-vavpi.html (accessed 20 October 2020)

[36] MŠMT (2017): Závěrečná zpráva o provádění operačního programu Výzkum a vývoj pro inovace, p. 146, https://www.opvavpi.cz/cs/siroka-verejnost/zakladni-dokumenty-programu/vyrocni-zpravy-op-vavpi.html (accessed 19 October 2020)

The needed capacity of developed solutions was estimated based on the actual situation, estimations of the needs of newly built large infrastructures, and ICT trends monitored by the beneficiaries. According to the interviewees, however, some aspects at the time could have seemed to be rather oversized, as some opponents criticized – e.g. data storage. Nevertheless, once implemented, estimations made showed to be adequate, and already during the sustainability period, some potential users had to be refused due to insufficient capacity. Data storage was a new service, not provided by the beneficiary until then.

Web conferencing was a new service stemming from the project, as well. Its importance is growing even now in the period of the Covid 19 pandemic. This service was originally developed on this project's platform; however, after the sustainability period, a technological shift was reported. According to the Fifth ongoing evaluation, this improved communication between workplaces[37].

Communication and cooperation of R&D institutions in the Czech Republic were also strengthened in general. The interviewees from the side of the project's beneficiaries confirmed more intensive cooperation, not really in terms of the number of institutions but rather from the perspective of demanded capacity. The newly developed large projects in the Czech Republic were integrated as a part of already existing institutions; they thus have not become new members.

The Newly developed infrastructure shifted the Czech system at the European level and opened a gateway to European cooperation. Although the interviewed beneficiary did not become a member of the European Research Area directly thanks to the project (it is rather attributable to another project, according to the analysed organisation's annual report), the analysed project, however, enabled fully-fledged cooperation. According to interviewees, the European community took a lively interest in results, and the project was presented among others at the GÉANT meeting. Important, but hardly measurable within this rather superficial sonde, is the quality of this cooperation. This brings a lot of benefits and opportunities for Czech organizations: from the representation of foreign researchers in advisory bodies, joint projects with international participation, cooperation agreements at the level of organizations, employment and posting of workers, potentially foreign suppliers, higher quality of publications realized based on international cooperation, focus on cooperation with industry as an international practice.

The relevant evaluations and interviews pointed out some unintended effects:

- Savings of electricity at universities - thanks to a high-quality connection and high computing and storage capacity, university employees began to use virtual desktops, which save up to 90% of electricity;[38]
- Effects on higher quality of organisations management, as the management was obliged to ensure administratively complicated projects.

2) Electronic information resources

This logical pathway had a supportive character for Czech R&D. Nine supported projects (see the following table) from the call for projects no 4.3 received the overall ERDF contribution of nearly EUR 20 million. Two indicators were relevant for this group of projects, and targets of both of them were exceeded. The number of supported projects of professional scientific and branch libraries - four projects were planned and ten supported; and the number of involved partners / cooperating organizations of professional scientific and branch libraries – 60 organisations were planned and 84 organisations achieved.

[37] MŠMT (2014) Průběžná evaluace OP VaVpI, 6 Hloubková analýza – Detailní zhodnocení výsledků, výstupů a dosavadních dopadů projektů realizovaných v rámci OP 3.2 a 4.1, 5. Průběžná zpráva
[38] MŠMT (2014) Průběžná evaluace, p. 8, *Ibid.*

Table 7. Breakdown of funded projects – Electronic information resources

Title of the project	Type of direct beneficiary	ERDF contribution (€)
Information sources for medicine and related fields	Higher education institution	3,367,240.57
Research Information Infrastructure for Technology	Higher education institution	1,755,831.23
MENDELU RESEARCH LIBRARY	Higher education institution	1,762,029.12
Natura: the scientific resources of natural sciences	Higher education institution	3,019,448.62
SCI-INFO: scientific information sources for the Czech Republic	Higher education institution	2,196,722.94
STMFull: full text databases for research and development	Higher education institution	1,702,002.60
RELICEO	Hospital (inc. university hospital) or treatment centre	644,883.96
Chemical electronic information sources for R&D	The University of Pardubice	3,670,005.55
Library of Agricultural Applied Research	Agrovýzkum Rapotín	1,551,801.57

Source: own elaboration based on Task 1 data.

The projects supported within this call for projects should ensure the availability of electronic information resources and their effective use and thus create conditions for producing quality scientific research results through investments in scientific information resources and related infrastructure[39]. All interviewees (reaction reported from four projects) confirmed that the ERDF support brought clear progress compared to the previous situation (before the OP RDI was implemented).

Electronic information resources, licences, SW for discovery system were predominant output (also in terms of share of projects' budgets). Renewal of HW and networks, equipment of libraries, trained researchers and other users of information resources completed effects at this level according to circumstances of a specific project. It does not mean that electronic information resources were completely unavailable until then, though the qualitative change was evident in all interviewed projects. The change concerned Science, Technology and Medicine area only; social sciences were not included.

The projects enabled the purchase of new electronic resources, crucial for research in the respective scientific area and filling missing fonds (e.g. older volumes of journals). Complemented by an effective discovery system, it provided efficient, modern and user-friendly use of acquired information sources. It was agreed by all interviews and also by available evaluations. Using new discovery systems (and necessary training as other activities of supported projects) increased partly also information literacy of users. Some interviewees noted that the training was in some cases rather over-sized, as the systems

[39] https://www.opvavpi.cz/cs/siroka-verejnost/prehled-ukoncenych-vyzev/vyzvy-v-ramci-prioritni-osy-3/vyzva-cislo-4-3-vybaveni-odbornych-vedeckych-a-oborovych-knihoven-po-3-op-vavpi.html (accessed 20 October 2020)

of using these resources are quite similar and general training should have been sufficient. All interviewees agreed on the improved availability of scientific information resources, including for the general professional public, in long-term guaranteed availability.

The projects were designed on a significant partnership basis. Because Prague universities were excluded from the measure, regional universities/libraries were obliged to take the place of respective Prague institutions, which up to that year ensured electronic databases for the whole country. According to professional orientation, some libraries (typically from bigger universities) agreed to take responsibility for certain topics and submitted projects covering relevant databases for themselves and other partner universities. Such a partnership covered even 21 partners (example from one specific project), partners together selected resources in a specific branch and ensured sustainability. Undoubtedly, libraries' cooperation was strengthened and intensified; however, it cannot be generalised for all R&D institutions, especially at the universities' level[40].

The quality shift of available resources in the supported regions was evident. However, without state intervention, which covered later Prague universities, not convergence but divergence would have happened. The area of R&D was seriously and long-term under-funded in the whole country, and the situation was the same in Prague and out of the capital. Neither universities nor other R&D institutions are established by the regional administration; they are part of a national system that deals with the issue of the whole country, dominantly convergence regions. National resources open for R&D institutions, including Prague, prevented regional disparities in the availability of electronic information sources. Because the dominant share of universities and other R&D institutions is settled in Prague, this could have endangered the overall quality of the Czech higher education system and the R&D structure.

Availability of necessary resources is a crucial precondition for contemporary science (however, not the only one). The interviewees were rather sceptical about the contribution of these projects on stimulation of interest in R&D or popularization of science and raising awareness of its results. Even if activities towards popularization of science are a common component of library mission, it was not an unambiguous effect of analysed projects.

The evaluations and the interviews pointed out an unintended effect related to a higher quality of management of organisations, as the management was obliged to ensure administratively complicated projects.

At the level of final outcomes, both pathways concur. Both of them had a supportive character and made an important precondition for research.

The interviewees from some beneficiaries were very optimistic about their project's positive effects on a more complex level. Their main argument was that most Czech research results had used the infrastructure of this project or its followers (however, in a diverse manner). There are approximately 450 thousand users, but it is impossible to assess the developed infrastructure's influence on each produced article or any other R&D results. Nevertheless, it can be confirmed that ICT infrastructure created appropriate conditions for R&D, at least in terms of technological parameters.

The same can be summed up as for electronic information resources. Again, high-quality electronic resources are a precondition for research as it keeps researches informed and

[40] MŠMT (2014): Průběžná evaluace OP VaVpI, 6 Hloubková analýza – Detailní zhodnocení výsledků, výstupů a dosavadních dopadů projektů realizovaných v rámci OP 3.2 a 4.1, 5. Průběžná zpráva

connected to the top scientists in the world. Without such resources, it is unimaginable to conduct science at all. An on-going evaluation also pointed out that electronic information resources, available directly in the user's computer, spare time that can be devoted to the research. Even if the interviewees were very careful concerning these projects' direct contribution, an on-going evaluation argues, based on the interviewees with some researchers that thanks to electronic resources, they can produce impacted articles more easily[41]. Another evaluation was though more cautious in such a claim when arguing: "The longer-term intended impact in the form of a higher number of published scientific articles in impact journals has not yet been demonstrated, but can be expected"[42].

Contemporary science does not operate on an individual basis, and the analysed policy instrument has supported connectivity among workplaces and scientific teams. This can contribute to strengthening the efficiency of Czech R&D and positive effects on applicability in the world, however not as self-standing intervention. Therefore, it could not have been confirmed that this policy instrument supported the development, competitiveness, innovation and excellent research capacities of the territory.

Verification of assumed pre-conditions

The interviews proved good knowledge of needs and trends that designed supported projects (pre-condition 1). All interviewees underlined it, but it should be highlighted that the policy instrument's objectives can be difficult to contradict, as electronic information resources and ICT infrastructure is, in reality, absolutely fundamental and without them, science cannot be conducted nowadays.

The projects brought a higher technological level for discovery systems in libraries; this new approach was supported by its users' training. Even in the case of ICT infrastructure, there was no doubt that the change was revolutionary. Again, again, the new technology readiness level (pre-condition 3) was adequate, as no problems in this sense were reported. The same is true concerning the absorption capacity (pre-condition 2). As regards libraries (beneficiaries as well as partners), demands for electronic resources could have been probably even more ambitious; nevertheless, the obligation to sustain purchased databases kept all beneficiaries in relatively feasible measures. All interviewees, the available internal documentation and some indicators confirmed that ICT infrastructure and information resources were used by a wide range of users (pre-condition 8).

The pre-conditions that were not fully verified concern the administration system on the side of applicants/beneficiaries (pre-condition 4) and the Managing Authority to administer and manage supported projects (pre-condition 6) successfully. There were no unresolved issues that would endanger any project, but on the side of beneficiaries, the administrative burden was unanimously considered very high. One beneficiary reported that the extreme burden was behind the premature retirement of a crucial library worker. Even if this is rather anecdotal evidence, also other beneficiaries described the excessive amount of documentation archived due to their projects. They considered this as incomparable with any other grant system. A part of identified problems was caused by high staff fluctuation at the Managing Authority. Another cause could be seen in the previous system when typically, Prague institutions used to ensure electronic information resources for its regional counterparts, however not from EU funds, and the EIR beneficiaries were thus inexperienced.

No issue was reported concerning the necessary resources to ensure sustainability for the partners' side (pre-condition 7). To the point "Well-designed and stable rules and

[41] *Ibid*

[42] MŠMT (2015) Průběžná evaluace OP VaVpI, 7. Hloubková analýza – Zhodnocení očekávaných dopadů OP VaVpI, 6. Průběžná zpráva, version 1.1.

requirements for providing support" (pre-condition 5), rather negative experiences were collected. Of course, it is necessary to underline that in general terms, rules, as laws and other standards, are stable in the Czech Republic as in a sound democracy. In more detail, at least the public procurements system and some cases of unclear methodical guidance were mentioned by the interviewed beneficiaries as factors corroding this pre-condition. Another frequently mentioned issue was the inflexibility of the system that disabled reaction to rapidly evolving technologies. As there were long delays between the preparation of a project and its selection, it would be useful to modify certain aspects, but the system did not allow it.

Verification of supporting factors

All identified points were verified as factors supporting the policy instrument's expected results. The Roadmap for Large Research, Development and Innovation Infrastructure (supporting factor 1) in the Czech Republic was prepared for the first time in 2010. Since then, it has been regularly updated and assessed. The strategy is important as it sets up a continuous approach aiming to grasp the situation and significance of large research, development and innovation infrastructures within the Czech Republic and the European Research Area. This factor was not relevant to the pathway of electronic information resources.

All other factors were valid for both identified pathways. Complementary actions in Prague (supporting factor 2) and continuous public support over time enabled to ensure effects for the whole Czech R&D system. In 2017, a project to ensure electronic information resources centrally followed (CzechELib[43]) (supporting factor 3).

Demand for ICT infrastructure and EIR is obvious, as an above-discussed precondition for R&D in general. However, such demand needs to be correctly anticipated. Demand for ICT infrastructure was estimated in the preparatory phases of projects. The interviewees of electronic information resources reacted on demand among scientists in respective institutions. They pointed out that no one can imagine any comeback to unsatisfactory conditions before the realized projects. The difference between what is and what used to be considered a standard in these libraries grew significantly.

However, an interesting view is on "demand" in ICT infrastructure (supporting factor 4). The representatives of the analysed project described the preparatory process reflecting not only perceived needs but also expected demand and trends. Demand for ICT infrastructure was significantly increasing, and it even exceeded estimations. For example, the interviewed beneficiary was obliged to deny some institutions interested in data storage services during the sustainability period due to the full capacity. However, it is interesting that an opponent of the project criticised that planned storage size as excessive.

Verification of risks and threats

None of the identified risks and threats materialised to the extent that they would negatively influence expected results. Uncertainty, instability of the interpretation of rules, long-lasting and complex public procurements process control was the most threatening for all projects (risk 3). Even if this is a typical risk of all projects in the Czech Republic, within the R&D area, this was even more strengthened as unique investments or services are often purchased. These services first have to be made-to-measure frequently; second, they can be supplied by only a few (or even by only one) provider and cannot be substituted by anything less expensive (e.g. by a collection of cheaper journals). Considering modifications of the respective law, inexperience of the majority of beneficiaries and high pressure from the Managing Authority (similarly

[43] https://www.czechelib.cz/en/56-about-czechelib (accessed 23 October 2020).

inexperienced) and other Czech institutions led to delays, repeating of tenders and important strain.

No interviewee reported problems with the sustainability of projects' results (risk 4). As far as electronic information resources, the only issue for beneficiaries was the number of fees of purchased databases. Partnerships resolved this issue among universities, with reduced fees for each of them. Acquired services were so important for all workplaces that were sustained even after the period of sustainability, even though the system was centralized into the National Centre for Electronic Information Resources CzechELib.

Nevertheless, another point of view on sustainability has to be applied within ICT infrastructure. Everything was sustained during the sustainability period, but after it, some devices purchased within the respective project have been already replaced by new ones (e.g. data storages) due to technological changes. From the perspective of newly developed services, this has been sustained up to now (risk 1).

The exclusion of Prague from the support for convergence regions was compensated by the national resources (risk 2). Thus, this risk was mitigated, though, without the state intervention, this would completely pervert the problem that the intervention should have resolved. The result would be not the convergent situation that all regions, including Prague, have the same conditions, but the divergent situation when Prague institutions and the majority of Czech students could not have attained the same conditions. This risk was confirmed by the interviewees as well as some evaluations[44].

The risk of bad interconnectivity of ICT infrastructure between supported regions and unsupported Prague has not been unequivocally confirmed – some interviewees admitted this hypothetical option. In any case, thanks to the national intervention, this had not happened.

3.3.3. General assessment of the policy instrument

The policy instrument successfully achieved expected effects at the level that the supported projects could directly influence (especially the outputs and the immediate outcomes). The relevant monitoring indicators were even exceeded. Slightly questionable is the outcome "Increasing information literacy" – the policy instrument strengthened information literacy but only to limits defined by the calls for projects, definitely not in more general terms. Starting with the intermediate outcomes, the influence is not as evident; however, it contributed to the environment enabling them.

On the more complex level, some effects were verified to a limited extent ("Integration of Czech R&D institutions into the European Research Area", "Strengthened and more intensive cooperation of R&D institutions!). In case of some outcomes, no evidence was (could be) reported and remain unknown ("Stimulating of interest in R&D, Popularization of science and raising awareness of its results"). This does not mean that the policy instrument was not successful. This policy instrument has a supporting character for the R&D area, and more complex effects can be attained only with the concurrence of other activities and causal links. Therefore, having achieved the intermediate or the final outcomes to a limited extent should be considered a success.

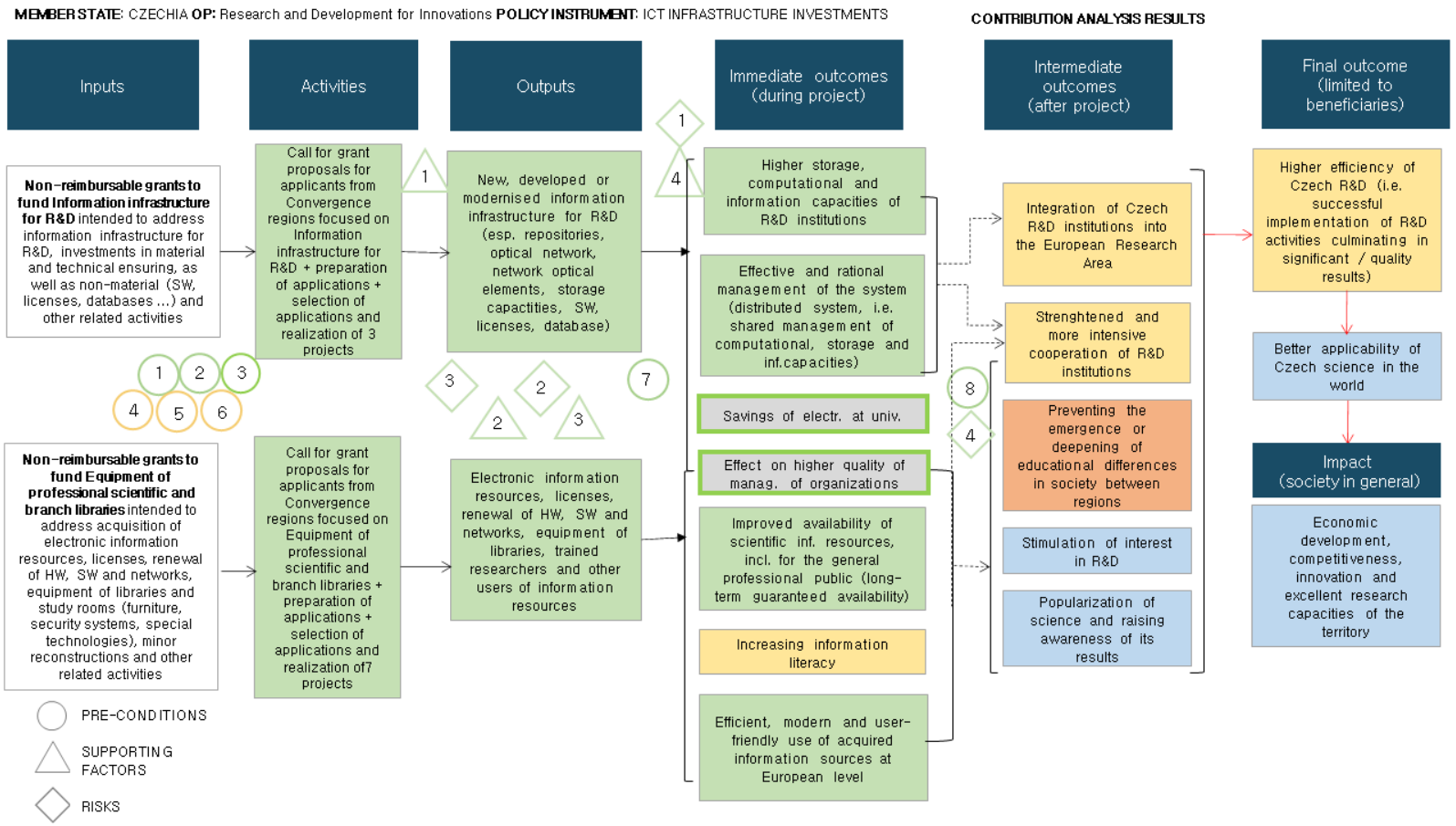
Preventing the emergence of deepening of educational differences in society between regions was the only intermediate outcome that was not achieved. First, the calls for proposals' setting-up could have divergent effects, i.e. if not compensated by the

[44] MŠMT (2017): Závěrečná zpráva o provádění operačního programu Výzkum a vývoj pro inovace, p. 146, https://www.opvavpi.cz/cs/siroka-verejnost/zakladni-dokumenty-programu/vyrocni-zpravy-op-vavpi.html (accessed 19 October 2020).

national resources for Prague institutions, disparities would rather grow in analysed aspects. Second, once reflecting both the ERDF and the national resources, there was an equalization effect (the same conditions before and after the intervention; however, the overall situation improved).

Some pre-conditions were verified only to a limited extent, but it was not proved that this fact would threaten planned effects. According to collected evidence, the risks and the threats were managed or mitigated, and the supporting effects were verified – according to collected evidence, these existed and positively influenced effectiveness.

Representation of the results of the contribution analysis for the ICT Infrastructure Investments policy instrument



Source: Own elaboration based on primary and secondary data collected.

3.4. Policy Instrument: ELI: Extreme Light Infrastructure implemented under the Operational Program Research and Development for Innovation

3.4.1. Theory of Change of the major project

This section focuses on the case study's major project, ELI: Extreme Light Infrastructure (hereinafter ELI), financed under the Priority Axis 1 (PA 1 - European Centres of Excellence) in the OP RDI.

Overview and rationale of the investment

The PA 1 under the OP RDI was designed to support a critical mass concentration in excellent and quality research activities around existing institutions. It represented the key part of the OP RDI in financial terms. In many research domains (i.a. Physics, Photonics and Lasers), there was an existing tradition and relevance in the Czech Republic; however, a significant upgrade was needed to be competitive on the European and global level. The call for projects for European R&D Centres of Excellence (No 1.1.) was intended to support the state-of-art of R&D infrastructure in fundamental and applied research. Therefore, this call's main goal was to develop new research capacities that aimed to match the top level of quality and research excellence on the European and global level.

The main rationale behind the target of investment in the PA 1 (and partially also in PA 2) was to support excellent and internationally reputable research infrastructures. It should have provided the national research ecosystem with significant enlargement of mission-oriented academic research and applied research. These were the expected main effects of the planned investments in PA 1 of the OP RDI, and the ELI project was supposed to play a key role in this task. In the longer term, these investments were anticipated to boost the competitiveness of the Czech economy and contribute to developing new technologies and solutions to benefit society (not only in the Czech Republic but worldwide).

The ELI project was bottom-up designed, as history and the achieved level of excellence of the Institute of Physics of the Czech Academy of Sciences (hereinafter IoP) were important factors. The project reacted to the international research demand in many European countries, and thus beneficiaries created an alliance among those countries already in the preparatory phase of the project. This phase was supported by a project from the Framework programme – the project put together partners from future the ELI consortium and created a platform for the development of the ELI network infrastructure.

Policy instrument and ToC description

The ELI Beamlines was planned as a part of the European roadmap of next-generation major research facilities identified by the European Strategic Forum for Research Infrastructures (ESFRI). ELI is an international research facility using new and emerging laser technologies to generate the world's most intense light pulses. The whole Extreme Light Infrastructure can be described as a distributed facility including three nodes located in three different countries[45]: the ELI-Beamlines, which was built in the Czech Republic and became a major component of the whole ELI infrastructure, the ELI-ALPS (in Hungary) and the ELI-Nuclear-Physics (in Romania).

During the preparatory phase, the IoP managed the national Consortium ELI-CZ, involving 14 major universities and research institutions. The proposed ELI project's main goal was to establish an internationally recognized excellent research infrastructure as a part of the pan-European ELI network and ESFRI.

The main expected objectives of the ELI project were:

[45] In future, it should be more as a network connecting also other partners.

- To enable world-class research in the field of interaction of laser light with matter at the intensities exceeding about 100 times the values achieved at that time;
- To establish an environment for the development of advanced cutting-edge technologies and strengthen the research, development and innovation potential of the Czech Republic able to contribute to its competitiveness and future economic growth, to contribute to the creation of highly qualified workplaces, so that the Czech regions can become locations for major high-level research activities within Europe.

The project was designed to cover the construction of a modern specialized building (of about 30,000 m^2), its equipment with laser systems, compressors of optical pulses, vacuum systems, computing facility, and data storage. It also included start-up activities such as setting up a technology transfer centre, library services and other general services required for the operation of a European Centre of Excellence.

This new research infrastructure with a state-of-art research facility should have enabled using new and emerging ultra-high intensity laser technologies to generate the most intense light pulses in the world. It should have established international excellent research teams providing the global laser community with expertise and background for fundamental research and capacities for cooperation with application partners. It should have helped the IoP (and other partners, too) to boost the quality and quantity of research outputs (scientific publications, patents), improved the possibilities to educate and train young scientists and, in the long run, bring economic development and competitiveness built on new technologies, knowledge and high added value.

Before the project proposal was submitted, the MA organized a pre-call for projects in the PA 1. The reason was to motivate applicants to prepare complex and bottom-up projects that reflected the research environment's needs. The project proposal ideas' assessment was based on international relevance and excellence, practical needs, readiness and quality, and experience of the management team. The ELI project went through this pre-call successfully, and the process helped the management team design the final proposal.

The strong position of the IoP, a tradition in lasers and photonics domain, and planned synergic projects played an important role. The IoP was "on the map" of the European research community thanks to the PALS[46] , and there was long-time cooperation with other foreign partners. International relevance and respectable position among the European community enabled the IoP to agree with research institutes from other countries to set up a flagship project in the Czech Republic. The fact that two other ELI infrastructures (in Hungary and Romania) were established in the same period (and provided by the ERDF financing) was also an important factor. It was necessary to convince other international partners to provide financing once the infrastructure was fully operational and under the ELI-ERIC pan-European consortium. ELI was also included in the European ESFRI Roadmap (the only project in the Czech Republic), which helped to all these steps.

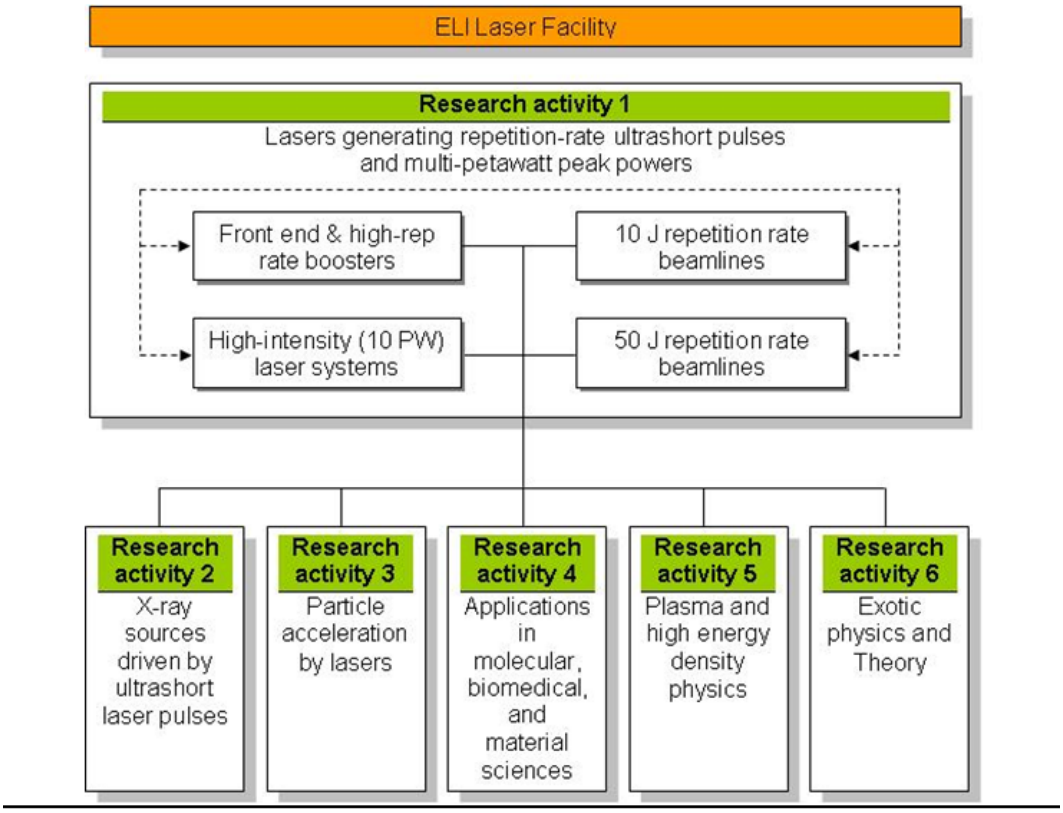
The key rationale behind the project and also the proposed outputs were (i) construction of the new ELI site with the ability to accommodate the planned research infrastructure and R&D personnel; (ii) development and acquisition of high-end laser technologies and related laboratory equipment. These outputs were indispensable for achieving the proposed results. Once the ELI facility was in full operation, the project supposed to a gradual increase in numbers of scientific outputs47. That was reflected in monitoring indicators. The development of research activities and projects should have also resulted in a broader cooperation with the applied sphere. Technology transfer and collaboration with industry was a key focus of the projects in PA 2, but also the projects in PA 1 were asked to bring some results in that area. Considering the specialization of ELI and the

[46] Prague Asterix Laser System co-developed by the IoP and partners during previous decade.
[47] Patents, scientific publications and other applied research outputs.

nature of its research activities, the development in that area was expected to reach the full potential several years after completion.

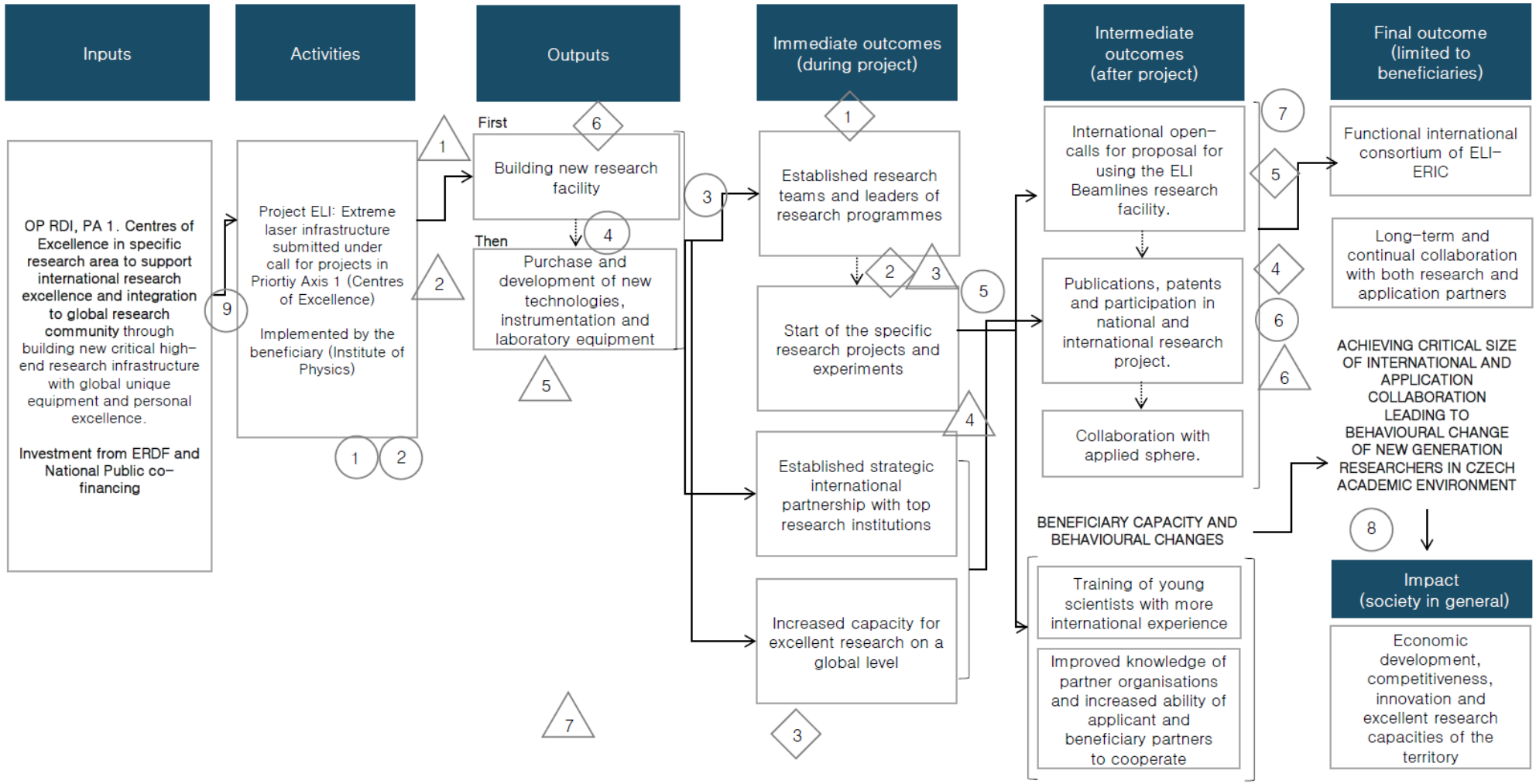
The proposed short, medium and long-term intended results of the ELI project complied with anticipated outcomes of the OP RDI (and the PA 1). Project realization should have contributed to establishing internationally experienced research teams that would have enabled to start six proposed research activities within the ELI facility (see the figure below). The international constitution of research teams helped to establish international partnerships with the top foreign R&D infrastructures worldwide. This process significantly increased the capacity for excellent research in photonics and lasers because the facility should concentrate on world-class technologies and experts.

Research activities in the ELI Beamlines facility



Source: Project proposal for OP RDI (ELI: Extreme Light Infrastructure).

Theory of change of the ELI: Extreme Light Infrastructure policy instrument



Source: own elaboration based on project proposal documentation and secondary data.

Pre–conditions

1. Long-term specialisation and experience of Instititutes of Physics in the field the project is focused on.
2. Applicant needs to upgrade current infrastructure to stay at global lead position in related fields of research
3. International network and brand of Institute of Physics and project itself, based on previous successful international project which help established new ELI consortium.
4. Well prepared development & construction process of the physical infrastructure
5. High activity of research teams in generating applications for research grants and thus be able to provide the centre with financing
6. Excellent project management and quality of researchers
7. Uniqeness of technologies on a global level and relevance to needs within research community
8. Functional networking at local, national and global level both in science and industry
9. Sufficient organizational, staff and expert capacity on the side of the MA to successfully support the project

Supporting factors

1. ELI and Institue of Physics are strong members of the European laser network
2. Additional infrastructure and research investment in the locality of Dolni Brezany which increase the attractivity for foreign researchers and help to build R&D hub for lasers and optics in Central Europe.
3. Attractivity of Czechia and locality (level of wellbeing) are strong pull factors for top foreign researchers
4. Availability of national and international research schemes where can apply for project funding
5. Availability of specialised suppliers of technology both locally (in Czechia) and globally
6. Societal and research relevance of research projects and alignment with public policy goals in R&D
7. Continuous support by government bodies and Academy of Science

Risks and threats

1. Low relevance of research programs to global trends/needs in science and societal challenges
2. Rigidity of czech academic sector and international competition for talents
3. Inappropriate focus of research schemes (both nationally and internationally) make it difficult to get long-term funding
4. Low international excellence and acceptance in research community
5. High operational cost represents a barrier to secure sustainability of cutting edge technologies
6. Delays and problems regarding acquisition of land and securing construction permit

Source: own elaboration based on project proposal documentation and secondary data.

3.4.2. Contribution analysis of the major project

Verification of intended intervention implementation

The project was implemented by a management team of the IoP between 2011 – 2016. The gross total ELI project costs were EUR 206.6 million, including EUR 206.6 million eligible costs, with EUR 175,6 million ERDF contribution. The national public contribution was EUR 30.9 million. The ELI project represented more than 11% of the investment of the whole OP RDI and almost 19% of funds invested in the PA 1 and the PA 2. Moreover, in the second phase of the project,[48] funded by the following OP, ELI received the support of EUR 74,4 million. The preparatory phase was supported by EUR 0.04 million from the 7FP. The ELI project's financial support took the form of non-reimbursable grants, providing 85% funding from the ERDF and 15% of national co-financing. According to interviews with stakeholders, without the financial support provided by the ERDF, such a major project would have never been realized in the Czech Republic. Achieving the critical mass of financing from the national resources would not have been possible.

There were some delays regarding construction permission and public tenders, but the local authority, the management team and the managing authority helped solve the situation. Significant delays continued in constructing the infrastructure (buildings) and in the assembly part of the project. Therefore, some intended effects were postponed in time.

Non-eligibility of the Prague region directed the project out of the capital's borders, and specific requirements on land and space only underlined this direction. Once the site's construction was nearing completion, project leaders and research teams were established and already started to work. Their salaries were supported not only by the OP RDI but also by the OP Education for Competitiveness, which helped bring excellent senior researchers from abroad. Setting-up of research teams and their full operationalization enabled ELI to be active and successful in international proposals for grants (Framework Programme, Horizon 2020). The production of research outputs significantly increased (see figures in 3.3.3.), which led to higher relevance and cooperation in the international scientific community. It also contributed to additional financing for ELI, and they can build on it for the future.

The development of laser technologies and other special and laboratory equipment was a big issue because they were supposed to be state-of-art. And thus, the best suppliers and researchers (not only from the ELI consortium) were put together to develop the solution that was not on the market yet. In the preparatory phase of the project (before the call for projects was published), the MA planned to motivate potential applicants into broader cooperation with industry partners and incorporate this into the call parameters. But there was no such a threshold in the end, and the projects were asked to be focused dominantly on fundamental and mission-oriented research. In the case of ELI, the plan was to cover about 12% of its operational costs with its operational revenues in the operational phase (from 2016 onwards). Those revenues include contract research, royalties and patent revenues.

The ELI was the first project of that size and complexity prepared and realized by the Czech academic institutions in history, with a very ambitious goal to develop the world's most powerful lasers in their specific categories. Management of such complex projects is extremely demanding, and some budget or time-schedule modifications can be necessary. Nor did the ELI avoid the prolonged realization. The ELI project was divided into two subsequent phases[49]. Therefore, some of the ELI project's

[48] ELI was divided to phases because of delays during the constructions.

[49] Project in the second phase was funded by the OP Research, Development and Education (OP RDE) within the 2014-2020 programming period, No. EF15_008/0000162 - ELI - EXTREME LIGHT INFRASTRUCTURE - FÁZE 2. Eligible costs of this project were 1.859 million EUR.

proposed activities were postponed to the next programming period (2014 – 2020) – ELI – Extreme Light Infrastructure Phase II[50]. The subsequent project was focused on completing the highest intensity laser equipment in the world (in that category), testing the facilities and became fully operational. This exception was negotiated and approved by the EC before 2013[51]. Especially the outcomes and impact had to be postponed in the time.

ELI represented a significant share of the funding within the OP RDI. Because of delays in the realization, the MA was under pressure for the EU funds absorptions when nearing the end of the programming period 2007-2013. Construction works had negligible delays caused by certification of allocated funds, which led to complications on the side of the MA with their monitoring indicators. Moreover, state administration came up with changing regulation in public procurement. Therefore, the beneficiary was under the pressure of time (forced to speed up with their proceedings - acquisition of land, public tenders for construction works, technology equipment), too. Despite these troubles, the beneficiary fulfilled all indicators and successfully launched globally unique infrastructure, inspiring leading economies in the world like the USA or South Korea.

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

The main intended effects, especially all immediate, intermediate and final outcomes, **of the ELI project were in general achieved** (see Figure 21). However, many of them later than expected, mostly due to the delays described in the previous section and the character of fundamental research in lasers. These effects represent fully operational state-of-the-art laser research infrastructure with international science teams, established cooperation with other institutions in the ELI-ERIC consortium and volume of scientific outputs.

All monitoring indicators (see table 8) **reflect most of the intended effects and were successfully fulfilled.** Most of them are connected to the immediate or intermediate outcomes, like newly created jobs (in the ToC, the IMO1 Established research teams and leaders of research programmes or the INO4 Training of young scientists with more international experience). **Moreover, some of them were more than 20% above the target value**, as the "Increase in the total number of recognized R&D results for supported workplaces" as an intermediate outcome (INO2) or, more importantly, "Newly created R&D jobs for women" (Number of newly created jobs, R&D employees – women), relevant for as both immediate (IMO1) and intermediate outcomes (INO4). Key intended outcomes were the construction of the facility and the operation of a high-performance laser. Therefore, it is important that the indicator "Number of researchers using the built infrastructure" exceeded the target value of 20%. Based on the successfully achieved indicators and the character of some intended effects - jobs creation and young researchers training, it can be presumed that ELI set conditions for the beneficiary's behavioural change and its collaborating partners in the Czech Republic and in the EU.

Table 8. Overview of relevant monitoring indicators at the level of policy instrument

Monitoring indicator	ToC element	Target value	Achieved value (2015)
Number of newly created jobs, total researchers (PM - Number of jobs)	Immediate outcome: IMO1 - Established research teams and leaders of research programmes; Intermediate outcome: INO	101	109,99
Number of newly created jobs, researchers – women (PM - women - Number of jobs – women)		0	14,11
Number of newly created jobs, researchers under 35 (PM -		54	77,48

50 Investments were made not only from the OP RDI (2007-13) but also from the subsequent OP Research, Development, Education, prepared for the period 2014-20.

51 According to interview with former representative of the OP RDI.

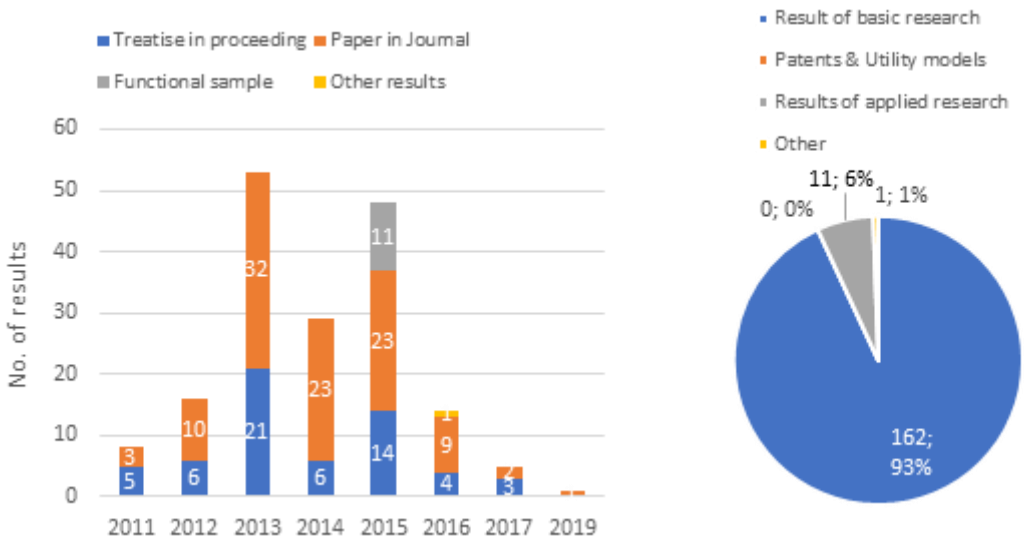
Number of jobs)	4 - Training of young scientists with more international experience		
Number of newly created jobs, researchers under 35 – women (PM - women - Number of jobs - women)		0	11,81
Number of newly created jobs, R&D employees – total (PM - Number of jobs)		229	250,15
Number of newly created jobs, R&D employees – women (PM - women - Number of jobs - women)		0	51,62
Number of researchers using the built infrastructure (Number of persons - Number of persons)		101	123
Number of successful graduates of master's and doctoral study programmes (Number of persons - Number of persons)	Intermediate outcome: INO 4 - Training of young scientists with more international experience	7	7
Number of successful graduates of doctoral study programmes (Number of persons - Number of persons)		7	7
Increase in the total number of recognized R&D results for supported workplaces (Number)	Intermediate outcome: INO2 - Publications, patents and participation in national and international research project.	132	167,65
Professional publications (according to the RVV methodology) (Number)		121	156,65
Research results protected based on a special legal regulation (according to the RVV methodology) (Number)		0	
Applied research results (according to RVV methodology) (Number)		11	11
Reconstructed, expanded and newly built capacities (m2 - Area in m2)	Output: O1 - Building new research facility; O2 - Purchase and development of new technologies, instrumentation and laboratory equipment	30.887	30.887
Newly built capacities (m2 - Area in m2)		30.887	30.887
Volume of funds for R&D obtained from foreign sources (EUR[52])	Immediate outcome: IMO3 - Established strategic international partnership with top research institutions; Intermediate outcome: INO1 - International open-calls for proposal for using the ELI Beamlines research facility.	120.000	236.743,18

Source: National Coordination Authority, CSIL calculations.

For validating the intended effects, it is important to go beyond the indicators themselves, and therefore, the specific results were analysed. Figure 19 and figure 20 demonstrate the split of the project type of results. **Phase I produced more theoretical outputs, like treatise or papers. On the other hand, during Phase II, the ELI researchers produced more applied results - several patents and utility models (8% of results in the Phase II – in the Phase I, no patents and utility models were produced)**. Comparing the results of Phase I and Phase II, we can also observe a growth of applied results from 6 to 9%. This trend is key for fulfilling the initial idea of the PA 1 of the OP RDI, i.e. the support of applicants into broader cooperation with industry partners.

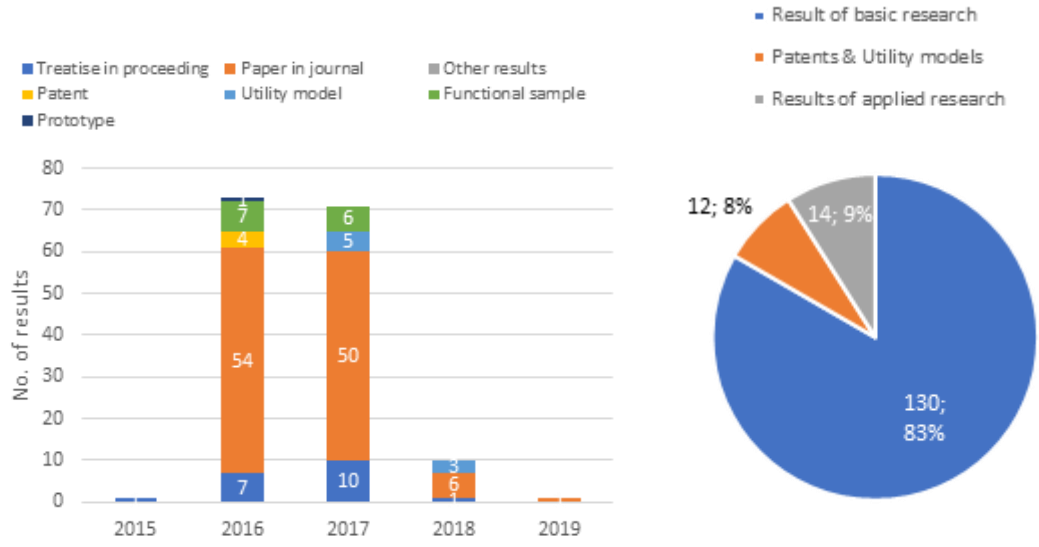
52 Amount of the investment was converted from CZK to EUR (1 EUR=25 CZK).

Direct results of the ELI project Phase I and their types



Source: Technology Agency of the Czech Republic, Starfos database, downloaded 15/10/2020.

Results of the ELI project Phase II (following project from the OP RDI) and their types



Source: Technology Agency of the Czech Republic, Starfos database, downloaded 15/10/2020.

One of the expected main effects was full involvement in international research activities and projects. **ELI became a firm and respected part of the pan-European laser community,** and after the full completion following results were achieved:

- There were nine submitted projects for the FP7 and two project proposals for the Horizon 2020 prepared by ELI already by the end of 2015[53]. And this number increased in the following years, once the infrastructure was nearing its full operation.
- A lot of senior and junior researchers from abroad have joined the ELI team. The share of foreign researchers and R&D personnel is more than 50% today, unique

[53] According to the document: Průběžná evaluace OP VaVpI, 7. Hloubková analýza – Zhodnocení očekávaných dopadů OP VaVpI, 6. Průběžná zpráva, MEYS (2015).

in the Czech context. At the end of the realization phase (in 2015), there were 330 new employees[54].

Several important unintended effects occurred. First, the **core management team gained new experience and skills** during the project's preparatory and realisation phases. Skills like the orchestration of the development of a new research facility, hiring the top talents and construction of the most powerful lasers are important prerequisite for the consortium's success. Moreover, some of the key managers are still active in ELI, ensuring the continuity and **increased self-confidence** of the whole academic community that such a large project can be implemented.

Second, **ELI brought significant development in the whole locality** of Dolní Břežany, e.g. public services (education, leisure and cultural activities, level of well-being) or housing facilities. At a general level, this improvement is important for ELI itself because the high-quality environment for living is one of the pull factors, attracting the top researchers from the world to the locality of the ELI site.

The realisation of ELI also brought to this locality a **smaller research centre, HiLASE (also financed from OP the RDI), focused more on the applied research**. Both institutions closely cooperate, and scientists and innovators' local buzz **was a key factor behind the establishment of a regional science and innovation cluster called STAR** (Science, Technology Advanced Region). Concertation of these two laser facilities into the locality attracted several companies like Rigaku or Cardam and other companies that sat up long-term collaborations with them. This was a seed for creating the milieu, potentially replicable in other ELI localities or translated into the virtual milieu, so important in the current pandemic situation. These effects are outcomes of synergies with other investments made in the locality. They are prerequisites for a long-term and continual collaboration with both research and application partners and general impacts on economic development in general. However, a global pandemic has impacted the whole ELI-ERIC consortium, mostly by limitations of international travelling (international experiments) and goods delivery (components for testing from the client). On the other hand, the pandemic impacts only a part of the ELI-ERIC activities, which should not dramatically affect the ELI itself. Moreover, because of the facility's uniqueness, there is a need among the partners in the milieu to "go back to the normal" as soon as possible.

Verification of assumed pre-conditions

Long-term specialisation and experience of the IoP on lasers (pre-condition 1) **took place and played a critical role**. The previous generation of the internationally renowned laser system PALS helped to gain the attention of foreign scientists and put the Czech laser research on the map of Europe. There was a **need to upgrade the infrastructure (in fact, build a brand new one) to stay at a leading global position in related fields of research** (pre-condition 2)**. This was recognised by all stakeholders** around the ELI project (and the ELI-ERIC consortium) and the EC and domestic politics level. This condition played an important role in all negotiations and also in the implementation of the project. Moreover, **due to the international network and brand arranged by the IoP thanks to the PALS, the IoP was capable of ensuring the interest of the international research community** (pre-condition 3) before the setting of conditions of calls from the OP RDI.

On the MA level, a strong need for sufficient organisational, staff and expert capacity (pre-condition 9) **was an important enabling condition to support the realization of the project successfully**. Especially regarding the changes and phasing of the project (the second phase was prolonged to the 2014-20 period), this was also supported by the EC's attitude. It influenced the possibility to change the schedule flexibly and enabled to generate of necessary outputs (infrastructure and technology equipment) that served for achieving outcomes and results in the following years.
The ELI project attracted skilled people with strong managerial and international experience (pre-condition 6). Several of those people are still working

[54] According to the monitoring indicators of the ELI project and interview with the representatives of the ELI management.

for ELI and ensure the continuum of the project. **These skills and network of key people beyond ELI helped prepare the development and construction of the physical infrastructure** (pre-condition 4). Without the network and capability to ensure support from the Czech governments, ELI would have never achieved the planned results.

Nowadays, ELI is one of the most internationalized academic workplaces in the Czech Republic. The **high-quality and experienced researchers** attracted by the vision of ELI and experience with the PALS **played an important role in attracting talents from around the world**. **Only the top talents could build the globally unique and the most effective lasers globally and be able to receive national and international prestigious funding** (pre-condition 5). This initiated a snowball effect and started to attract other talents and new partners. **ELI became relevant to many industrial and science use cases** (pre-condition 7) and could build a strong collaboration with external partners (pre-condition 8).

Verification of supporting factors

It was verified that synergies with other interventions from the ESIF represented an important supporting factor (supporting factor 2), and they also contributed to intended effects. The IoP received another support from the OP RDI (PA 2) for the project of HiLASE, a new infrastructure for applied research and industry collaboration based in the same locality. And at the same place, the Centre for Technology Transfer of the IoP was established, also thanks to the OP RDI. These two projects had their individual own goals and intervention logic. Still, in synergy with ELI, they offered a unique possibility to strengthen the capacity for technology transfer and collaboration with industry. The ELI management team also aimed for synergies with the OP Education for Competitiveness to provide additional financing for attracting senior foreign researchers that should represent the core scientific team.

The IoP was a respected partner in laser research from the PALS acquisition time and running the first project. **On the PALS, the IoP built the brand in the laser research community, which significantly helped the IoP attract ELI into the Czech Republic and received support from other partners in the community (like the UK)** (supporting factor 1).
Laser research received significant support from the EU level, which enabled ELI to apply for several projects in the FP7 and the H2020 and fulfil public policy goals in R&D (supporting factor 4 a 6). In the FP7 and the H2020, almost 19 thousand research projects somehow connected to laser were supported. This is a significant change compared to previous Framework programs 5 and 6 (only 2 thousand research project were connected to the lasers). Moreover, research in laser technology is in alignment with the National innovation strategy.

Moreover, **continuous support by government bodies, the Academy of Science in the Czech Republic and in some periods also a local authority in Dolní Břežany played a key role in the process** (supporting factor 2 and 7). Their support contributed to the successful negotiation process with the EC, funding from national funds, and solving construction works and legal proceedings with public tenders. This supporting factor had a positive effect on the fact that the total budget was not exceeded[55]. Without this strong support, delays would have been much more significant. These stakeholders' support was important because the project was "too big to fail", as many of them mentioned. Importantly, **the ELI project always had political support from the Czech government (across the parties), which is not common in the Czech Republic.**

The additional infrastructure, especially HiLASE, a research centre for applied laser research, was critical for the success of ELI. These centres create the core for the laser milieu and **attract researchers and private companies** like Rigaku, which

[55] Delays during the project implementation (in comparison with the project timetable) are mentioned in other parts of this report.

built their R&D centre on the campus in Dolní Břežany, or Cardam (supporting factor 2). Next to the ambitions of ELI to build a globally unique laser, the **locality in Dolní Břežany represented an important supporting factor for attracting the best world talents in lasers**. Modern physical infrastructure and very good public services like schools, parks or cafés were important for satisfying high-quality well-being for incomers (supporting factor 3).

One of the issues was the availability and skills of specialised suppliers and developers of laser technologies (supporting factor 5) planned to be built as equipment of this new infrastructure. Because these technologies were state-of-the-art, suppliers had to develop them together with scientists in ELI and other academic institutions around the world. Several delays and issues occurred during the development and installation. For example, one of the planned lasers will start its operations at the end of 2020.

Verification of risks and threats

Failure to meet the deadline for completion of the construction was the biggest risk known before realising the project. And during the implementation phase, this factor even gained importance. Some delays were reported due to long processes of the land acquisition, obtaining a construction permit and development and purchase of laser systems (risk 6), caused by public procurements and legal issues, because there was a limited number of potential suppliers of such a technology. That affected the scheduled timetable and realization of outputs and impacts of the project.

Providing continuous funding for further development and growth of the centre was an issue after the completion and remains some threat for the future. The beneficiary prepared a specific scheme in the project proposal – international open-calls for using beamtime and other ELI equipment and services. This scheme should help to broader cooperation with international scientific and industry partners and provide the global community with access to unique laser technologies. These special services were designed for ELI to remain financially sustainable and, together with the ELI-ERIC consortium,[56] should be the important pillars of financial stability. Nevertheless, the National sustainability programme, combined with successive financing from the ESIF in the period 2014-2020,[57] played a key role. However, ELI is still dependent on the partners' EU financing from the member states in the ELI-ERIC consortium.

Moreover, EUR 0,5 billion per year is allocated by the national government to secure the operation of ELI, which represents approximately 90% of the ELI budget and 5% of the government R&D expenditures. The high government subsidies open discussion in the national R&D ecosystem about long-term sustainability. Now, the biggest challenge for ELI is a diversification of funding in future years to satisfy relatively high operational cost. On the one hand, ELI is a strategic EU research infrastructure and will always need support from the EU or member states. On the other hand, current research funding trends create more pressure on quality and competitiveness which should favour ELI in the next years.

Risks and threats as a low relevance (risk 1 and risk 3)**, low excellence** (risk 4), **or rigidity** (risk 2) **have not been proved to be important or occurred in a limited way.** The beamtime is almost fully booked; the ELI research teams attract scientific partners around the world. There is an existing strong relevance of research programs to global trends/needs in science and societal challenges (risk 1). The risk (no. 4) of low international excellence and acceptance in the research community proved not to be in place. Moreover, the internationalisation of research teams was not diminished by the Czech academic environment's rigidity that is still evident in some other areas of academia (risk 2). This was proven by the establishment of quality international research teams in the case of ELI. However, we could observe that some talented researchers are

56 ELI-ERIC consortium is a specific legal form that enables the member countries to govern the facilities jointly and make them available to the scientific community as a single international organisation.
57 New international grants gained by the ELI research teams.

ostracized from the Czech environment. Fortunately, in the case of ELI, we observed only small numbers of these cases.

According to some stakeholder interviews, there were differences of opinions between the DG Regio and the DG Competition regarding the State Aid interpretation. This led to a changing application of this rule during the period 2007-2013, manifested in changes in prioritisation and even of eligibility of supported activities. While in the beginning, applicants were requested to maximize the volume of intended industry cooperation and income from these activities, later this condition was changed, and the EC strictly set the maximum level of contract research. According to the interviews, this change resulted in many difficulties on beneficiaries' side (e.g. changes in proposed activities, outputs and outcomes) and the overall sustainability strategy. This development also influenced the management at the OP level, as the focus on industry collaboration was not as high as expected at the beginning of OP.

3.4.3. General assessment of the major project

There is a consensus that the ELI project contributed to a significant enhancement of excellent research activities in the Czech Republic and set up a strong international collaboration with academia and industry partners. Collected evidence verified that ELI managed to give a real contribution to the goal of the PA 1 in OP RDI.

The whole intervention mechanism (and thus also the ToC) was affected by the delays in the project realization and the fact that the effects became evident later than expected. In general, the whole intervention logic did not change, and the main causal linkages and supporting factors were in place.

The project achieved all outputs. Relevant monitoring indicators for the project were also achieved. The main and evident effect was the considerable enlargement of research capacities in the Czech Republic with unique quality and performance globally. The new infrastructure was slowly involved in the international research community, and that created a unique testing and research facility for various teams from research institutions and other stakeholders.

The main enabling factors behind these results were:

- Continuous support from the European, national, and local levels includes financial support by additional sources (other OP, national budget) and specific local servicesthat helped create a functional local ecosystem friendly to the research community. The ERDF support was one of the contributory causes leading to the project's outcomes.
- Firm linkages with other laser and optics research infrastructure HiLASE (also financed from the OP RDI) focused more on applied research and cooperation with companies. Both institutions closely cooperate in projects and research and further develop local research and innovation-intensive ecosystem.
- Management of the project succeeded in incorporating ELI as a vital part of the European laser and optics research network. That helped to attract foreign senior and junior researchers and to be part of many international projects.

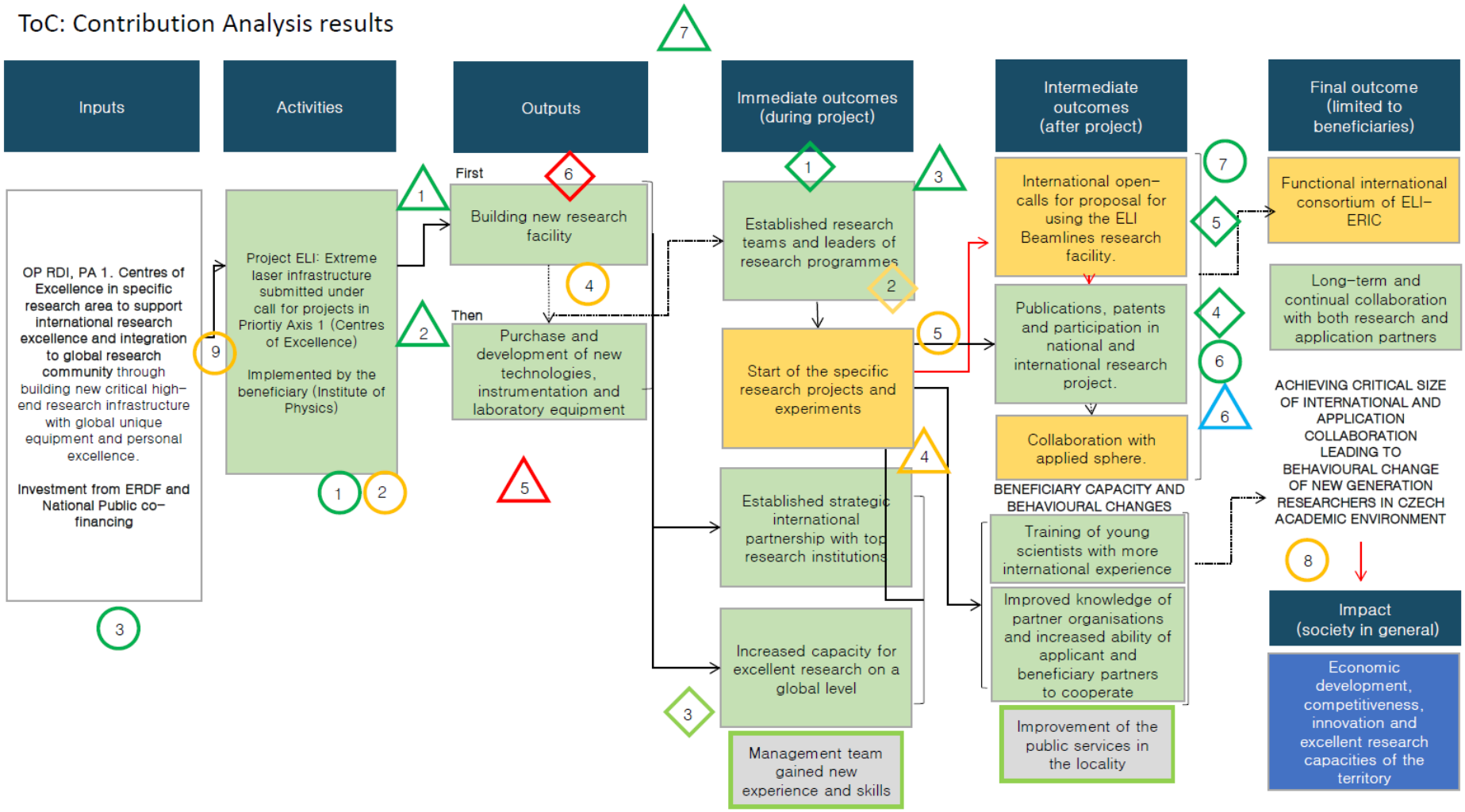
Some specific intended effects were achieved later or maybe to a lesser extent than originally planned, e.g. "*the start of the specific research projects and experiments"*. While initially, this was expected to be an immediate outcome straight after the end of the project, this effect happened a couple of years later because laboratory and technology equipment was fully operational in this later development of the whole ELI site. Therefore, this can be viewed as an intermediate outcome. Also, a broader collaboration with the applied sphere was developing slower than expected. This was influenced by the fact that some projects with external partners from the applied sphere started, but the full extent (and potential) will be reached in the coming years.

The ELI centres' international consortium (ELI-ERIC) was established, but it has not been fully functional and operational yet. There are on-going discussions regarding the roles

and responsibilities of partner states. And the full onboarding of all ELI sites is still in process.

All preconditions were proved to be in place. Some of them were crucial, and others played a minor role and did not develop to the full extend according to the contribution analysis. Risks and threats were managed, but some of them still affected the realization phase and were the reasons behind the implementation delays and complications.

The sustainability of the ELI infrastructure remains a key issue for the future. The ELI management and the whole ELI-ERIC consortium will have to deal with it in the coming years. The MA was aware of that, and therefore they emphasized quality, international relevance, and connection to the ESFRI network in the call for projects in the PA1. These new excellent international R&D infrastructures represented a strong commitment for public budgets (on the national and European levels) because they will predominantly rely on public financing. ELI management is aware of that, and they work on a concrete strategy to mitigate this risk. The strategy will focus on maximizing the diversification of financial sources for operation and development of the ELI site, highlighting the EU research programmes (e.g., Horizon 2020), generated incomes from users of beamtime (during open-calls) and expansion of the cooperation with industry.


ToC: Contribution Analysis results
Inputs
Activities
Outputs
Immediate outcomes (during project)
Intermediate outcomes (after project)
Final outcome (limited to beneficiaries)
OP RDI, PA 1. Centres of Excellence in specific research area to support international research excellence and integration to global research community through building new critical high-end research infrastructure with global unique equipment and personal excellence.
Investment from ERDF and National Public co-financing
Project ELI: Extreme laser infrastructure submitted under call for projects in Priortiy Axis 1 (Centres of Excellence)
Implemented by the beneficiary (Institute of Physics)
First
Building new research facility
Then
Purchase and development of new technologies, instrumentation and laboratory equipment
Established research teams and leaders of research programmes
Start of the specific research projects and experiments
Established strategic international partnership with top research institutions
Increased capacity for excellent research on a global level
Management team gained new experience and skills
International open-calls for proposal for using the ELI Beamlines research facility.
Publications, patents and participation in national and international research project.
Collaboration with applied sphere.
BENEFICIARY CAPACITY AND BEHAVIOURAL CHANGES
Training of young scientists with more international experience
Improved knowledge of partner organisations and increased ability of applicant and beneficiary partners to cooperate
Improvement of the public services in the locality
Functional international consortium of ELI-ERIC
Long-term and continual collaboration with both research and application partners
ACHIEVING CRITICAL SIZE OF INTERNATIONAL AND APPLICATION COLLABORATION LEADING TO BEHAVIOURAL CHANGE OF NEW GENERATION RESEARCHERS IN CZECH ACADEMIC ENVIRONMENT
Impact (society in general)
Economic development, competitiveness, innovation and excellent research capacities of the territory

4. GENERAL FINDINGS AND LESSONS LEARNT[58]

Overall, the ERDF investments from the OP Research and Development for Innovations (OP RDI) 2007-2013 **represented the largest investment in the R&D sector in the Czech Republic's contemporary history.** The intention of policy-makers was that the OP RDI would have been a catalyst for the Czech R&D system's fundamental changes that suffered from a range of bottlenecks and difficulties (see section 3.1.) conditioned by a long-term underfunding of this sector and the low political priority.

The volume of financial support provided by the ERDF to support RTD activities and infrastructures was sufficiently high to "move the needle" for the country's research system. The Czech Republic received the third-highest (after Poland and Germany) volume of ERDF funding to the R&D sector from the MSs, counting to EUR 1.9 billion. The amount represented almost 14% of the total ERDF contribution of the country. One of the key needs of the RTD system in the Czech Republic was to significantly improve infrastructure, capacity and material equipment of public R&D organisations that were obsolete and not suitable to perform high-quality research producing applicable research outputs. The existing national and regional policies in support of RTD were marginal in comparison to the ERDF RTD investments in 2007-2013. They would not have been able to provide this amount of funding, moreover within such a short time.

The thematic relevance of the support from the OP RDI and all evaluated instruments has proved to be high as the ERDF support responded to the infrastructural R&D needs of the Czech Republic. All evaluated policy instruments achieved to full extent compliance with analytical findings prepared for the OP RDI and reflected actual trends in the R&D sector. Thus, the ERDF RTD investment strategy focused on infrastructural development - more than a half of the budget concentrated on the expenditure of the 02 category, and an additional 37% was a mix of the categories 01 and 02.

There is a wide consensus that the OP RDI has succeeded in its prime goal – to build, develop and modernized R&D infrastructure in the Czech Republic – and it has enabled to shift the R&D infrastructural capacities at a qualitatively different level. The OP was less successful in ensuring adequate R&D human resources that could have fully exploited all established capacities, even though this was the domain of complementary ESF OPs. Unfortunately, the OP investments were not accompanied by any principal reform of the R&D system and higher education that would have supported the investment efforts and contributed to the needed systemic changes (e.g., doctoral study).

The evaluation proved that the **policy instrument 1 Infrastructure investments into research-related teaching at higher education institutions** succeeded to fulfil its prime aim to eliminate the abysmal difference in the quantity and, in particular, quality of infrastructure for research-related education as compared to the European standards. The policy instrument enabled in conjunction with a range of complementary actions to improve higher education institutions' technological competitiveness. For some regional institutions, the support implied increased competitiveness rather within Czechia. The majority of supported institutions acquired the high-standard new or reconstructed capacities for research-related education and top-class research equipment. The increased tertiary education capacity and significant improvement in research-related teaching and research conditions were achieved at supported HEIs. Overall, "quality of life" at supported universities was increased. It is believed that tertiary education quality was improved at least to some extent (practical training on high-standard research equipment, modern and pleasant environment) jointly with other policy instruments and actions.

Moreover, the positive outcomes related to improvements in managerial, organizational and communication processes at HEIs (and the focus on energetic aspects of university real estate) were also detected. However, the intended outcome of the intervention of an increased number of PhD graduates has not been fully achieved. Nevertheless, the reasons for that lie beyond the

[58] The evalution was focused on the three policy instruments under the OP RDI and thus the assessment and general findings are attached especially to these. Other policy instruments, more important in financial and factual terms, were evaluated for example by EACE (2018).

policy instrument (i.e. in demographic decline, framework and conditions for PhD study in Czechia, the low interest of young people in a research career, rigidity in management of HEIs). The qualitative evidence nevertheless suggests that the PI contributed at least to some extent to the maintenance of a certain level of PhD graduates. Consequently, any contribution to the increased quantity and quality of human resource for R&D is less evident as Czechia still lacks sufficient human capital for research and innovations.

The infrastructure investments are considered the necessary prerequisites for the possible involvement of HEIs into the international RDI arena and the cooperation between universities and the application sector. To a certain extent, the achievements of these long-term effects were demonstrated at some supported universities by the evaluation, even though these effects cannot be attributable only to the investigated policy tool but to a number of projects and actions realized at the institutions and in the region. As an important supporting factor for the materialization of the middle and long-term effects, the existence of a regional strategic approach to the RDI development was proved. However, a more profound achievement of these effects requires more time since the interventions were accomplished.

The realization of policy instrument 1 brought about a set of not directly intended negative effects related to the polarization between the regional HEIs and Prague's HEIs despite the additionally negotiated exception for Prague for this policy instrument. As far as the **policy instrument of ICT Infrastructure investments** is concerned, outputs and immediate outcomes were, in principle, achieved, and relevant monitoring indicators were even exceeded. More questionable was the more complex level of the ToC, as some effects were verified only to a limited extent. This does not imply the policy instrument was not successful. This policy instrument had a supporting character for the R&D area, and the more complex effects can be attained only with the concurrence of other activities and causal links. Therefore, having attained intermediate or final outcomes to a limited extent should be considered for success. The only effect that was not achieved is preventing the emergence of deepening educational differences in society between regions due to the calls for proposals.

The evaluation proved that the main intended achievements of the **policy instrument of the ELI major project** were achieved to a full or important extent. The main and evident result was the considerable enlargement of research capacities in the Czech Republic with the unique quality and performance at the global level.

The investment into the excellent R&D infrastructure was a necessary precondition to the involvement of Czech research institutions in the European network and collaboration with the top research partners from abroad[59]. ELI played a key role in this process and became an example for others to follow.

Important synergies with other investments into R&D in the locality of Dolní Břežany were also factors that have supported the achievement of intended effects. This newly created research cluster[60] concentrated a critical mass of fundamental and applied research activities. It helped facilitate a change of the whole local research ecosystem, attracting excellent foreign researchers. However, it is still early to measure the impact of ELI on the national RDI ecosystem, and the competitiveness of the Czech economy as this complex investment was fully accomplished only recently. This complex and ground-breaking project needs time to settle in the ecosystem and fully develop its potential.

Although there were identified no **factors** that would have completely hindered the implementation of the analysed instruments, some of them hampered the realization of projects, complicated the project work of beneficiaries and endangered the achievement of objectives to a full extent. First, an enormous delay in the launch of the OP RDI negatively affected the entire implementation and the pressure on withdrawing at the end of the period. Unfortunately, the political and managerial instability and the vibrant expert capacity in specific RDI support elements were revealed on the Managing Authority's side during the certain implementation phases, inducing a complicated regulatory framework for applicants and

59 Not only from public research sector but also from private.

60 It is called STAR cluster (Science, Technology Advanced Region).

beneficiaries. A limited experience on beneficiaries' side was also a challenge considering they had to realize the complex investment projects without previous experience with the EU funds. The analysed policy instruments' situation was exacerbated by significant financial and content demands of supported R&D projects.
Further, as the character of RDI effects is typically long-term, the strategic parameters of the R&D system need a certain degree of stability and predictability. Unfortunately, this was not fully met in the Czech case. The criteria for the national funding of research institutions and universities changed several times over the programming period (from the focus on the number of students, then on the quality and quantity of research results, and later on the internationalization and the third role of universities) and affected the practical operation of supported projects mainly in the period of compulsory sustainability. Moreover, the country has struggled from the institutional fragmentation of responsibilities for the RDI management and from the low political commitment (e.g., as an indirect implication of the economic crisis, the government did not increase the public R&D expenditure over the period as initially anticipated beyond the compulsory co-funding of projects supported by the Structural funds).

Probably the most severe practical issues concerned the system of public procurements and state aid. Both themes suffered from similar key problems: unclear interpretation and legislation changes over the period; however, the former from the national level (Act on Public Tendering), the latter from the EU level.

The entire OP RDI and anticipated effects were strongly influenced by only very limited Prague R&D institutions' eligibility. Prague's region was not eligible for most ERDF RTD support as it was delineated for the Competitiveness Objective. Unfortunately, this delineation did not reflect Prague's central position in the tertiary education system and in the R&D structure of Czechia (the pronounced share of the country's R&D capacities were concentrated in Prague). The negative consequences of the regional targeting of the ERDF RTD support concern in particular:

- A distortion of R&D structure of the Czech Republic: while the regional HEIs and regional RDI capacities were dynamically developing, Prague's capacity and infrastructural deficit pertained over the period;
- A more favourable position of the supported HEI's in the "competition" for (talented) students due to modernized infrastructure in the regions;
- As Prague's organizations were excluded from the national competition for the OP RDI sources, it can be assumed that to a certain extent, the OP RDI support was also provided to projects that would not have succeeded if Prague's R&D organizations would have participated.

It thus appears that the excessive focus on the territorial cohesion objective of convergence regions most probably threatened a potential for positive effects from the OP RDI as a whole for Czechia as the whole country. Consequently, the ERDF RTD support potential was most probably underutilized (in terms of territorial cohesion at a higher level, i.e., towards the EU). On the other hand, the OP RDI proved to be a qualitative change catalyst for some convergence regions. This is apparent in terms of a launch of the new development phase of some regions, based on knowledge and innovations. This OP provided adequate sources to "move the needle" the infrastructure basement (e.g., Jihomoravský, Olomoucký and Moravskoslezský regions). However, the proven achievements of cohesion "catch-up" of these regions and the macroeconomic perspective impacts can be expected in the much longer-term than this evaluation can provide. The important aspect is that science, research, and development demonstrate the immense inertia in the cumulation of knowledge. Any changes in the deeply-rooted regional patterns will take an indeed long time (generations).

The **sustainability** of all analysed policy instruments depends dominantly on public resources. The sustainability of invested infrastructure within the PI1 throughout compulsory sustainability was ensured with internal sources of supported HEIs without severe challenges. However, questions arise as concerns the sustainability of acquired technological competitiveness and thus related to the needed sources for a gradual upgrade of the purchased equipment. Also, HEIs and the state have to systematically address the declining trend in the number of (PhD) students to ensure that created capacities will be efficiently used.

Also, within the policy instrument ICT Infrastructure investments, no issue was reported with project results' sustainability. Acquired services were sustained for beneficiaries of electronic

information resources and ICT infrastructure as well. After the sustainability period, for electronic information resources, the system was centralized into the National Centre for Electronic Information Resources CzechELib.

On the other hand, the sustainability of the large excellence R&D infrastructures newly developed thanks to the OP RDI remains the key issue for the future. The MA was aware of that, and therefore they emphasized, quality, international relevance, and connection to the European research network during the preparatory phase of projects. These new excellent international R&D infrastructures have created a strong commitment to public budgets (on the national and European level) because they predominantly rely on public financing. The overwhelming majority of projects are not sustainable without public financing. This is valid for all projects funded under the Priority Axis 1 of the OP RDI, not only the ELI project. In order to ensure the period of compulsory sustainability, the national programmes of sustainability for newly created research centres were opened and funded from the state budget. However, this is not a long-term sustainable solution. The management of these new R&D infrastructures will have to focus on the diversification of funds for operation and further development. It will have to rapidly increase the volume of industry cooperation, set up their own spin-off companies and use other ways how to get financial resources from the private resources and commercial activities.

The evaluation confirmed that without the ERDF RTD support, the infrastructure investments into the majority of supported institutions would have never been realized in this scale and time-space. Therefore, the **ERDF funding (EU added value) role was irreplaceable** in the Czech Republic casa. Some of the supported projects of Centres of excellence (incl. ELI project) (and a couple of regional competence research centres funded from the Priority Axis 2) significantly improved the added value of science and research capacities at the European level. They became an important part of the European network with the high intensity of international research activities. For example, ELI successfully overcame the initial issues in establishing the consortium and now attracts new countries like Germany, France or Lithuania as observing partners of ELI consortium.
Further, it can be mentioned that in the USA, new development projects for public research use of lasers were stopped due to the already existing ELI infrastructure. Instead of that, they will use the ELI facilities for testing and collaborative research. This enabled to rapidly enhance the added value of EU research capacities in the worldwide competition. Besides, investments into the HEIs infrastructure undermined the enhancement of international R&D cooperation and production of top-ranked research results, as confirmed by the interviewed universities.

ANNEX I. OVERVIEW OF EVIDENCE COLLECTED ON EXPECTED EFFECTS OF THE INFRASTRUCTURE INVESTMENTS INTO RESEARCH-RELATED TEACHING AT HIGHER EDUCATION INSTITUTIONS POLICY INSTRUMENT

Effect type	Expected effect	Targets defined by MA	Summary of evidence collected	Level of achievement of threshold
Outputs	Reconstructed or newly built infrastructure for research-related teaching (buildings, classrooms, labs)	YES Supported projects – R&D teaching-related infrastructure – 20 projects Area capacity designated to R&D teaching and activities – 70,000 m² (1st OP version), 270,000 m² (last OP version)	**Monitoring indicators**: Based on the information in the Final report on the realization of the OP RDI, the indicator of supported projects in R&D teaching-related infrastructure reached 65 out of which 62 projects were under the scrutiny of this evaluation. Further, the Area capacity designated to research-related teaching built or modernized thanks to this PI is 419,099 m². **Interviews:** All interviewees agreed that the policy instrument enabled to upgrade underfunded infrastructure from the past and shift, especially regional public HEIs at a new qualitative level that is internationally competitive. Such massive investments would not have been realized without the ERDF support. **Desk research:** The paper of Růžička and Voráček (2019) assessed the investments into HEIs' infrastructure and concluded that thanks to these investments (including support from PA1 and PA2), one of the most serious handicaps of Czech universities in comparison to the Western countries – that of insufficient infrastructure and instrument equipment for R&D – was balanced.	TO A FULL EXTENT
	Modernised equipment of research-related infrastructure (instruments and lab equipment, ICT infra, improvement of material and technical provision)	YES (same as above) Supported projects – R&D teaching-related infrastructure – 20 projects Area capacity designated to R&D teaching and activities – 70,000 m² (1st OP version), 270,000 m² (last OP version)	**Monitoring indicators**: Based on the information in the Final report on the realization of the OP RDI, the indicator of supported projects in R&D teaching-related infrastructure reached 65 out of which 62 projects were under the scrutiny of this evaluation. Further, the Area capacity designated to research-related teaching built or modernized thanks to this PI is 419,099 m². **Interviews:** All interviewees agreed that the policy instrument enabled to upgrade underfunded infrastructure from the past and shift, especially regional public HEIs at a new qualitative level that is internationally competitive. Such massive investments would not have been realized without the ERDF support. **Desk research:** The paper of Růžička and Voráček (2019) assessed the investments into HEIs' infrastructure and concluded that thanks to these investments (including support from PA1 and PA2), one of the most serious handicaps of Czech universities in comparison to the Western countries – that of insufficient infrastructure and instrument equipment for R&D – was balanced. Purchased equipment was summarized in Final monitoring reports for projects.	TO A FULL EXTENT

Immediate outcomes	Increased capacity of tertiary education infrastructure	YES Students benefiting from new/reconstructed infrastructure – 50,000 (1st OP version), 100,000 (last OP version) PhD students benefiting from new/reconstructed infrastructure - 5,000 (1st OP version), 8,000 (last OP version)	**Monitoring indicators**: The monitoring indicators at the Priority Axis level covering students benefiting from new/reconstructed infrastructure and PhD students were exceeded more than twice – 213,481 students, respectively 21,044 PhD.	TO A FULL EXTENT
	Significant improvement of conditions for research-oriented teaching and research itself	NO	**Interviews:** All interviewees agreed the policy instrument enabled to upgrade underfunded infrastructure from the past and shift, especially regional public HEIs to a new qualitative level. Similarly, substantial improvements in research-related teaching and research conditions were reached: supported projects purchased needed equipment and created a comfortable and respectable environment for teaching and studying related to research. **Desk research:** Purchased equipment was summarized in Final monitoring reports of projects. The effect is also reported in the paper of Růžička and Voráček (2019).	TO A FULL EXTENT
Intermediate outcomes	Increased attractiveness of supported particularly regional universities	NO	**Interviews:** The effect of increased attractiveness od supported all relevant interviewees confirmed hEIs.	TO A FULL EXTENT
	Increased number of post level graduates	YES (at OP level) Number of post-graduate students in the convergence region – 1,700	**Monitoring indicator**: The target set at the OP RDI level of 1,700 PhD graduates was not fully achieved (in 2017, it was reached 1,387). **Interviews:** All consulted interviewees agreed that apart from the reason of demographic decline in the respective population cohort, more fundamental reason for not reaching this outcome has been the low rate of PhD study completion undermined by constantly unfavourable systemic conditions for doctoral study in the Czech Republic. Nevertheless, the interviews confirmed that without the ERDF support, the decline in the number of PhD graduates would have been even greater.	TO AN LIMITED EXTENT
	Increased quality of tertiary education leading to improved skillsets of graduates and young researchers	NO	**Interviews**: All interviewed representatives of beneficiaries validated to full extent that modernized infrastructure enabled to increase the quality of education (e.g. increased capacity and improved instrumental equipment are widely used in practical training, students can work with high-quality equipment that is used in companies, and eventually they are better prepared for the needs of the labour market, mostly PhD students are more involved in the realisation of research projects). Some interviewees also confirmed that thanks to new equipment,	TO A FULL EXTENT

			students' final thesis's quality has been significantly increased, and interesting research topics with practical relevance have occurred. However, no systemic analysis of the state-of-art of graduates' competencies is at disposal for the supported HEIs.	
Final outcomes	Improvements in internal management of public HEIs (incl. third role of universities)	NO	**Interviews:** At all interviewed supported universities (also by contextual interviewees), the following aspects of internal managerial improvements were confirmed: (i) Development managerial, organizational and communication processes within the supported organizations and changes in process management of public tenders; (ii) Establishment/enlargement of professional project management teams at faculty/university levels; (iii) Acquirement of know-how of project thinking, know-how to prepare, realize and accomplish large investment projects; (iv) Development of a strategic approach to prioritization of investment intentions at HEIs (e.g. via passportization of investment needs); (v) Increased thinking about energetic demands of university real estate at supported HEIs. Furthermore, at some universities, the strengthening of the third role of the university was confirmed.	TO A FULL EXTENT
	Increased quantity and quality of RDI human resources at labour market	Partially (at OP level) Number of post-graduate students in the convergence region – 1,700	**Monitoring indicator:** The target value of PhD graduates at supported institutions (not only by this PI) was not fully reached. It can be anticipated that the needed human resources in the R&D sector are thus missing (also approved by the analysis of Ernst&Young 2020). **Interviews:** As pointed out above, interviewees agreed on the increased quality of graduates in some fields; however, from a wider point of view, it is not possible to confirm the effect.	TO AN VERY LIMITED EXTENT
	Involvement of supported HEIs into international R&D space increased	NO	**Interviews:** All interviewed beneficiaries stated the ERDF investments from this PI had brought technological upgrade that created competitive conditions for the Czech HEIs in the international R&D arena. Some of the well-ranked benefited universities confirmed to increase its attractiveness and competitiveness for international research partners and programmes, the growth of projects receiving the Horizon2020 funding and other prestigious grant schemes. However, it is important to bear in mind that these achievements were not enabled by a sole ERDF project under this PI but with the help of the other ERDF/other sources investments at particular university/in the region. Furthermore, the occurrence of the final outcome has been achieved at a limited number of interviewed HEIs. **Desk research:** Overall, the success rate fo the Czech Republic in Horizon2020 or other European RDI programmes remains still low (Pazour et al., 2018).	TO A LIMITED EXTENT

	Acceleration of cooperation between HEIs and application sectors	NO	**Interviews:** All interviewed beneficiaries stated the ERDF investments from this PI had brought technological upgrade that created competitive conditions and space for cooperation with the private sector at the ERDF supported Czech HEIs. However, it is important to highlight that these achievements were not enabled by a sole ERDF project under this PI but with the help of the other ERDF/other sources investments at a particular university/in the region. Furthermore, the final outcome has been achieved at the majority of interviewed HEIs. Still, this evidence does not provide a sufficient base for an overall assessment at the PI's level. **Desk research:** Analysis of Růžička and Vondrák (2019) indicates that at the universities also supported by this PI, the share of income from contracting research has increased at regional technical universities in particular between 2012-2017. Importantly, on this achievement, ERDF investments from another Priority Axes had a much greater impact.	TO A LIMITED EXTENT
	Spillover effects from Prague's supported HEIs to the convergence regions		**Interviews:** Some interviewees confirmed that in their expert views, these spillover effects had been materialized. Similarly, in Prague's interviewed HEI, it was confirmed that spillovers effects are present there as the majority of its cooperating companies is based in the convergence regions. However, these statements are rather a piece of anecdotal evidence and cannot provide a sufficient confirmation level. Overall, all anticipated aspects of the spillovers could not have been verified within this evaluation's scope; thus, the level of achievement is unknown.	UNKNOWN
Impact	Development of knowledge-based economy and society and strengthening of the long-term competitiveness of the Czech RTD system and economy	NO	No evidence of the contribution of the PI to this impact was possible to collect.	UNKNOWN

ANNEX II. OVERVIEW OF EVIDENCE COLLECTED ON EXPECTED EFFETS OF THE ICT INFRASTRUCTURE INVESTMENT POLICY INSTRUMENT

Effect type	Expected effect	Targets defined by MA	Summary of evidence collected	Level of achievement of threshold
Outputs		YES/NO	Text justification	TO A FULL EXTENT/TO AN IMPORTANT EXTENT/TO A LIMITED EXTENT
	New, developed or modernised information infrastructure for R&D (esp. repositories, optical network, network optical elements, storage capacities, SW, licenses, database)	PARTIALLY - defined an indicator: 132500 Number of supported information infrastructure projects for R&D - two projects were planned, and three supported Target: 2 projects / attained: 3 projects	**Task 1 data**: funding was distributed in three projects within the respective call for proposal. **Desk research**: details on projects and respective call for projects in Final Report OP RDI, project documentation of one of three projects. **Interviews**: interviewees confirmed that listed outputs were purchased.	TO A FULL EXTENT
	Electronic information resources, licenses, renewal of HW, SW and networks, equipment of libraries, trained researchers and other users of information resources	PARTIALLY - defined an indicator: 111400 Number of supported projects of professional scientific and branch libraries Target: 4 projects / attained: 10 projects	**Task 1 data**: funding was distributed in seven projects within the respective call for proposal, including this policy instrument. **Desk research**: details on projects and respective call for projects in Final Report OP RDI, project documentation of two of seven projects. **Interviews**: interviewees confirmed that listed outputs were purchased.	TO A FULL EXTENT
Immediate outcomes	Higher storage, computational and information capacities of R&D institutions	NO	**Desk research**: details on projects and respective call for projects in Final Report OP RDI, project documentation of one of three projects. **Interviews**: interviewees confirmed that provided services were developed or modernized and some new services established.	TO A FULL EXTENT
	Effective and rational management of the system (distributed system, i.e., shared management of computational, storage and information capacities)	PARTIALLY - defined an indicator: 132400 "Number of entities using information infrastructure services for R&D" Target: 65 entities / attained: 113 institutions	**Desk research**: indicators in the Final Report OP RDI, Final Report of one of three projects. **Interviews**: interviewees confirmed distributed system of relevant capacities.	TO A FULL EXTENT
	Improved availability of	NO	**Desk research**: details on projects and respective call for	TO A FULL EXTENT

Effect type	Expected effect	Targets defined by MA	Summary of evidence collected	Level of achievement of threshold
	scientific information resources, including for the general professional public (long-term guaranteed availability)		projects in Final Report OP RDI, project documentation of two of seven projects, web pages of some projects. **Interviews**: interviewees - beneficiaries were unambiguously convinced that the availability of scientific information resources was improved. Confirmed by an interview with the MA.	
	Increasing information literacy	NO	**Desk research**: details on some projects in project documentation of two of seven projects, web pages of some projects – some projects followed a number of downloaded full texts, number of hits, the figure is in thousands (documentation was available for two projects). **Interviews**: interviewees pointed out to partly increased information literacy for information literacy focused on resources research. It is linked to realized educational workshops funded by projects. Note: projects could have contributed only to a limited extent to overall literacy; no activities supporting general literacy were realized.	TO A LIMITED EXTENT
	Efficient, modern and user-friendly use of acquired information sources at the European level	NO	**Desk research**: details on some projects in project documentation of two of seven projects, web pages of some projects – some projects followed a number of downloaded full texts, number of hits, the figure is in thousands (documentation was available for two projects). On-going evaluation of the OP RDI (2014) **Interviews**: interviewees confirmed the quality of available resources, compared the situation with the European level and described discovery systems, enabling user-friendly use.	TO A FULL EXTENT
Intermediate outcomes	Integration of Czech R&D institutions into the European Research Area	NO	**Desk research:** confirmed quality of cooperation within the ERA in the Annual report of the beneficiary. **Interviews**: interviewees of already integrated institution considered the quality of integration of Czech R&D institutions into the ERA as a full-fledged, however direct influence on the integration of other institutions was not confirmed.	TO A LIMITED EXTENT
	Strengthened and more intensive cooperation of R&D institutions	PARTIALLY - two relevant indicators: 111401 Number of involved partners / cooperating organizations of professional scientific and branch libraries Target: 60 organizations / attained: 84 organizations 132400 "Number of entities using	**Desk research:** relevant indicators, Final report on OP RDI. **Interviews**: interviewees confirmed cooperation between libraries aimed at the preparation and realization of projects. Partly was supported cooperation with the ERA.	TO A LIMITED EXTENT

Effect type	Expected effect	Targets defined by MA	Summary of evidence collected	Level of achievement of threshold
		information infrastructure services for R&D" Target: 65 entities / attained: 113 institutions		
	Preventing the emergence or deepening of educational differences in society between regions	NO	No evidence was collected; even more, opposite effects threatened without national intervention.	TO NO EXTENT
	Stimulation of interest in R&D	NO	Supported projects improved conditions for Czech science; even more ICT infrastructure enables interconnection with the ERA. However, there is no direct evidence that these projects directly influenced the stimulation of interest in R&D.	UNKNOWN
	Popularization of science and raising awareness of its results	NO	Supported projects improved conditions for Czech science; even more ICT infrastructure enables interconnection with the ERA. However, there is no direct evidence that these projects directly influenced the popularization of science and awareness of its results.	UNKNOWN
Final outcomes	Higher efficiency of Czech R&D (i.e., successful implementation of R&D activities culminating in significant / quality results)	NO	**Desk research**: on-going evaluation OPRDI (2015) argues, based on interviewees with some researches, that thanks to electronic resources, they can produce impacted articles more easily. **Interviews**: interviewees were rather cautious and were not at one. Some of them pointed out to spared time thanks to available discovery systems. In general, electronic information resources and ICT were highlighted as fundamental condition for science.	TO A LIMITED EXTENT
	Better applicability of Czech science in the world	NO	Supported projects improved conditions for Czech science; even more ICT infrastructure enables interconnection with the ERA. However, there is no direct evidence that these projects directly influenced Czech science's applicability in the world.	UNKNOWN
Impact	Economic development, competitiveness, innovation and excellent research capacities of the territory	NO	No evidence was collected.	UNKNOWN

ANNEX III. OVERVIEW OF EVIDENCE COLLECTED ON EXPECTED EFFETS OF THE ELI: EXTREME LIGHT INFRASTRUCTURE POLICY INSTRUMENT

Effect type	Expected effect	Targets defined by MA	Summary of evidence collected	Level of achievement of threshold
Outputs		YES/NO	Text justification	TO A FULL EXTENT/TO AN IMPORTANT EXTENT/TO A LIMITED EXTENT
	Building new research facility	YES Reconstructed, expanded and newly built capacities (30 887 m^2) Newly built capacities (30 887 m^2)	**Monitoring indicators:** Based on the MA (MEYS) information in the Table of Monitoring indicators in projects of OP RDI, the proposed area of new and reconstructed capacities was achieved. **Interviews:** Public stakeholder (locality of ELI site) confirmed that the ELI facility was built on a land that had been an agriculture brownfield before.	TO A FULL EXTENT
	Purchase and development of new technologies, instrumentation and laboratory equipment	NO	**Interviews**: Based on the information from interviews, instrumentation, laboratory and laser technology equipment were co-developed in cooperation with suppliers and members of the ELI-ERIC consortium. Delivery of equipment was a bit postponed in time, and the full operation was delayed.	TO AN IMPORTANT EXTENT
Immediate outcomes	Established research teams and leaders of research programmes	YES Number of newly created jobs, total researchers (101)	**Monitoring indicators:** Based on the MA (MEYS) information in the Table of Monitoring indicators in projects of OP RDI, the number of newly created research jobs was 110 (in 2015). Thus, the value was achieved.	TO A FULL EXTENT
	Start of the specific research projects and experiments	YES Number of cooperation projects of the application sphere with	**Interviews**: Based on the information from interviews, ELI research teams are well	TO AN IMPORTANT EXTENT

Effect type	Expected effect	Targets defined by MA	Summary of evidence collected	Level of achievement of threshold
		centres of excellence (no target value)	connected to international research projects and domestic ones. **Desk research**: According to the MEYS (2015), there were 9 submitted projects from FP7 and 2 project proposals from Horizon 2020 prepared by ELI already by the end of 2015. And this number increased in the following years once the infrastructure was nearing its full operation	
	Established strategic international partnership with top research institutions	YES Volume of funds for R&D obtained from foreign sources (EUR 3 m)	**Monitoring indicators:** Based on the MA (MEYS) information in the Table of Monitoring indicators in projects of OP RDI, the volume of funds obtained from foreign sources (which indicates international cooperation on projects with other research institutions) was achieved to even higher extent. **Interviews**: Based on the information from interviews, international cooperation is very strong and considered one of the evident positive results.	TO A FULL EXTENT
	Increased capacity for excellent research on a global level	NO	**Interviews**: Based on the information from interviews, the capacities for top quality international research and testing activities in photonics and laser area were reasonably increased.	TO A FULL EXTENT
Intermediate outcomes	International open-calls for proposal for using the ELI Beamlines research facility.	NO	**Interviews**: Based on the information from interviews, the international open calls for using laser beamtime for the scientific and research community started a couple of	TO A LIMITED EXTENT

Effect type	Expected effect	Targets defined by MA	Summary of evidence collected	Level of achievement of threshold
			years after completing the project. During this year, this open calls for proposals are limited by the situation with covid-19.	
	Publications, patents and participation in national and international research project.	YES Professional publications (according to the RVV methodology) - **129**	**Monitoring indicators:** Based on the information provided by the MA (MEYS) in the Table of Monitoring indicators in projects of OP RDI, Professional publications (according to the RVV methodology) was achieved to an even higher extent (151). **Desk research**: According to the MEYS (2015), there were 9 submitted projects from FP7 and 2 project proposals from Horizon 2020 prepared by ELI already by the end of 2015. And this number increased in the following years once the infrastructure was nearing its full operation Moreover, in the 2nd phase (which wasn't part of OP RDI), ELI produce patents and utility models.	TO AN IMPORTANT EXTENT
	Collaboration with applied sphere.	NO	Collaboration with the applied sphere was not the main goal of the project. In parallel with the ELI project, IoP also worked on HiLASE, a laser research centre focusing on applied research.	TO A LIMITED EXTENT
	Training of young scientists with more international experience	YES Number of newly created jobs, researchers under 35 - **54** Number of newly created jobs, researchers under 35 – women - **0** Number of successful graduates	**Monitoring indicators:** Based on the information provided by the MA (MEYS) in the Table of Monitoring indicators in projects of OP RDI, Number of newly created jobs, researchers under 35 (women) and Number of	TO A FULL EXTENT

Effect type	Expected effect	Targets defined by MA	Summary of evidence collected	Level of achievement of threshold
		of master's and doctoral study programs - **7** Number of successful graduates of doctoral study programs. - **7**	successful graduates of master's and doctoral study programs (women) were achieved to even higher extent (all above 20 % over target value, women even more (target value 0, achieved value almost 12)	
	Improved knowledge of partner organisations and increased ability of applicant and beneficiary partners to cooperate	NO	**Interviews**: Interviewers from ELI management mentioned that ELI (also due to colocation with HiLASE) attracted several partners from the business and public sector. However, due to the delays during the constructions and laser building, the potential of ELI is still not fulfilled.	TO A LIMITED EXTENT
Final outcomes	Functional international consortium of ELI-ERIC	NO	**Interviews**: Interviewers from ELI management mentioned that there are still on-going negotiations about the final set-up of the ELI-ERIC consortium. Even though the cooperation between the consortium members has been intensive since the preparatory phase, in 2020, the Czech Republic, Italy, Latvia and Hungary asked EC to establish this legal entity officially. ELI ERIC will support the common management of all ELI sites.	TO A LIMITED EXTENT
	Long-term and continual collaboration with both research and application partners	YES (Proportion of capacities of new infrastructures used by other entities) (Volume of contract research) Both indicators with no defined target values	**Interviews**: Interviewers confirmed what has been investigated during desk research. There are strong linkages with both industry and academic partners already established. Concerning the prevailing nature of the	TO A LIMITED EXTENT

Effect type	Expected effect	Targets defined by MA	Summary of evidence collected	Level of achievement of threshold
			research (fundamental), the broader long-term collaboration will be crucial for the next period	
Impact	Economic development, competitiveness, innovation and excellent research capacities of the territory	NO	Due to the limited scale and focus of the evaluation, there was no evidence collected in that area. Only some indices that ELI project created good possibilities to make such an impact in the next decades.	UNKNOWN

ANNEX IV. INTERVIEW LIST

Stakeholder category	Organisation (current)	Role in the organization (current)
MA - implementation structure	Ministry of Education, Youth and Sports	Director of Department of Projects Administration
MA - implementation structure	Ministry of Education, Youth and Sports	Evaluator
MA - implementation structure/thematic expert/regional stakeholder	South Moravian Innovation Centre	Director for strategy, CSO
Thematic and regional expert	South Moravian Innovation Centre	Director, CEO
MA - implementation structure	Ministry of Agriculture	Head of unit
Thematic expert/scientist	Technology Agency of the Czech Republic	Director
Thematic expert	Technology Centre of Czech Academy of Sciences	Head of Department of Strategic Studies
MA - implementation structure/thematic expert	Ministry of Industry and Trade	Professional staff
Beneficiary	CESNET	Project manager
Beneficiary	CESNET	Deputy director
Beneficiary	Palacký University Olomouc, library	Director
Beneficiary	Tomas Bata University in Zlín, library	Director
Regional stakeholder	Municipality of Dolní Břežany	Mayor
Beneficiary	ELI	Director
Beneficiary	ELI	Transfer technology manager
Regional stakeholder	Star Region; HiLASE	Director; Marketing and project manager
Beneficiary	Institute of Physics	Researcher
Business owner/thematic expert	Crytur	Owner, CEO
Beneficiary	The University of Chemistry and Technology	Project leader
Beneficiary	The University of Chemistry and Technology	Project manager
Beneficiary	Brno University of Technology	Bursar of university
Regional stakeholder/thematic expert	South Moravian Innovation Centre	Manager of RIS3
Beneficiary	Technical university in Liberec	Project manager
Beneficiary	University of Ostrava	Project manager
Thematic expert	Independent expert	Independent thematic expert
Beneficiary	Mendel University in Brno	Director
Beneficiary	Masaryk University in Brno	Head of the Cybersecurity and Data Management Division
Beneficiary	Hospital Ústí nad Labem	NA
Beneficiary	Jan Evangelista Purkyně University in Ústí nad Labem	Dean of the Faculty of Mechanical Engineering
Beneficiary	Tomas Bata University in Zlín	Project manager
Beneficiary	Tomas Bata University in Zlín	Bursar of university
Beneficiary	Tomas Bata University in Zlín	Dean of the Technological Faculty
Beneficiary	University of West Bohemia - library	Director
Thematic expert	Technologické centrum AVČR Národní informační centrum pro evropský výzkum	Horizon 2020 National Contact Point
Beneficiary	Masaryk University in Brno, library	Librarian

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KN-06-21-210-EN-N

Publications Office
of the European Union

ISBN: 978-92-76-45982-8