Croatia Public Expenditure Review in Science, Technology and Innovation

EX POST EVALUATION OF CROATIA'S S3 POLICY FRAMEWORK

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Ex Post Evaluation of Croatia's S3 Policy Framework

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Note

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Acronyms and Abbreviations

BERD	business expenditure on R&D
CROQF	Croatian Qualifications Framework
CS-DiD	Calloway-Sant'Anna difference-in-differences
CSF	Croatian Science Foundation
DDML	Double Debiased Machine Learning
DiD	difference-in-differences
HRZZ	Croatian Science Foundation
ERA	European Research Area
ERC	European Research Council
ESIF	European Structural and Investment Funds
EU	European Union
EUR	Euro (currency)
FTE	full-time equivalent
GDP	gross domestic product
GERD	gross expenditures on R&D
HAMAG-BICRO	Croatian Agency for SMEs, Innovations, and Investments
HRST	human resources in science and technology
HRZZ	Croatian Science Foundation
IPR	Intellectual property rights

M&E	monitoring and evaluation
MESD	Ministry of Economy and Sustainable Development
MO	main objective
MRDEUF	Ministry of Regional Development and EU Funds
MSE	Ministry of Science and Education
NIC	National Innovation Council
NRRP	Croatian National Recovery and Resilience Plan 2021–2026
PRO	public research organization
R&D	research and development
RCT	randomized controlled trials
RDI	research, development, and innovation
S3	Smart Specialization Strategy
SME	small and medium enterprise
SO	specific objective
STI	science, technology, and innovation
STPA	sub-thematic priority area
ToC	theory of change
TPA	Thematic Priority Area
TRL	technology readiness level
TTO	technology transfer office
WB	World Bank

Executive Summary

In recent years, Croatian policymakers have been intensively exploring opportunities to increase the effectiveness of public spending for science, technology and innovation. The country's research sector performance has been subpar, investments in research and development (R&D) have been lagging and innovation performance has been muted. With EU accession there has been a significant increase in the amount of public funds available for research and innovation investments. In order to improve the outcomes of those investments, the Ministry of Science and Education (MSE), in cooperation with other ministries and innovation policy stakeholders, initiated extensive analytical work to examine the needs of the innovation system, uncover gaps in the targeting of funds, their design, implementation, governance, cost efficiency, monitoring and evaluation (M&E) and effectiveness.

This report presents the findings of the final (ex post) evaluation of the central research and innovation funding mechanism in Croatia—the Smart Specialization Strategy (S3) 2016–20. The S3 2016–20 provided access to the largest funding envelope for RDI projects in Croatia's history. The funding was provided through a portfolio of instruments that aimed to enhance knowledge and innovation capabilities to boost economic competitiveness, including through five specific investment areas (Thematic Priority Areas or TPAs).

The first part of the evaluation uses various analytical tools to evaluate the results of selected S3 instruments. The analysis covers seven S3 programs, representing a budget of over EUR 400 million or 42 percent of the total budget for S3 instruments. The analysis includes a survey of applicants, a before-and-after analysis, and a counterfactual impact evaluation of selected outcomes. We selected the programs based on the feasibility of conducting an evaluation, subject to program design and data availability constraints.

The second part of the evaluation analyzes results against the monitoring indicators and targets defined in the S3 and reviews the evolution and quality of the S3 governance. The analysis of the S3 monitoring indicators and governance structure takes stock of the results associated with the S3 against set targets without attempting to establish a causal relationship between the two. Finally, the report reviews the evolution of S3 governance since the midterm evaluation in 2021.

Analysis of selected S3 instruments

This part of the report covers instruments that are likely to continue being funded in the future, and for which an analysis was deemed feasible based on their design and data availability constraints. Among the analyzed instruments, two are directed only to research organizations, two are implemented in partnership between research organizations and firms, and three are grants to firms. The two instruments supporting research organizations provided funding for research projects focusing on applied R&D. Instruments implemented in partnerships between research organizations supported applied R&D projects of research organizations, implemented in mandatory partnership with firms, as well as firms' R&D projects to develop new products or processes, in optional partnerships with research organizations. Finally, instruments supporting firms provided funding for commercialization of innovations, commercialization in newly-established firms, and vouchers for innovation services.

Severe data challenges limited the analysis to a review of programs, and its findings cannot be equated with what would come out of a rigorous evaluation. The analysis in this report primarily relies on program application data, financial reporting data, and online databases. Although the MSE provided all the data requested, the Ministry of Economy and Sustainable Development (MESD) provided only lists of beneficiaries and non-beneficiaries and their partners. Moreover, the Croatian Science Foundation (CSF) shared no data except what was already publicly available. These limitations on data made the evaluation very difficult. It particularly limited the counterfactual impact analysis, which is a data-intensive process. Due to small sample sizes, we had to pool the programs to achieve sufficient statistical power. This process sacrificed some specificity in terms of recommendations. In addition, we deployed surveys for researchers and firms to collect additional information not in administrative records. The survey had a relatively low response rate, and we could not use the collected data in the impact evaluation. Nevertheless, it is presented in the report as part of the overall evaluation. Finally, not all projects were completed at the time of the analysis. Because innovation outcomes take some time to materialize, the results must be considered preliminary.

Analysis of S3 instruments on researchers' outcomes

Although researchers remain focused on publication outcomes, they also appear to be making promising steps toward intellectual property protection. The number of publications reported by researchers went up over time, particularly from 2017 onward. Funded researchers published at a higher rate than non-funded researchers, and the rate of publications went up faster for funded researchers than unfunded ones. Publishing scientific papers was one of the most frequently reported outcomes among firms. Although the analysis did not find a statistically significant impact of programs on publication quantity and quality, this result may change because papers take some time to get published and accumulate citations. Around a third of researchers who responded to the survey reported submitting patent applications due to their projects. The counterfactual impact evaluation found that two programs supporting researchers (Science and Innovation Investment Fund—SIIF and Strengthening Capacities for Research, Development, and Innovation—STRIP)[1] resulted in about 70 percent more patent applications by beneficiaries than non-beneficiaries. Although this estimate should be interpreted cautiously due to the small sample size, it signals to policymakers that efforts to stimulate intellectual property

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1 The program to support Centers of Research Excellence (ZCI) could not be included in the impact evaluation analysis because all proposed projects were funded, so no adequate control group could be formed.

protection may have been fruitful. Applicants to the STRIP program had the most granted patents (83 patents), whereas SIIF applicants had the highest success rate (65 percent).

Establishing collaborations between researchers and firms appears to be challenging. Researchers tend to collaborate with other researchers and research organizations, whereas collaborations with firms are more concentrated around large research organizations. Researchers reported six collaborations with research organizations, 21 collaborations with individual researchers and three collaborations with firms. Firms report fewer collaborations with researchers (a little over one per firm). Establishing long-term collaborations is among the most often reported project outcomes. Regarding collaboration with the private sector, we draw conclusions from the STRIP program because it included mandatory collaborations in its program design. STRIP applicants mainly partnered with micro and small firms, though many also collaborated with large firms. Collaboration networks tend to concentrate around a few prolific research organizations in terms of the number of submitted applications. Although this may be a function of the small number of firms with the capacity and willingness to engage in R&D, it may also indicate difficulties for new entrants to become part of these established networks.

Researchers require more support to develop and commercialize their inventions. Researchers averaged around one product or process innovation, more than design innovations. However, researchers commercialized only one in two product innovations and one in three process innovations. Researchers rarely reported achieving commercialization outcomes, such as establishing a spin-off or developing a commercialization strategy, because of their projects. Non-funded researchers reported about half the number of collaborations with research organizations and firms compared to funded researchers, and about 30 percent fewer collaborations with other researchers.

Evaluation of the effect of S3 instruments on firms' outcomes

Intellectual property protection of innovations in firms is lagging. Firms report developing over one product or service innovations on average. Firms commercialize about half of the developed innovations but seek intellectual property protection for only 28 percent. Many of the developed innovations (65 percent) were reported to be green or sustainable. Interestingly, unfunded firms reported developing, commercializing and protecting more innovations than funded firms. Over 60 percent of survey respondents reported outcomes that could be associated with early stages of innovation, such as acquiring new knowledge, generating applied research outputs, and articulating ideas for new research projects. Few firms reported intellectual property protection outcomes or outcomes related to preparation for market entry.

Younger and smaller firms face barriers to accessing public financing for innovation, which may hinder productivity gains. Some data suggests that funded firms had a stronger financial position and more intangible assets even before the programs started. Although this may result from program design intentionally selecting firms larger, more mature firms with more robust implementation capacities, it may also reflect the overall complexity inherent in the application process and project implementation. However, younger and smaller firms have a strong argument for receiving public support, as they face many market and system failures and have the strongest potential for productivity gains as a result of R&D investment.

Early findings of the impact analysis of selected S3 programs on firms suggest short-term effects on increasing revenues and intangible assets but also increasing costs, which may be an initial consequence of expanding operations because of the grant. In some sense, this is expected because the grants initially provide room to expand firm operations, increasing costs without necessarily having an immediate effect on revenues. This effect seems largely consistent across programs, though it is challenging to draw program-level conclusions due to small sample sizes. Nevertheless, the long-term effects should be closely monitored.

Analysis of the S3 monitoring indicators and governance system

Assessment of S3 monitoring results

Croatia reached most of the output targets set in the S3, but more than half of the outcomes are yet to be achieved or are missing data. Although there were delays and challenges with launching some instruments, limiting progress in 2020, the targets for most outputs have already been reached or will be achieved by the end of 2023. Targets were exceeded, among others, in the number of RDI infrastructure projects supported, scientific production, and in the number of projects supporting collaboration between research organizations and enterprises and introducing new products. Figures on outcomes are less favorable, and most targets have not been met, or data is missing. As for the outcomes tracked through the revised monitoring framework, the data availability is limited because the timepoints of three and five years upon completion have not yet been reached for most programs.

There have been improvements regarding tracking progress in S3 Thematic Priority Areas (TPAs), but the progress is difficult to contextualize due to a lack of specificity in TPA scope and objectives. During the S3 implementation, the number of instruments for which TPA-level data is available increased. In some cases, policy makers conducted ex post analysis to analyze the attribution of the funded projects to S3 TPAs, providing a more comprehensive picture of TPA achievements. The image, however, is blurry due to the lack of detailed information about TPA scope and quantified TPA objectives. Nevertheless, it appears that TPA Energy and Sustainable Environment, TPA Transport and Mobility, and TPA Health and Quality of Life excel in most indicators compared to the overall progress made for the programs where TPA data is available.

S3 governance evolution and quality

Although some S3 governance improvements are planned, the overall architecture, especially for implementation governance, seems to have remained in place. Some advances in streamlining the governance structures are planned, especially at the policy governance level. The MSE has implemented many improvements in M&E processes, particularly by introducing new instruments that feature revamped results frameworks and theories of change and by upgrading the tracking of TPA-level progress. However, implementation governance, which refers to the governance of funding instruments remains highly fragmented and rigid. The process of S3 adoption has yet again been lengthy, which is a shortcoming from the governance perspective. The momentum gained in the entrepreneurial discovery process during the preparation of the S3 seems to have dissipated.

Both researchers and firms expressed dissatisfaction with the application process, which was driven by S3 implementation governance. Over 93 percent of researchers and 85 percent of firms found the application process moderately or very cumbersome. Despite recent efforts to simplify requirements, application and selection processes remain highly bureaucratic and burdensome to applicants.

Conclusions and recommendations

The analysis provides general feedback on structuring support to researchers and firms and lessons for conducting future evaluations. Recommendations on specific types of support are tentative, given the early nature of the analyzed results and the small sample size. However, the analysis points to the following:

- *Clearly distinguish between research excellence and applied research and market-oriented outcomes in support to researchers*. Early results suggest that programs have succeeded at raising intellectual property protection outcomes, so policymakers should prioritize such outcomes in market-oriented programs. Programs supporting research excellence might be better suited to increasing the quality and quantity of publications.

- *Reduce barriers for applicants and beneficiaries to participate in public support programs*. Most researchers and firms found the application process burdensome. Some data even suggests that firms with more resources had a better chance of receiving funding. In addition to improving program targeting through selection criteria, the application process and obligations related to project implementation should be simplified.

- *Invest in supporting industry-science collaboration*. Researchers and firms both tend to develop collaborations within their sectors but not with each other. Efforts to establish closer connections between researchers and firms should be intensified.

- *Collect more and better-quality data, which will allow for more in-depth analysis to help improve program targeting and policy delivery*. More data will allow more sophisticated analysis and provide precise and granular information for policymakers to consider in their decision-making.

- *Define a clear protocol allowing the use of confidential data for evaluation purposes*. Research teams engaged to work on future evaluations should receive access to data from application forms, supporting documentation, and scoring results for all projects. The MSE has already introduced language in their call to introduce informed consent for data use and survey participation. This practice could be expanded to other funding institutions, including the MESD, CSF, Ministry of Regional Development and EU Funds (MRDEUF) and HAMAG-BICRO.

S3 monitoring results show a need to harmonize monitoring practices across institutions and institute a process for updating the monitoring framework clearly and transparently. Recommendations include:

- *Introduce clearer definitions and uniform measurement practices.* To streamline M&E processes, facilitate data aggregation, and enable policy-level monitoring, it would be beneficial if connected and similar indicators applied consistent rules and definitions.

- *Institute a clear and transparent process for updating the S3 regularly, including revising the monitoring framework when appropriate*. Targets should be reexamined and revised when appropriate, for example, following any (and especially major) budget or policy mix revisions and when original targets appear mismatched with performance during implementation.

S3 governance reforms are under preparation, but early signals suggest that critical challenges remain in the system. Recommendations include:

- *Simplify the design of application and selection processes*. Implementing bodies should have more flexibility in designing the calls for proposals, application forms, and selection processes to reduce administrative and bureaucratic burdens to applicants significantly.

- *Expedite the implementation of the new S3 to kickstart a more effective governance system.* The new S3 2029 should formalize the proposed changes to the S3 governance structure and address the main governance challenges identified in the midterm evaluation.

Introduction

Introduction

This report provides an ex post evaluation of Croatia's Smart Specialization Strategy (S3) 2016–20. Its adoption was a major milestone in the development of the Croatian National Innovation System, providing access to the largest funding envelope for RDI projects in Croatia's history. The S3 2016–20 aimed to enhance knowledge and innovation capabilities to boost economic competitiveness and identified five focus areas of investment (Thematic Priority Areas or TPAs).[2] It unlocked over EUR 890 million in RDI project financing (mostly grants) from the European Structural and Investment Funds (ESIF), distributed over four years. The report aims to explore the results and outcomes of investments made under the S3 and generate evidence of their effectiveness. Although RDI investment does not automatically lead to innovation, studies confirm the positive influence of increasing RDI investments on productivity, exports, job creation, and poverty reduction. However, there is little evidence about the effectiveness of public support for innovation in Croatia and in general. Considering the large public investment in these initiatives, assessing their effectiveness is highly important.

This is the last in a series of reports aimed at creating an analytical basis to improve the effectiveness of public spending for research, development, and innovation (RDI). It was produced under the Public Expenditure Review (PER) in Science, Technology, and Innovation (STI) project. The project follows a framework proposed by Correa (2014) that explores the following questions:

- How much is the government spending on RDI, and for what expected objectives?
- Are RDI expenditures generating the expected outputs and doing so efficiently, with a reasonable level of inputs?
- Are public expenditures effective at producing the desired outcomes?
- How is the composition and level of public expenditures (the policy mix) affecting its impact?

The Croatia PER in STI project has tried to answer these questions, producing eight outputs so far (Table A). The findings of those outputs have provided a background for and informed the analysis in this report.

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2 The five TPAs were Health and Quality of Life, Energy and Sustainable Environment, Transport and Mobility, Security, and Food and Bioeconomy.

Table A Outputs delivered as part of the PER in STI project

OUTPUT TITLE (YEAR)	DESCRIPTION
Analysis of the Quality and Coherence of the Policy Mix (2019)	Provides a diagnostic needs assessment of the Croatian RDI system, an analysis of RDI spending through block funding and project funding, a complete portfolio mapping of RDI instruments, and an analysis of beneficiaries.
Functional and Governance Analysis (2020)	Identifies design and implementation issues affecting the performance of RDI instruments in Croatia.
Analysis of Theory of Change and Results Framework (2020)	Develops theories of change and results frameworks for RDI instruments with clear data collection protocols and consistent definitions across instruments, allowing for effective aggregation and disaggregation of data.
Analysis of Outputs and Outcomes (2021)	Measures administrative, operational, and application-related costs of selected RDI instruments and estimates their efficiency in generating outputs and outcomes.
Analysis of the Croatia Smart Specialization Strategy: Logical Framework, Instruments, and Indicator Results (2021)	Examines the overall intervention logic of the S3 2016–20, the formulation of objectives, the links between activities, outputs, and outcomes, and indicators.
Analysis of Design and Implementation of Croatian S3 Governance (2021)	Analyzes the institutional structures governing S3 policy design, implementation, and co-creation.
Proposal for Evaluation Design (2021)	Defines the plan for the impact evaluation of the S3 2016–20, including by identifying the scope, methodology, and data needs.
Report on Smart Skills (2022)	Reviews the skills development system in Croatia in the context of the S3 2016–20, focusing on training systems that prepare adults for labor market entry or lifelong learning.

Source: Staff elaboration.

The extended S3 implementation timeline and disruptions caused by the COVID-19 pandemic mean that some results are yet to materialize. Although the S3 formally covers the period up to 2020, some instruments selected and contracted projects as late as 2021, and many projects are being implemented until the end of 2023. The S3 has this prolonged expiration because its main funding mechanism—the Operational Program Competitiveness and Cohesion 2014–2020—expires at the end of 2023. Furthermore, disruptions caused by the COVID-19 pandemic adversely affected the implementation timelines of some instruments. COVID-related disruptions also likely slowed down the evolution of S3 governance in the 2020–23 period. Consequently, final output data will be available only in 2024. Some data on outcomes is tracked up to five years post-implementation; hence, it also remains unavailable.

The first part of the report relies on complementary analyses to provide the best estimate of the effectiveness of selected S3 instruments. Section 1 summarizes the method, scope, and data sources used for the analysis. Section 2 describes the context for the evaluation, including a brief description of the national innovation context and a descriptive analysis of the applicant population. Section 3 analyzes instruments for researchers, whereas section 4 does the same for firms. The analysis of selected S3 instruments includes a survey analysis, before-and-after analysis, and a counterfactual impact evaluation.

The second part of the report summarizes cumulative S3 results against expected objectives and indicators and provides an overview of developments in S3 governance. Section 5 focuses on assessing the accomplishments under the S3 2016–20 and analyzing results as defined by the S3 implementation monitoring framework. The analysis covers both the overarching policy level and, where data permits, the S3 TPA level.[3] Section 6 reviews the evolution and quality of S3 governance. The analysis includes a qualitative assessment of governance evolution until now, following up on the findings of the mid-term evaluation (World Bank 2021a). The same analytical approach is applied to assess any improvement in the S3 governance system.

The third and final part of the report (comprising section 7) completes the report by summarizing the findings in the previous two parts and providing recommendations. The conclusions and recommendations are structured around three main topics explored through the report: improving the effectiveness of instruments, monitoring, and governance.

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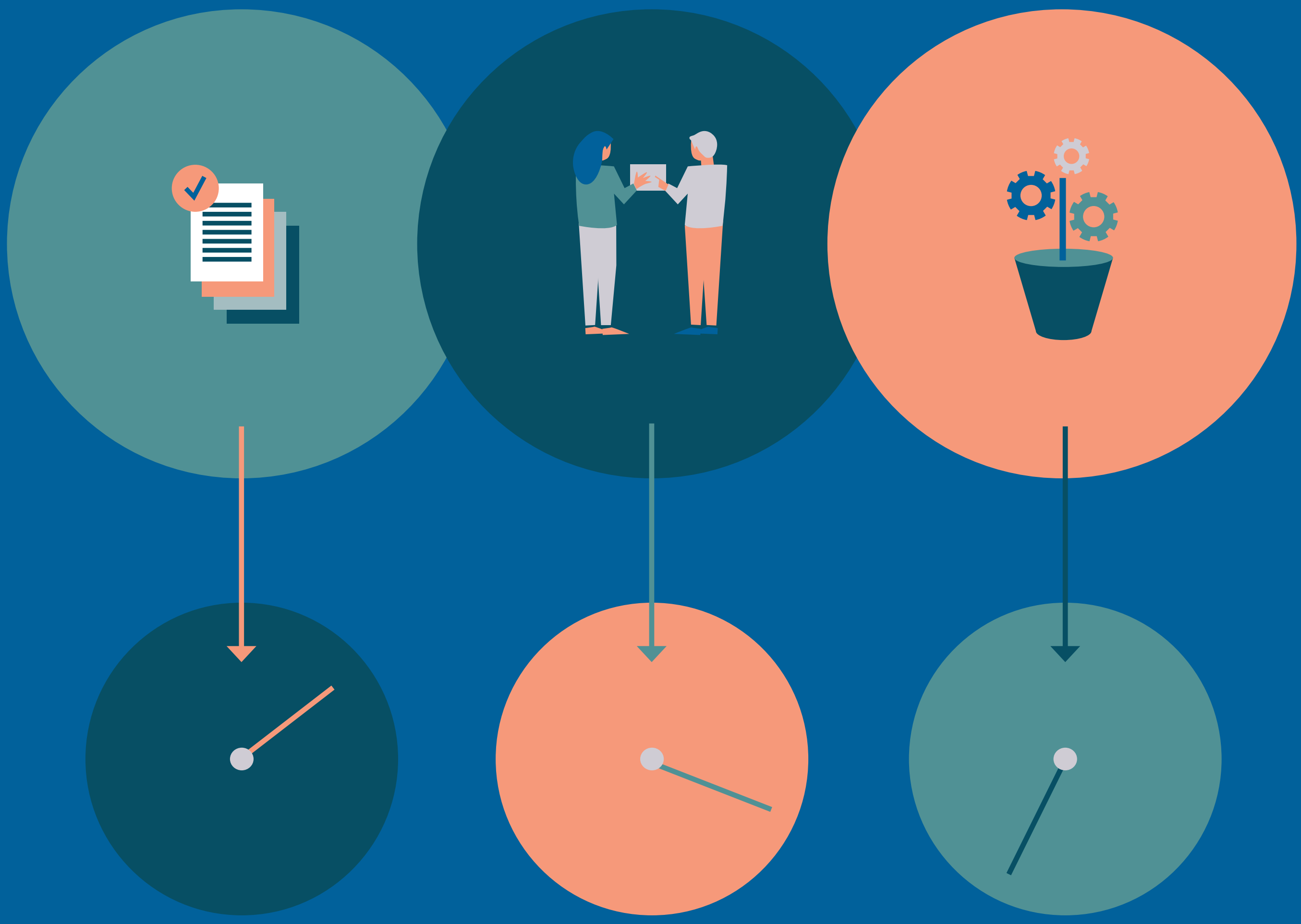
3 TPAs are divided into 13 sub-thematic priority areas. However, no data is tracked at the level of sub-thematic priority areas.

Part 1

Evaluation of selected S3 instruments



1 Methodology

Methodology

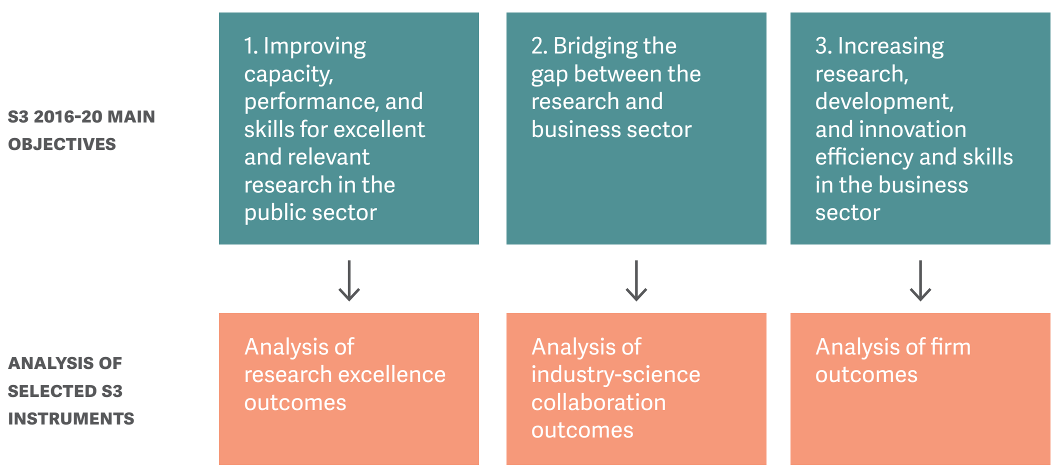
1.1 Scope of the analysis

The structure of the analysis mirrors the structure of the S3 2016–20 main objectives. The S3 consists of six specific objectives organized into three main objectives:

1. Improving capacity, performance, and skills for excellent and relevant research in the public sector
2. Bridging the gap between the research and business sector
3. Increasing RDI efficiency and skills in the business sector

Accordingly, the analysis focuses on estimating three types of outcomes: research excellence outcomes, collaboration outcomes, and firm outcomes (Figure 1.1).

Figure 1.1 Analytical framework for the analysis of selected S3 instruments



Source: Staff elaboration.

The analysis of selected S3 instruments relies on complementary approaches. The analysis entails a survey analysis, before-and-after analysis, and a counterfactual impact evaluation. The survey analysis presents data on a wide range of outcomes reported by beneficiaries and non-beneficiaries and their overall satisfaction with the instruments. The before-and-after analysis reviews the outcomes achieved by beneficiaries and non-beneficiaries to understand the dynamics of outcomes of interest without attempting to establish a causal relationship between the interventions and the results. Finally, the counterfactual impact evaluation isolates the impact that can be attributed to S3 instruments by assessing what would have happened to beneficiaries had they not received support through the instrument.

This part of the report covers seven S3 programs for which an analysis was deemed feasible based on program design and data availability constraints. Table 1.1 briefly describes the programs covered in the analysis. The analysis covers seven competitive grant scheme programs led by the MSE and MESD, covering a budget of over EUR 400 million or 42 percent of the total budget for S3 instruments.[4] Among the analyzed programs, two are directed only to researchers, two are implemented in partnership between research organizations and firms, and three are grants to firms. Initially, in the planning phase, the objective was to include 21 programs in the analysis, implemented under the authority of the MSE, MESD, and CSF, covering a budget of over EUR 800 million (equivalent to 84 percent of the portfolio) (World Bank 2021b). The MSE provided complete data for all the programs under their authority. However, the MESD provided only partial data, and the CSF provided no data, citing data confidentiality and privacy concerns. This paucity of data restricted the number of programs that the analysis could cover, the analysis methods that could be used, and the research questions that could be explored.

Table 1.1 Description of programs covered in the analysis

PROGRAM FULL NAME	PROGRAM SHORT NAME	PROGRAM DESCRIPTION
Centers of Research Excellence	ZCI	Grant scheme for Centers of Research Excellence to conduct research projects in S3 TPAs and cross-cutting themes defined in the S3. Grants fund various activities, including hiring new researchers, purchasing equipment, providing education and training, and transferring knowledge.
Science and Innovation Investment Fund	SIIF	Grant scheme for financing collaborative applied R&D and technology transfer projects implemented in partnership between at least two research organizations. Projects must be in line with the S3 TPAs.
Strengthening Capacities for Research, Development, and Innovation	STRIP	Grant scheme to support applied research activities of research organizations, implemented in mandatory partnership with firms. Projects must be in line with the S3 TPAs.

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4 Two programs (IRI and Startup Innovation) were implemented in two calls.

PROGRAM FULL NAME	PROGRAM SHORT NAME	PROGRAM DESCRIPTION
Commercialization of Innovations in Entrepreneurship	KIP	Grant scheme providing financing to small and medium enterprises (SMEs) for the commercialization of RDI results and start of production based on solutions applied.
Innovation in Newly Established SMEs	Startup Innovation	Grant scheme supporting innovation activities of firms established not more than 36 months before application, for the introduction of novel or improved goods or services. The program was implemented in two calls (Startup Innovation 1 and 2).
Innovation Vouchers	Inno-vouchers	Voucher program supporting SMEs to procure services from research organizations, including testing, demonstration, and technical knowledge for product and process innovation.
Increasing Development of New Products and Services from Research and Development Activities	IRI	Grant scheme supporting firms in implementing RDI projects to develop new products or technologies and improving their business processes in selected RDI topics within S3 TPAs and STPAs. Firms may implement projects in partnership with research organizations. The program was implemented in two calls (IRI 1 and 2).

Source: Staff elaboration based on program documentation.

The distribution of applicants across programs is fairly heterogeneous. Up to the beginning of the analysis, the programs received 1,750 applications, of which slightly fewer than half were funded. Two programs (ZCI and SIIF) supported a total of 41 projects primarily targeting public research organizations, two programs (STRIP and IRI) supported a total of 230 collaborative projects between research organizations and enterprises, and another four programs (KIP, Startup Innovation, Inno-vouchers, and IRI) supported a total of 550 firms' projects.[5] Some of the included programs were still ongoing and receiving applications for new projects at the time the data was collected. Hence, the numbers of applications and supported projects in Table 1.2 are not final.

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5 There are some exceptions and special cases. For example, the ZCI program predominantly financed public research organizations, although some firms were also involved through their membership in the funded Centers of Research Excellence. Similarly, the IRI program funded projects which could either be implemented independently by a single firm, or in collaboration with other firms or research organizations. The Inno-vouchers were granted to firms, but research organizations also benefited from the program because the voucher funded research organization services.

Table 1.2 Basic data on programs considered in the analysis, disaggregated by call (as applicable)

PROGRAM NAME	RESPONSIBLE INSTITUTION	BUDGET (MIL EUR)	NUMBER OF APPLICATIONS	NUMBER OF PROJECTS SUPPORTED	PROGRAM START DATE	EXPECTED END DATE OF PROJECTS
ZCI	MSE	50	10	10	11/28/2016	12/1/2022
SIIF	MSE	20.85	96	31	6/13/2017	12/20/2023
STRIP	MSE	23.76	75	31	5/2/2018	12/31/2023
KIP	MESD	15	87	20	12/9/2016	9/10/2021
Startup Innovation 1	MESD	9.74	214	63	5/1/2016	2/1/2020
Startup Innovation 2	MESD	26.32	422	131	2/15/2019	7/20/2022
Inno-vouchers	MESD	6.58	368	279	5/21/2018	5/1/2021
IRI1	MESD	131.32	147	87	5/4/2016	2/1/2023
IRI2	MESD	134.8	331	170	12/11/2019	9/30/2023
Total		**418.37**	**1,750**	**822**		
Average		46.40	194	91		

Note: The Startup Innovation and IRI programs were implemented through two calls for proposals, and their data is therefore shown separately. Data on the number of applications and number of projects supported is as of July 2022, as delivered by responsible institutions before analysis start. The program start date is the date the program launched. The expected end date of projects is the end date for the last project in each program as of the latest available cutoff date (May 2022).

Source: MSE, MESD, Strukturnifondovi, and program documentation.

The results of the analysis are preliminary because many funded projects ended just before the start of the analysis or are still ongoing. For various reasons, many projects were initiated late in the funding cycle. Project implementation extends until 2023 for four programs, whereas only three programs have all projects completed by the end of 2020 or 2021 (Table 1.2). Although the evaluation considered only completed projects, the programs ending in 2023 are expected to continue producing outcomes, which this analysis does not capture. This timing issue is significant given that innovation can be slow. Capturing the full effects of the programs would require a later analysis after the programs have ended for a reasonable period.

1.2 Impact evaluation design

An impact evaluation aims to isolate the effects of the implemented programs by comparison to what would have happened if the programs had not existed. The impact evaluation of any policy rests on understanding whether that policy had additionality, that is, changed the outcomes over and above what would have happened without the policy. This means that policy effectiveness should be evaluated and established in comparison with an alternative scenario, typically the status quo. The status quo, defined as the evolution of the outcomes of interest over time, is typically given by groups of subjects who did not receive support but are otherwise comparable to those who did. Did the beneficiaries and non-beneficiaries fare differently after the policy was implemented? Were they very different to start with? Which part can we causally attribute to the policy, and which part merely to existing differences before policy implementation or just time passing by? The methods used in the impact evaluation analysis can separate the policy effect from initial differences and natural changes over time (time just passes by, and outcomes change independently of any policy intervention). Because grants are not randomly assigned in the current context, and many confounding variables can affect both receiving the grants and the outcomes of interest, we must carefully discern causation from correlation.

The impact evaluation analysis faced numerous challenges due to the heterogeneity of programs. Impact evaluation involves comparing mean outcome values between the treatment group (recipients) and the control group (non-recipients) appropriately weighted and in periods before and after the grant. The difference between recipients and non-recipients before the grant sets the initial benchmark. Hence, the impact evaluation estimates the policy effect as a deviation from that initial difference. However, each unit of observation (for example, firms or researchers) is associated with many variables based on administrative records. Moreover, no clear model captures the decisions to award grants in such programs. There are various solicitations and many applicants, and different decision-makers with diverse objectives and varied competences award the grants according to assorted selection criteria. This, along with the small number of applicants and funded projects makes it difficult to apply many standard estimation techniques.

The impact evaluation analysis of programs uses novel methods to overcome data limitations. The impact evaluation analysis starts by using the Callaway-Sant'Anna difference-in-differences (CS-DiD) approach, which is an innovative technique to analyze programs with potentially dynamic and heterogeneous effects in which interventions or treatments are implemented at different points in time for different groups or units of analysis (Callaway & Sant'Anna 2021; De Chaisemartin & d'Haultfoeuille 2020). Particularly important in our analysis is that this approach allows for rebalancing and checks of pre-intervention differences. We implement the CS-DiD estimator pooling the data for all firms' devoted programs and we study financial and employment, as proxies of innovation outcomes. We complement CS-DiD with a novel approach using double de-biased machine learning (DDML, Box 11), which will likely measure the intended causal impact (Chernozhukov et al. 2018). The analysis also uses more traditional regression techniques, such as two-way-fixed effects. We incorporate researcher fixed effects for the DiD analysis to control for any unobserved heterogeneity, at the unit of observation level, between the treatment and control group and to reduce the risk of bias in our estimates.[6]

Box 1.1 Double Debiased Machine Learning

Evaluating the impact of non-randomly assigned grants requires using sophisticated estimation techniques. Under random assignment, given a sufficiently high number of participants, beneficiaries and non-beneficiaries would be balanced in terms of their observable and non-observable characteristics. Therefore, any difference in their outcomes could be attributed to the intervention. However, the main evaluation challenge in a policy setting comes from the fact that grants are not assigned randomly.

Recent advances in econometrics of causal inference using machine learning techniques offer an alternative for achieving a robust causal impact evaluation. One such technique is double debiased machine learning, which provides a new and versatile approach to evaluation. It uses the power of machine learning algorithms to overcome the challenge of evaluation in a non-randomized setting. It relies on the availability of a large enough data set and a rich set of variables to use machine learning tools. Although it is not advisable to use machine learning in small sample settings, the availability of a rich set of administrative data makes it appropriate for this impact evaluation.

The major contribution of double debiased machine learning is that it augments existing methods for causal inference with the ability to absorb large amounts of data. Traditional models are often criticized as unrealistic because they rely on many assumptions, fail to incorporate all the available information, and rely on simple mathematical models such as linear models or logistic regressions. Machine learning allows for the incorporation of a high number of variables. For example, a great amount of categorical information is collected on the projects and recipients through application and reporting forms. These techniques enable us to incorporate all available data regardless of the number of variables.

Another important aspect of any impact evaluation is the manner of grant allocation. In our scenario, it would be difficult or impossible to precisely model the mechanism by which grants are allocated. Machine learning is a suitable framework because it can create algorithms that predict the likelihood of receiving a grant using the available information. These algorithms work without us needing to understand all the inner workings.

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6 A lack of variables prevents us from employing more innovative methods on programs supporting researchers. The application files provide limited information that could be useful for estimation techniques such as DDML. Unlike with firms, it would not be possible, or particularly interesting, to analyze the impact of specific grants on the financial performance of institutions such as universities or research organizations. Furthermore, it is unclear at what level one could analyze the financial outcomes for public research institutions.

Double debiased machine learning can also help overcome difficulties arising from complex links between different variables. Outcomes of interest, such as employment or number of patents, are likely driven by many factors related to receiving a grant. These factors will affect both the likelihood of succeeding in a grant application and the likelihood of using the grant to achieve one of the many outcomes of interest. Still, it is unclear what the extent of the correlation is.

Double debiased machine learning also allows for studying different treatment effects across the population, with important policy implications for more effective program targeting. For example, the grants may boost innovation activity in small firms. In contrast, the effect may be marginal in larger firms, given pre-existing investment in innovation. Likewise, a grant provided to a young researcher in a leading university may have a different impact than a grant to an established researcher in a less prestigious university. These examples show that it is reasonable to expect that grants may have a differential impact across subgroups. Understanding which subgroups are critical matters both for the impact evaluation and for the future targeting and design of such programs. In the past, analysts chose specific groups manually. Now, they can use automated, data-driven algorithms to do so more effectively. This more detailed analysis of treatment effects across the population was not conducted in this report because it would be more beneficial with more data that captures the innovation process and its effects more accurately. However, it could be used in future evaluations. This approach could have significant policy implications. By creating simple targeting rules, policymakers can encourage researchers and companies in certain groups more effectively, based on past evidence of their higher potential returns from receiving a grant. Given limited resources, targeting future programs in this way may generate additional benefits by selecting applicants most likely to achieve important outcomes.

Due to data limitations, the impact evaluation focuses on limited outcomes. At first, the research proposal for the impact evaluation (World Bank 2021b) included nine outcomes for researchers and eight for firms (Annex 1). We expected data for most of these outcomes to come from a survey. Unfortunately, the survey did not yield a sufficient response rate for those outcomes to be included in the impact evaluation (see section 1.3). Therefore, the impact evaluation focuses on outcomes measured through data from administrative sources. For researchers, these include the quantity and quality of publications and patents. For firms, these include sales revenue and other operating income, costs of raw materials, cost of goods sold, material expenses, total operating expenses, value of intangible assets, and number of employees. The selection of these variables was driven by the impact evaluation objective, focusing on examining the first-order effects of projects on innovation and exploring spillover effects. Intangible assets are employed as a proxy for innovation, whereas other variables measure innovation spillovers. Table 1.3 offers definitions for these variables and identifies the channels through which the effects occur.

Table 1.3 Variables examined in the impact evaluation of programs on firm outcomes

VARIABLE NAME	DEFINITION	NOTE
Main variable (innovation)		
Intangible assets	Sum of intangible assets such as R&D, concessions, patents, licenses, trademarks, software and other rights, goodwill, advances for purchases of intangible assets, intangible assets in progress, and other intangible assets	The sum of all intangible assets used as R&D funding can materialize into assets such as R&D, concessions, patents, licenses, trademarks, software and other rights, and goodwill. Assets are chosen instead of expenses because they are outcome-oriented and less likely to undergo manipulation and earnings management. Another practical consideration is that we do not have a clean and accurate breakdown of R&D expenses.
Spillover variables		
Revenue	The sum of sales revenue and other operating income	Revenue is chosen because R&D can affect both key operating activities and other non-key operating activities. The hypothesis is that an increase in innovation will lead to an increase in revenue.
Cost of goods sold	The sum of costs of raw materials, direct labor costs, and material expenses	The aggregated cost of goods sold encapsulates all costs relevant to the direct costs associated with producing goods or services that a company sells. We hypothesize that an increase in innovation will lead to a decrease in the costs of goods sold. Firms can have increased market power, which leads to lower procurement costs.
Operational expenses	The sum of total operating expenses encompasses all costs associated with running the day-to-day operations of a business. It includes both direct and indirect costs (such as sales and marketing expenses, administrative expenses, R&D costs, rent, utilities, and other overhead expenses).	This overarching aggregated variable captures all the operating expenses incurred by the firm. We hypothesize that an increase in innovation will decrease total operating expenses as firms increase their efficiency for both direct and indirect costs, such as human labor.
Number of employees	The number of employees in the fiscal filling year.	An increase in innovation activities may lead to an increase in workforce needs as the firm size increases or a decline in workforce needs as the firm becomes more efficient and introduces innovative processes.

Note: R&D = research and development.

Source: Staff elaboration.

We had to pool the impact evaluation results due to a low number of observations in individual programs. The low number of observations per program would not allow for presenting impact evaluation results at the level of individual programs with sufficient accuracy and confidence. Reaching a sufficient number of observations required pooling together different programs. We considered different pooling options based on the type of outcome, responsible institution, grant size, beneficiary type, and stage of innovation supported. The only option that yielded enough observations was to bundle programs by type of outcome (Table 1.4). The main limitation of this approach is that it disregards the specificities and differences in the theories of change of each program. For example, a program providing funding for small-scale short projects is unlikely to have the same outcomes as a program supporting large-scale R&D investments. Nevertheless, the pooling was necessary to obtain reasonably reliable results. The results should be interpreted in the context of a portfolio of programs.

Table 1.4 Program pooling

RESEARCH OUTCOMES	FINANCIAL OUTCOMES (FIRMS)
ZCI	KIP
SIIF	Startup Innovation
STRIP (researchers)	Inno-vouchers
	IRI1 and IRI 2
	STRIP (firms)

1.3 Data sources

The analysis of selected S3 instruments relies on administrative records, online databases, and data collected from a survey of program applicants. Administrative records include program application data and financial reporting data. The analysis also uses online databases for patent data from the European Patent Office (EPO) PATSTAT Global (1992–2020) and scientific bibliography data from the Croatian Scientific Bibliography (CROSBI) and Google Scholar. CROSBI is the leading bibliographic database in Croatia. Google Scholar is a global academic search engine. Both sources include all types of publications and research work results. As for patents, we extracted patent data sets applied to the Croatian patent office and patents filed by Croatian investors or applicants to other patent offices (either regional or international). We collected additional data by surveying program applicants (beneficiaries and non-beneficiaries).

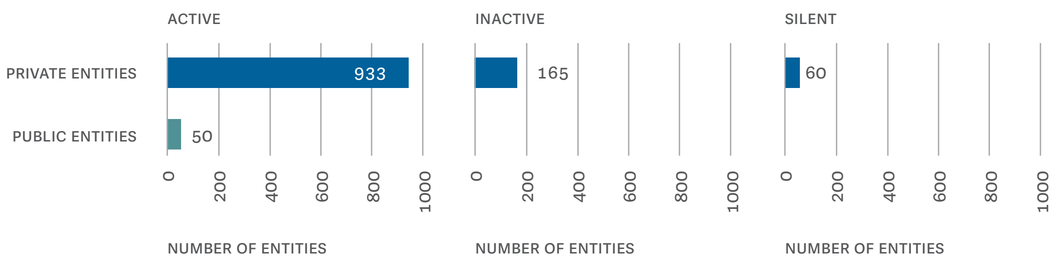
Collecting data presented considerable challenges, particularly in obtaining application data and program execution information. At first, our approach was to extract comprehensive application data to facilitate an in-depth analysis. Application forms included information about applicants, their partners (if applicable), past government support, project activities, planned outcomes, budget, costs, target groups, and sources of financing. Regrettably, we could only procure application data for three programs that the MSE executed: STRIP, SIIF, and ZCI. Although these applications were comprehensive, the small sample size in those programs—specifically, 206 applications, of which 67 received support—meant that the data was of limited use for the impact evaluation. The MESD provided only information about the name, ID, and funding status of the applicants, as well as the names of project partners, if applicable. This paucity of data serves as an important lesson, highlighting the need for future calls to have a centralized, standardized, digital, and accessible archive of all applications submitted to produce a sound impact evaluation.

The analysis uses data on publications from the CROSBI data set and Google Scholar for all researchers in the applications pool, irrespective of their beneficiary status. The data gathering process encompassed the following steps: (1) isolation of the principal investigators' and scientists' names from the grant application documents, (2) matching their names in the CROSBI/Google Scholar database and finding their work titles and journal information, and (3) mapping the data with the programs. CROSBI and Google Scholar have notable differences, with the latter being the sole source for the quality-adjusted publication record. Publication records can differ between these two sources due to differences in data management practice. In both cases, scholars must open an account. However, in CROSBI, scholars must also manually input their publication records. The majority of the publications in Google Scholar are automatically captured. As a result, we could not pick up the publication records from the applicants who never opened an account at either of the platforms or who opened a CROSBI account but did not update it regularly. However, the most notable difference is that, unlike CROSBI, Google Scholar offers features like citation tracking. We tried to manually verify several records because web scraping is prone to measurement error due to common names.

Surveys for firms and researchers were deployed to collect information on outcomes that could not be recovered from administrative records while also providing a second source of information on all the main outcomes. The survey aimed to collect data on different types of innovation output or synthetic measures of collaboration networks and information on the applicants' experience during the process of application, disbursement, and use of the funds. Although some data on outcomes could be collected from mandatory regular reporting submitted by beneficiaries, this was not the case for non-beneficiaries. Therefore, we employed survey instruments to capture these outcomes for both beneficiaries (treated) and non-beneficiaries (controls). The survey was initially piloted in March 2023, followed by the main survey conducted between April 19 and July 14, 2023. The survey collected data on the characteristics of the applicants, the main results of their projects achieved to date, general information about their research organization/firm, costs and benefits of innovation funding, collaborations developed within a project, and their general feedback about the application process. Protocols were developed to ensure the quality of collected data. Each engagement with respondents was recorded in a detailed log file, and the respondents were informed about regulations pertaining to data protection and privacy, including the General Data Protection Regulation (GDPR). A flag system was created to detect discrepancies in the data. The status of questionnaires and all weekly activities were included in the weekly report.

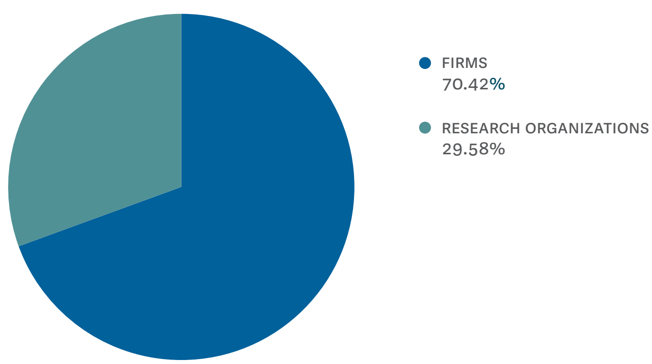
The survey had a relatively low response rate, and although the collected data could not be used in the impact evaluation exercise, it is presented in the report as part of the overall analysis. An questionnaire was designed for both researchers and firms and distributed to all applicants in the form of an online survey, regardless of whether they were successful or unsuccessful. There were 1,908 applications considered for funding within the programs subject to analysis. However, some entities submitted multiple applications, and some were inactive at the time of the survey distribution. Furthermore, for a small share of entities, data on unique ID was not available. To tackle these incongruencies, we conducted a data-cleaning process to identify unique entities to which the survey would be distributed. These refinements resulted in a final sample of 933 firms and 50 research organizations to be surveyed (Figure 1.2). The survey had a total of 211 responses, resulting in a total response rate of 20.95 percent. Among the overall responses collected, with a survey completion rate of 50 percent or higher, 70.4 percent of the responses were given by firms (Figure 1.3). Around 40 percent of respondents were funded, and the remaining 60 percent were unfunded (through the analyzed programs). The survey was implemented by a local research team, which was dispersed across Croatia to cover all regions and leverage local knowledge. The research team monitored the survey completion rate on a daily basis and initiated follow-up calls to encourage respondents to complete the survey.

Figure 1.2 Structure of the survey sample after data cleaning



Source: Staff elaboration.

Figure 1.3 Responses collected according to entity type (completion rate of 50 percent or more)



Source: Staff elaboration.

The implementation of the survey faced several challenges. Identifying designated contact people for survey distribution was one such challenge. A large proportion of email addresses belonging to the firms were generic and seemed to be inactive, which was confirmed through follow-up phone calls. Second, a significant number of firms were no longer active, dozens of firms (60 out of 993 firms) reported zero or one employee and zero revenues, and some were still active but were in the process of bankruptcy and closing the business altogether. These inactive, dormant, and micro entities are understandably unwilling to participate in surveys. More information on dormant firms is outlined in section 4.

2 Analysis context

Analysis context

This section provides background information to contextualize the analysis. The section is organized into two parts. The first part consists of a high-level summary of innovation outcomes in Croatia relative to other EU countries. The second part provides more information on the population examined in the analysis, that is, researchers and firms who applied to S3 programs and their characteristics.

2.1 Innovation context

The country's innovation performance is currently below that of the EU, but it is showing signs of convergence. According to the latest 2023 European Innovation Scoreboard, Croatia is at the top of the Emerging Innovator cohort.[7] Although its performance is above the average of the Emerging Innovators, it is still well below the EU average, specifically at 69.6 percent of the EU average. The literature highlights several key factors that contribute to limited R&D-driven innovation. These factors include limited access to internal and external resources, limited technology and market information, insufficient research excellence, obstacles to collaboration between researchers and industry, and systemic weaknesses in the governance of the innovation ecosystem (World Bank, 2018). Nevertheless, from 2016 to 2023, a trend of convergence in innovation performance toward the EU, driven by significant performance improvement, has been observed. During this period, Croatia experienced an improvement in innovation performance, with an increase of 14.8 percentage points. This improvement ranks as the largest performance shift among the Emerging Innovators and the ninth largest within the EU. According to the literature, the income convergence of EU member states results from the efficiency improvement linked to their own innovation activities (Dobrinsky et al. 2006; Alam et al. 2008). This initiated a discussion about a need for a new growth model based on increased productivity and export through innovation. To this end, the EU is focusing on economic development through targeted support for research and innovation. This support was greatly augmented by EU funds in the 2016–20 period and will continue going forward.

Public investments in innovation have been mostly focused on non-R&D. As the recognition of the role of innovation in productivity and GDP growth increases, so does public support for innovation (Mazzucato 2013; Hayter et al. 2018). In Croatia and other catching-up EU countries, public support is the main source of financing for innovation (Stojčić et al.,

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7 European Innovation Scoreboard is a taxonomy developed to assess the innovative performance of EU countries. Performance is measured by innovation index. EU countries are categories into four performance groups based on their innovation scores: Innovation leaders, Strong innovators, Moderate innovators, and Emerging innovators.

2020). However, the majority of investments have been focused on non-R&D innovation, whereas investments for R&D-based innovation were relatively low. Descriptive analysis of innovation data shows that the productivity of the innovation system in Croatia is low (Orlic et al., 2018; World Bank, 2019; World Bank, 2020b).

The lack of collaboration between researchers and firms has been recognized as one of the main impediments to innovation. Studies indicate a notable deficiency in collaboration between academia and businesses in Southeast Europe, including Croatia. This phenomenon is common in the region and contributes to a comparatively lower level of innovation (Radanovic and Gerussi, 2020). World Bank (2022) analysis detects institutional rigidity as the main collaboration impediment. In most cases, existing collaborations are started by individuals rather than official authorities. This is specifically the case with interdisciplinary collaborations, which have immense potential but are underdeveloped.

Croatian research institutions and firms are facing considerable challenges in the commercialization of innovation outcomes. Studies found there is a minimal presence of knowledge being commercially exploited (Kornai, 2010; Švarc, 2014). The problem is particularly pronounced in the case of innovation output of collaborative work, which is already very limited due to reluctance to embrace the change and generally low level of entrepreneurial spirit in the academia (Švarc and Dabić, 2019).

2.2 Applicant population

Roughly half of the projects that applied for funding under the analyzed programs succeeded in obtaining it, though this varies across beneficiary types and programs. The applicant population of the analyzed programs consists mostly of firms, as expected. Grants to which research organizations were the main applicants (ZCI, SIIF, and STRIP) naturally tended to attract a lower number of applicants because the population of eligible applicants was much smaller than the population of firms.[8] Overall, the success rate of applicants is about 47 percent, though this varies across types of beneficiaries and from program to program (Figure 2.1). Around half the firms that applied for funding succeeded in obtaining it, whereas for research organizations, the success rate was slightly lower (around 40 percent). The 100-percent success rate in the ZCI program is a result of the program design. Eligible beneficiaries were restricted to a pre-approved list of Centers of Research Excellence and the program awarded funding to all of them.

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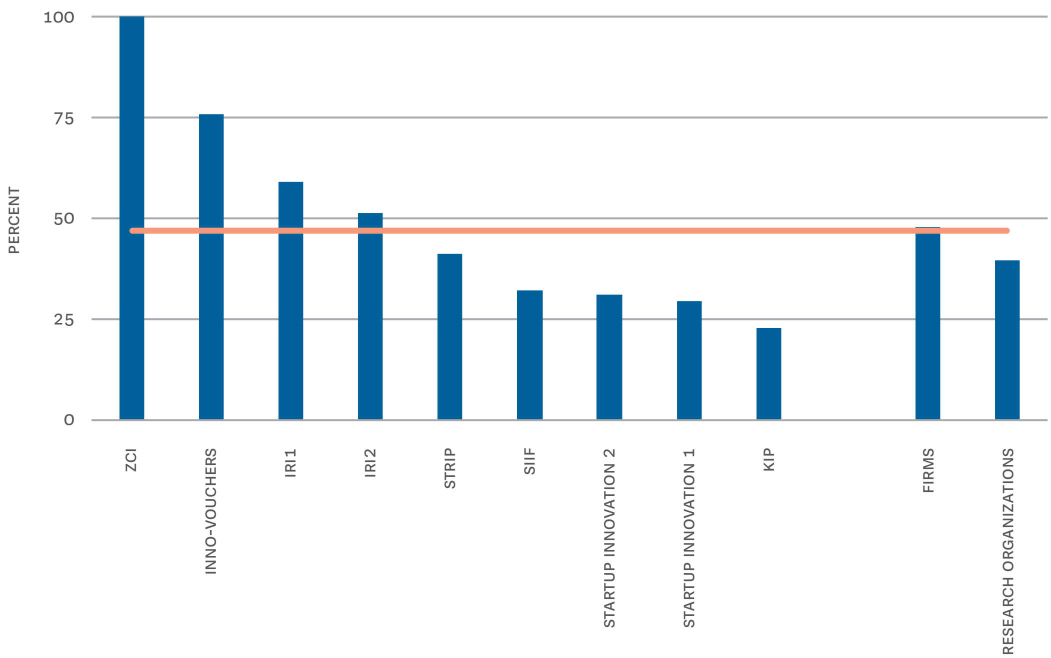
8 According to Croatian Bureau of Statistics data, there were 569 research entities in Croatia in 2022, of which 96 were higher education institutions, 68 were in the public and non-profit sector, and 405 were private sector organizations. For comparison, in the same year there were 225,975 active firms.

Figure 2.1 Success rate by program



Note: The success rate for firms and research organizations was calculated based on the eligible main applicant. For firms, this included Inno-vouchers, IRI, Startup Innovation, and KIP. For research organizations, it included ZCI, SIIF, and STRIP.

Source: Staff elaboration.

Programs with higher budgets tend to support larger projects. Figure 2.2 shows that there is an almost linear relationship between the program budget and the average value of supported projects. Another interesting feature is that, on average, grants tend to get larger as the requirement for co-financing from the beneficiaries' own funds increases. This trend is particularly pronounced in programs directed to firms, particularly the established ones that already have substantial funding from their own sources. As an example, the share of requested grants in programs such as IRI, KIP, and Inno-vouchers is between 45 and 60 percent of the total proposed project value.[9] By contrast, start-ups and researchers typically request larger grant intensity (over 70 percent). This is in line with state aid rules, which require the private sector to progressively co-finance RDI projects the larger the firm and the closer to market the project is.

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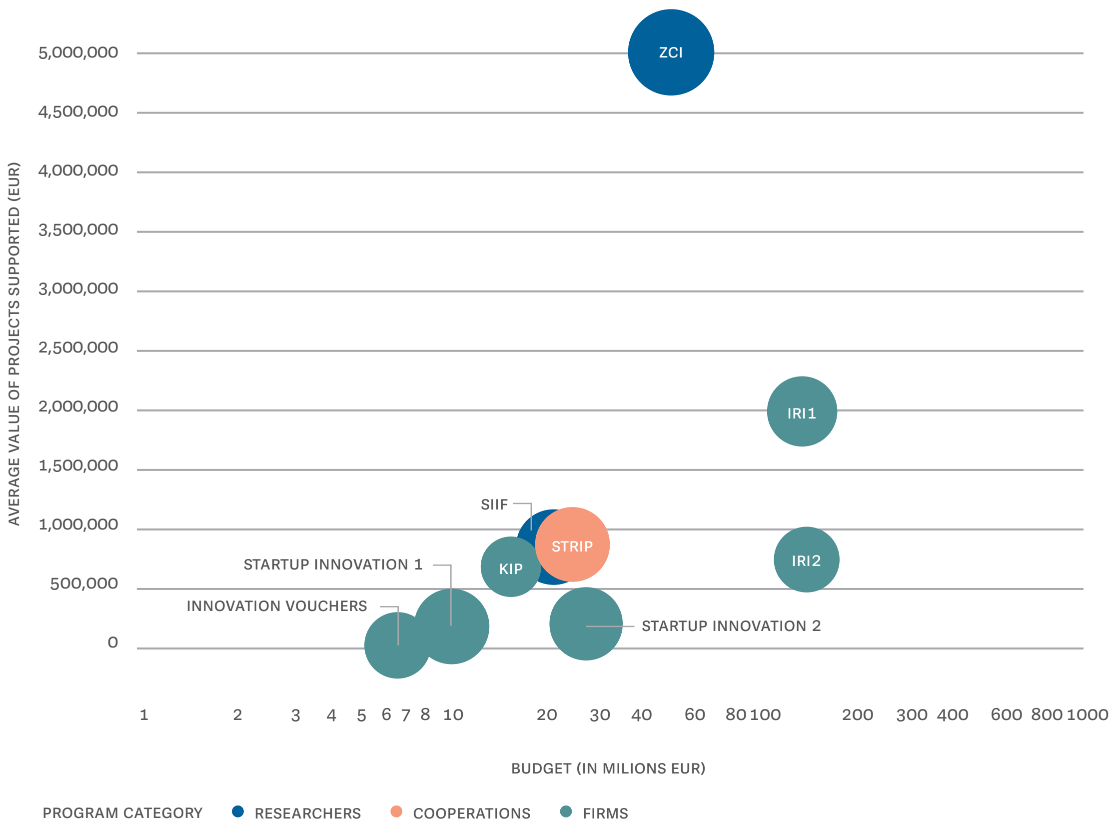
9 The proportion of requested grants within the overall value of supported grants is even lower, commencing at 37 percent for KIP.

Figure 2.2 Relationship between the budget and the size of the supported grant

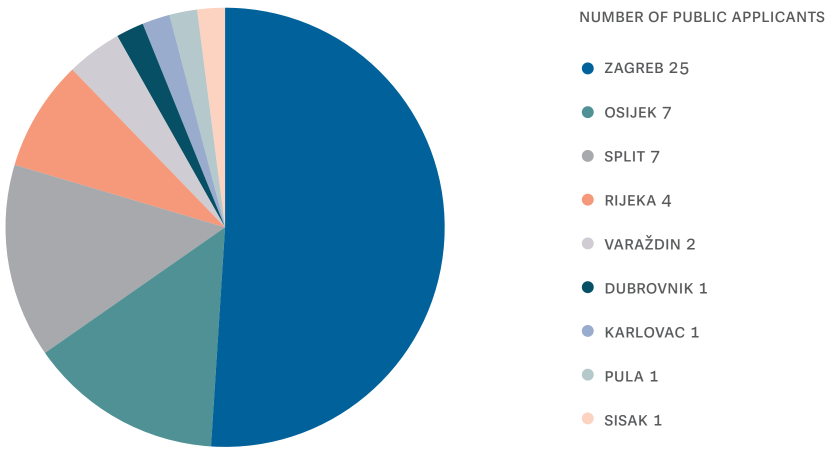


Note: The size of the circle reflects the share of requested grants in the total value of the project proposal received.

Source: Staff elaboration.

Public-sector applicants are highly geographically concentrated in the capital. A total of 50 public entities submitted 180 applications. The majority of applicants (37, or 74 percent) were higher education institutions. Public hospitals followed with seven applicants (14 percent), and research institutes with six applicants (12 percent). Despite being the smallest in terms of the number of applications, research institutes demonstrated notable activity by submitting multiple applications. Among them, the Institute Ruđer Bošković in Zagreb stood out as the leader, having submitted 21 applications. Additionally, the geographical distribution of public applicants is highly concentrated around the capital, with 50 percent of applicants originating from Zagreb (Figure 2.3).

Figure 2.3 Geographic distribution of public applicants



Source: Staff elaboration.

3 Analysis of research excellence and collaboration outcomes

Analysis of research excellence and collaboration outcomes

The analysis of S3 instruments on research excellence outcomes is based on descriptive analysis of survey data, data from publicly available databases, and a counterfactual impact evaluation for selected outcomes. The analysis considers research excellence outcomes achieved by researchers funded under three programs: SIIF, STRIP, and ZCI. (Researchers were also team members in some projects under the IRI program, but the MESD did not provide the detailed information on team composition that would have allowed including such researchers in this part of the analysis.) The analysis includes a before-and-after and program-level analysis of research excellence outcomes based on publicly available databases and a survey of applicants[10] and an impact evaluation for selected outcomes.

3.1 Survey results

The share of completed projects among researchers is relatively low, and many applicants' projects were not completed. Around a fifth of all researchers reported having fully completed projects, and another 46 percent are partially completed (Figure 3.1). Among funded projects, 28 percent were reported as not started at the time of the survey. This may result from the analyzed MSE programs starting relatively recently. Unfunded researchers reported a slightly lower share of completed projects and projects in progress, while the share of projects that were not started was much higher (55 percent). Unfunded researchers probably had no further funding options to implement their projects and, thus, could not start them.

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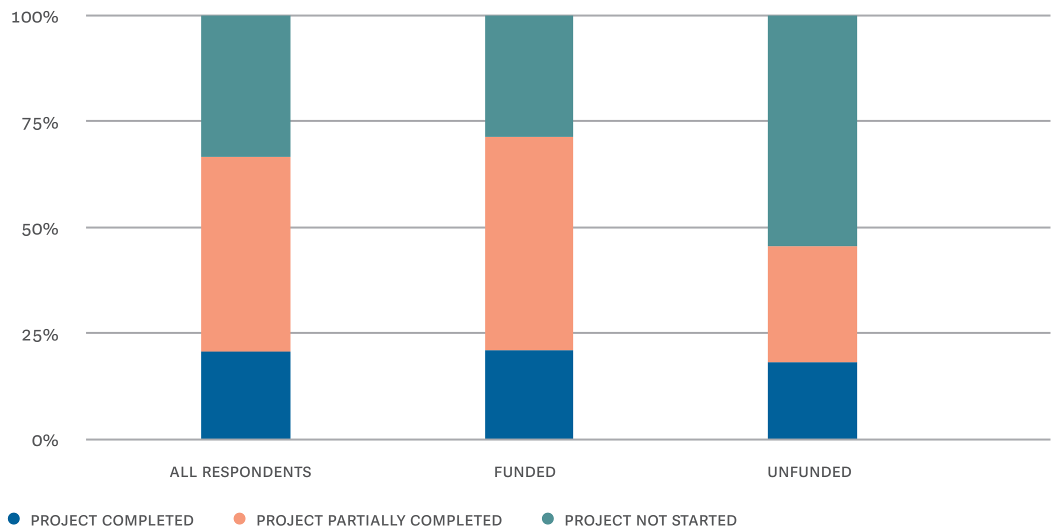
10 The results of the survey are presented here for informational purposes, but they are not representative of the researcher applicant population, and should be interpreted with caution. Due to the low response rate, the results cannot be extrapolated to the whole researcher applicant population. Nevertheless, the survey provides some interesting insights that, in some cases, are in line with the findings of previous analytical work.

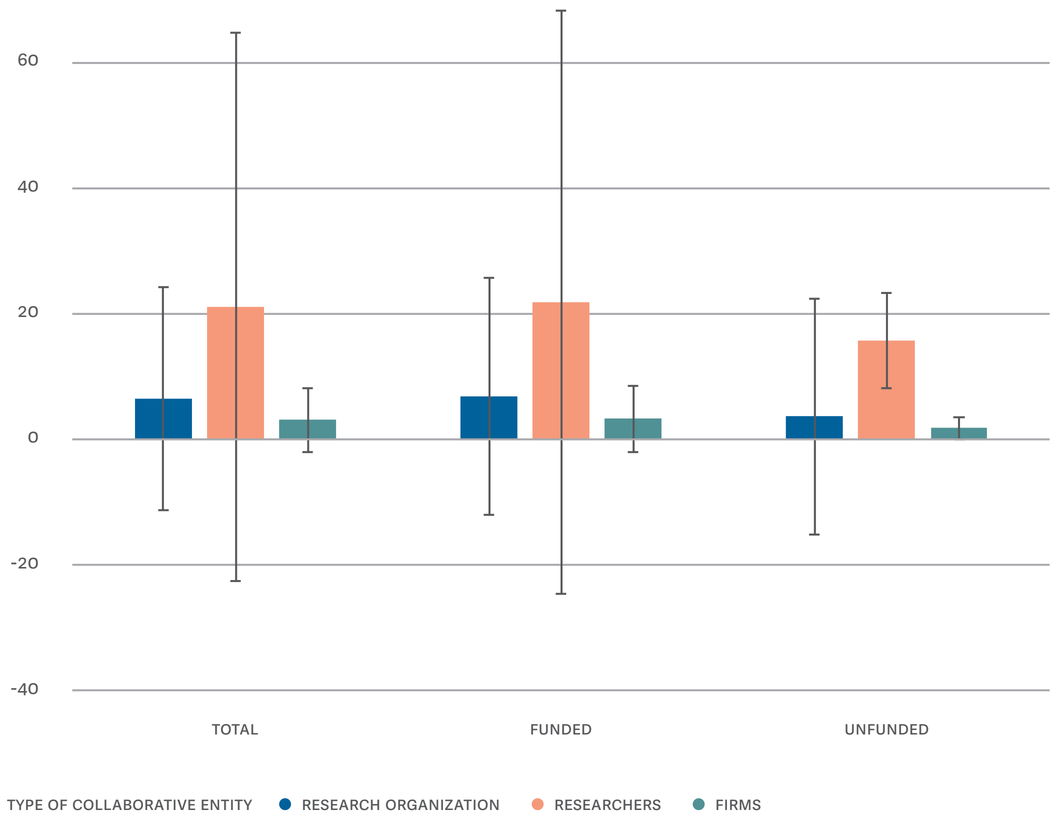
Figure 3.1 Project completion status of researcher survey respondents



Source: Staff elaboration.

Researchers naturally tend to collaborate more with other researchers and research organizations, and funded researchers tend to collaborate more with all groups. Researchers reported, on average, six collaborations with research organizations and 21 collaborations with individual researchers, with rather high standard deviations (Figure 3.2). (This means that there is the number of collaborations varies a lot across different projects, and in many cases are different from the average.) At the same time, researchers typically collaborated with three firms. Non-funded researchers reported about half the number of collaborations with research organizations and firms compared to funded researchers, and about 30 percent fewer collaborations with other researchers. The MSE is investing in several programs to support industry-science collaboration, including through grants and soft support for matchmaking and technology transfer.

Figure 3.2 Average number of collaborations (researchers)

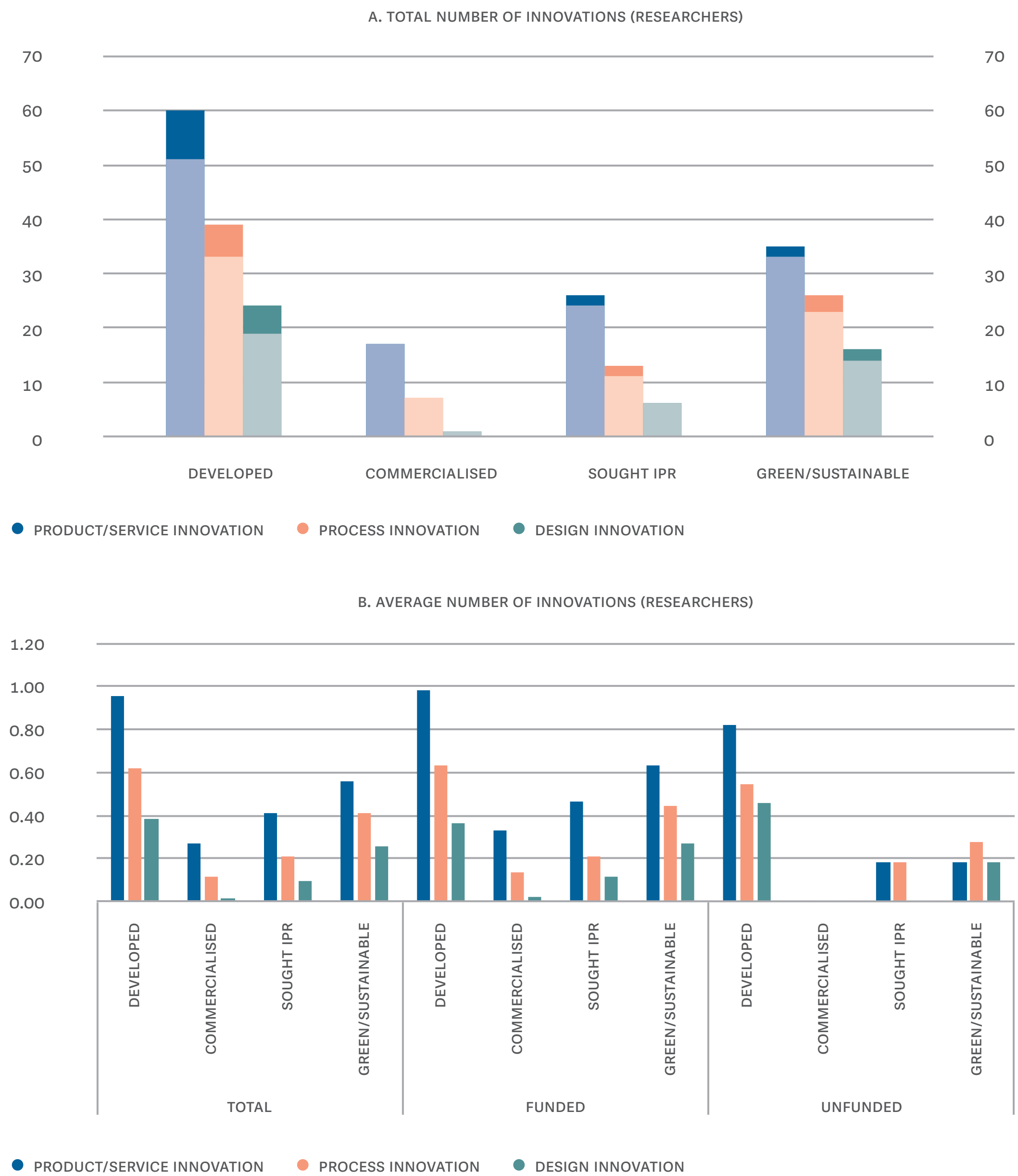


Note: Vertical lines (error bars) represent 95 percent confidence intervals.

Source: Staff elaboration.

Researchers mostly reported developing product and service innovations, and some were even commercialized. Researchers reported developing 123 innovations, of which around half were product or service innovations and 32 percent were process innovations (Figure 3.3, panel A). The light-shaded portions of the bars in Figure 3.3 represent the results for funded researchers while the darker shaded portions of the bar represent all researchers. Researchers sought intellectual property rights (IPR) for around a third of them, and around 20 percent were commercialized. Funded researchers were responsible for the the vast majority of innovations developed (84 percent), commercialized (100 percent), protected (91 percent), and green or sustainable innovations (91 percent). The average number of developed product, service, and process innovations is around one, and they were more often reported than design innovations (Figure 3.3, panel B). This number tended to go down for innovations for which IPR was sought (about one in two process innovations) and commercialized innovations (one in two product innovations and one in three process innovations).

Figure 3.3 Reported innovations by status

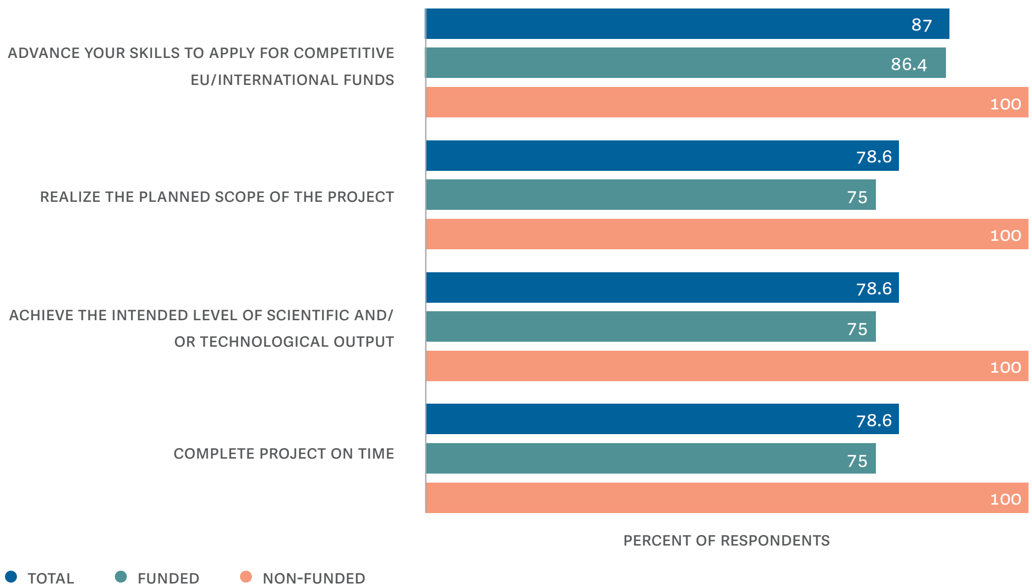


Note: Light coloured portions of the bar in panel A represent funded applicants.

Source: Staff elaboration.

A high share of researchers stated that applying to the program helped them advance their skills in applying to competitive EU or international funds. Three-quarters of researchers stated the program helped them realize the planned scope of the project, achieve the intended level of scientific and technological output, or complete the project on time (Figure 3.4). An even higher share (86.3 percent) indicated applying to the program helped them advance their skills, which could be useful for applying for competitive EU or international funds.

Figure 3.4 Benefits of applying, percent of researcher respondents

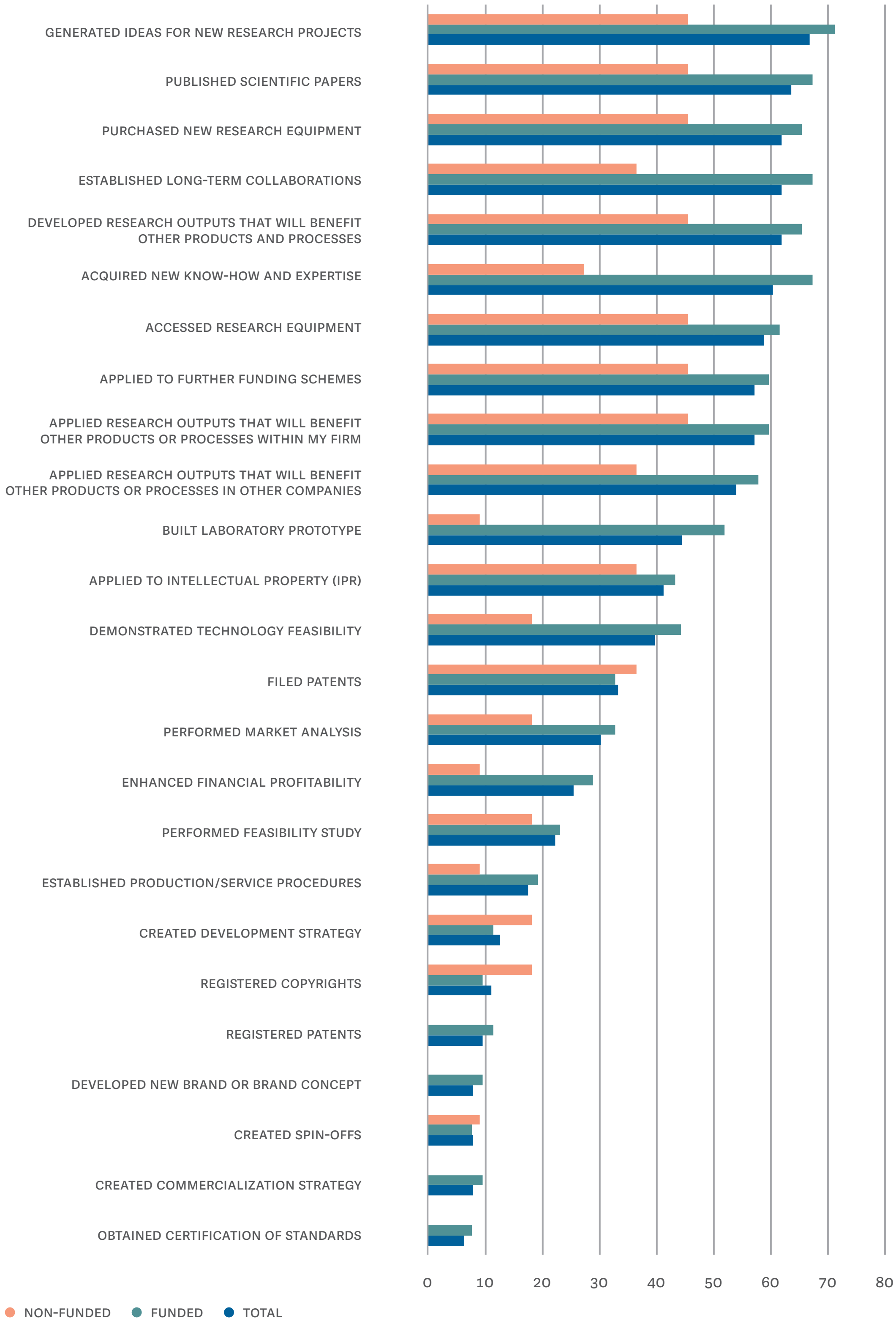


Note: A sizable share of respondents did not answer this question, percentages were calculated only for those that responded.

Source: Staff elaboration.

Researchers mostly reported specific outcomes related to research production, equipment modernization, and collaboration, whereas market-oriented and commercialization outcomes were less common. Over 60 percent of researchers reported that project implementation resulted in research-oriented outcomes (Figure 3.5). On the other side of the spectrum are the outcomes which can be considered more market-oriented. Only around a third of researchers reported having applied for patents and less than 10 percent of them reported research commercialization outcomes (Figure 3.5).

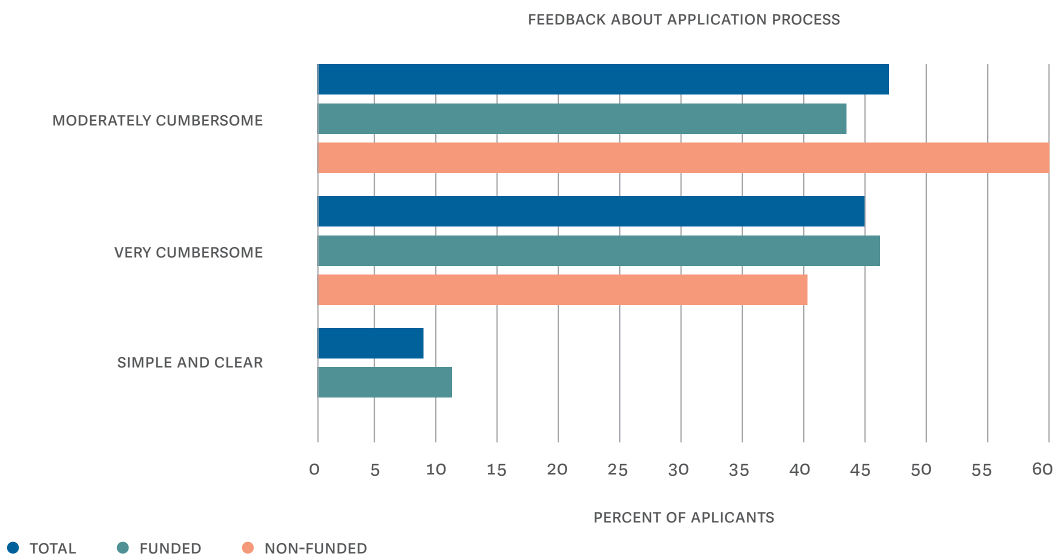
Figure 3.5 Reported project outcomes, percent of researcher respondents



Source: Staff elaboration.

Most researchers found the application process cumbersome. Over 93 percent of respondents found the application process moderately or very cumbersome, whereas only 6 percent considered the process simple and clear. Particularly concerning is the high share of researchers—44 percent of them—who found the process very cumbersome. This is in line with the findings of other researcher surveys in Croatia (World Bank 2020).

Figure 3.6 Feedback on the application process, percent of researcher respondents



Source: Staff elaboration.

Despite efforts to simplify requirements, application and selection processes will likely remain highly bureaucratic and burdensome to applicants due to the centralized nature of application and selection process design. The MSE has tried to simplify the application process in recent calls by reducing documentation requirements at the application stage. However, many administrative obstacles remain, such as the requirement to submit project proposals in both English and Croatian when international peer review is required. Line ministries (including the MSE) have little control over the design of the application and selection process because for the vast majority of programs—funded from EU structural funds—the design of the application process, including the call for proposals form, is centrally determined. Unless there is an agreement to provide more flexibility to line ministries around the design of application and selection processes, they will likely continue to be burdensome and highly bureaucratic to applicants.

3.2 Publications, patents, and collaborations

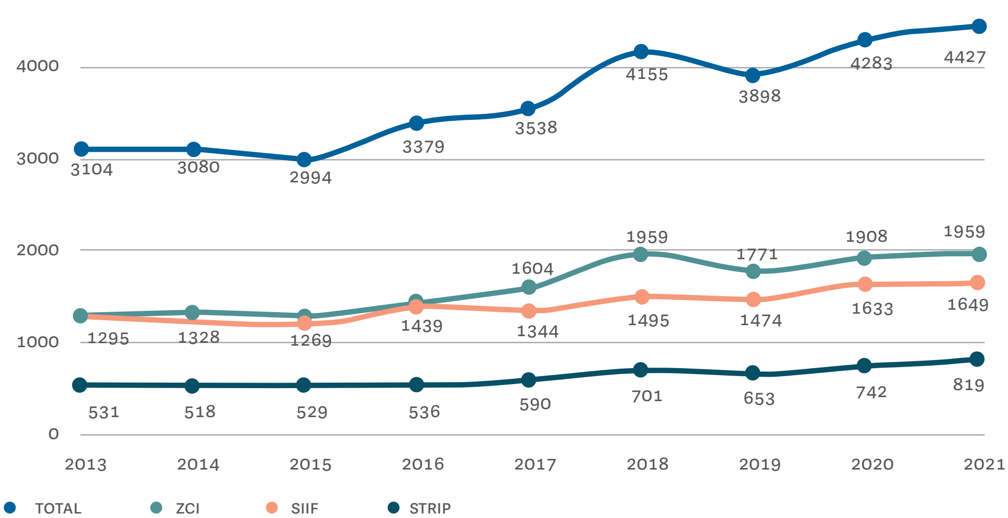
This section reviews outcomes before and after the grants were awarded for each program and is not meant to establish a causal relationship between the funding and the outcome. The data is presented for the sake of completeness and understanding of the underlying dynamics of each outcome. However, this should not be interpreted as results attributable to programs. Comparing outcomes before and after the award of grants, although seemingly intuitive, does not consider other factors that may have led to the realization of certain outcomes.

In this section, the outcomes of researchers are attributed to all programs that the researcher participated in. Out of 1,187 total researchers, 1,038 were part of a team that applied for a single program, 134 of them appeared in teams that applied for two programs, and 15 researchers appeared in applications for all three analyzed programs. Because the analysis relies on data from public databases and the programs run concurrently, it was difficult to discern the outcomes for researchers participating in two or three programs. Therefore, the analysis in this section counts outcomes for all programs in which researchers appear.

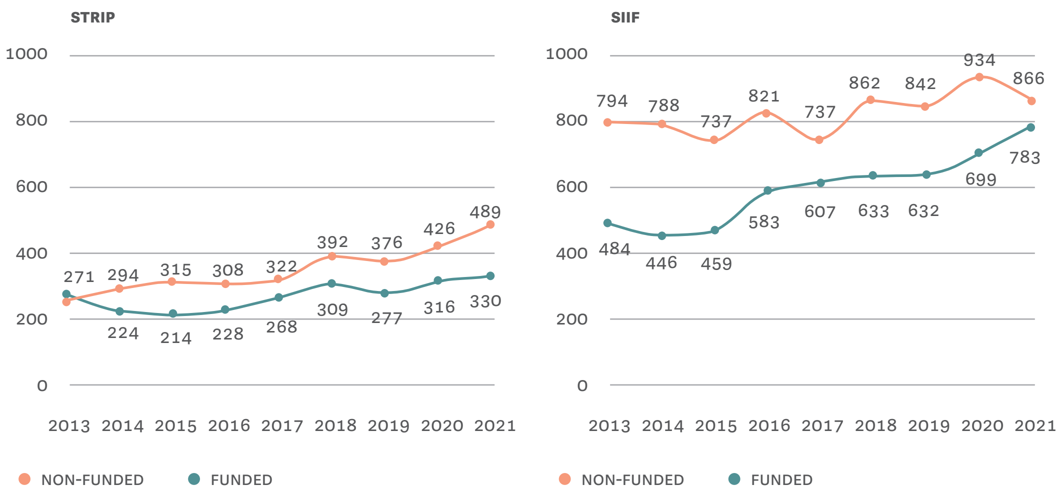
Publications

The number of publications reported by researchers increased over time, particularly from 2017 onward. The programs attracted highly productive scholars, as shown by the nearly 33,000 publications in CROSBI associated with 1,187 scholars from the application documents during the period 2013–21. The number of publications has surged across all programs, signaling a positive trend in the observed period (Figure 3.7).

Figure 3.7 Applicants' research output has increased tremendously in the period 2013–21



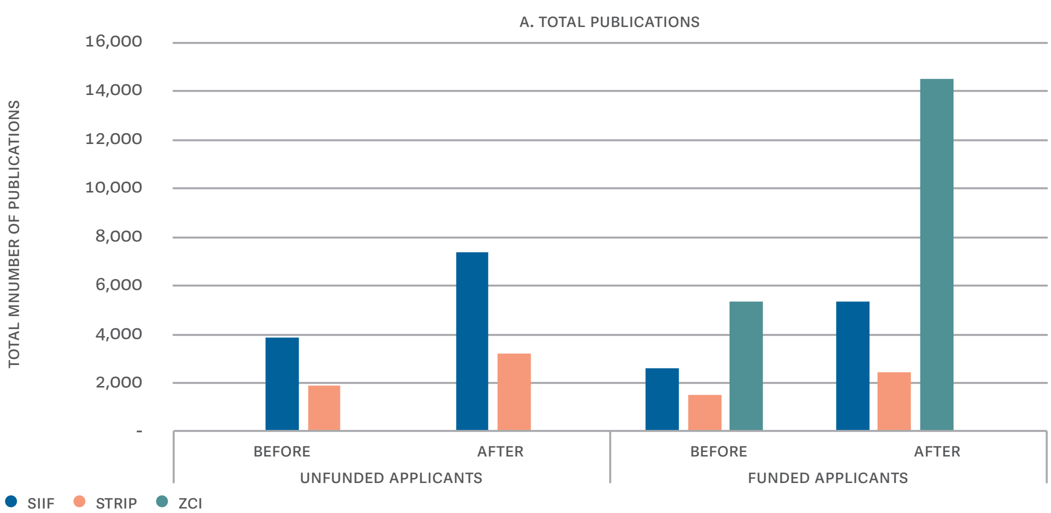
Source: CROSBI.

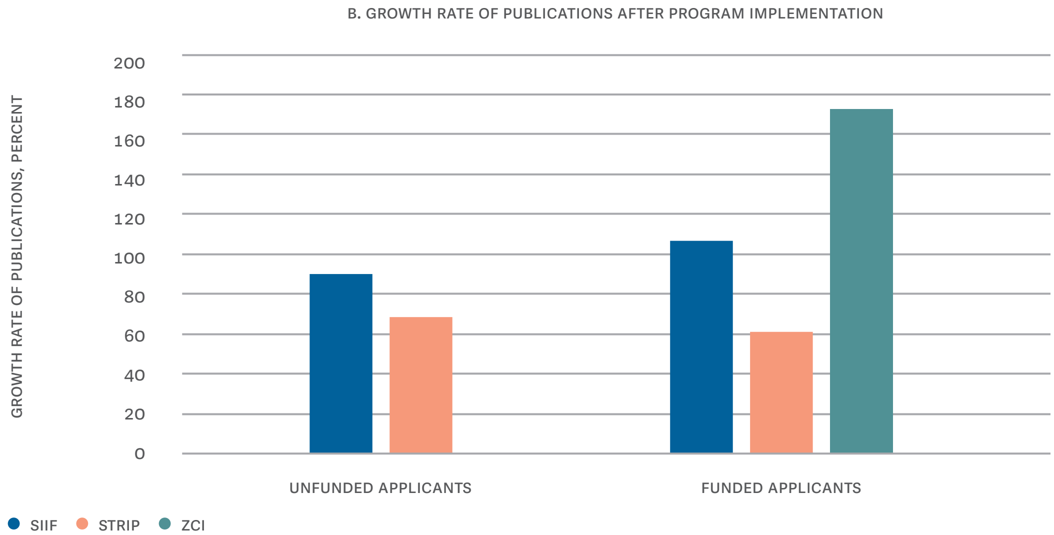


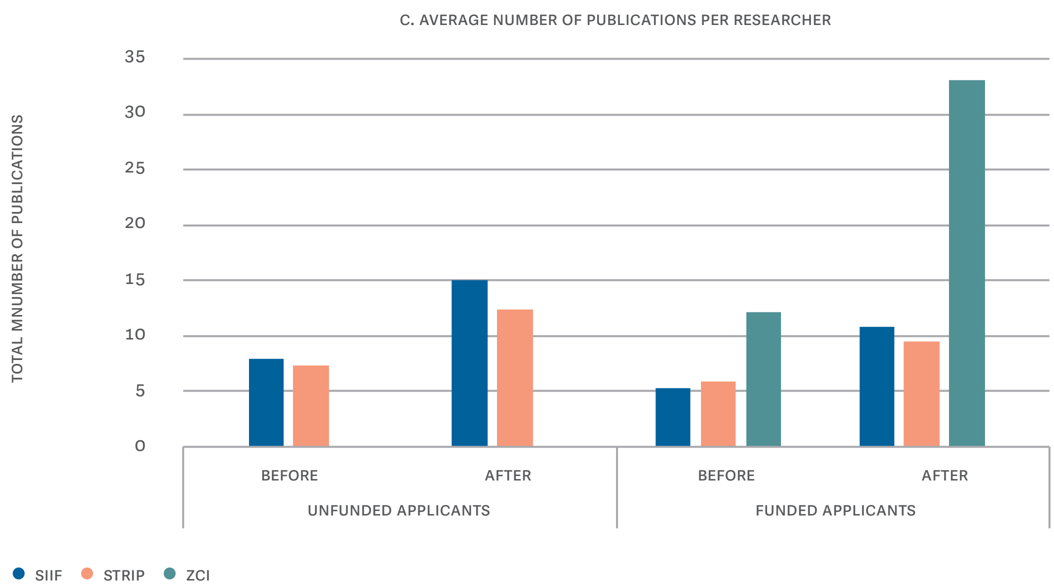
Source: CROSBI.

Funded researchers published at a higher rate compared to non-funded researchers, but this difference is not necessarily a result of S3 interventions. Figure 3.8 shows publication records before and after the implementation of each program for both funded and unfunded researchers. (All applicants to the ZCI program were funded, so the figure shows zero publications for unfunded researchers.) Before program implementation, funded applicants in the SIIF and STRIP programs had fewer publications compared to unfunded applicants (Figure 3.8 Panel A). However, the percent increase in publication after the award is in large favor of funded applicants (Figure 3.8 Panel B). This is especially true for researchers supported by the ZCI program, whose publication records increased by 172 percent after the program was implemented. Part of the increase might be due to better recording of publications for later years, but that should be common across funded and unfunded groups. Researchers supported through the ZCI program had the highest number of publications per researcher (around 12), and after program implementation, this increased to 33 publications per researcher (Figure 3.8 Panel C).

Figure 3.8 Number of publications per program





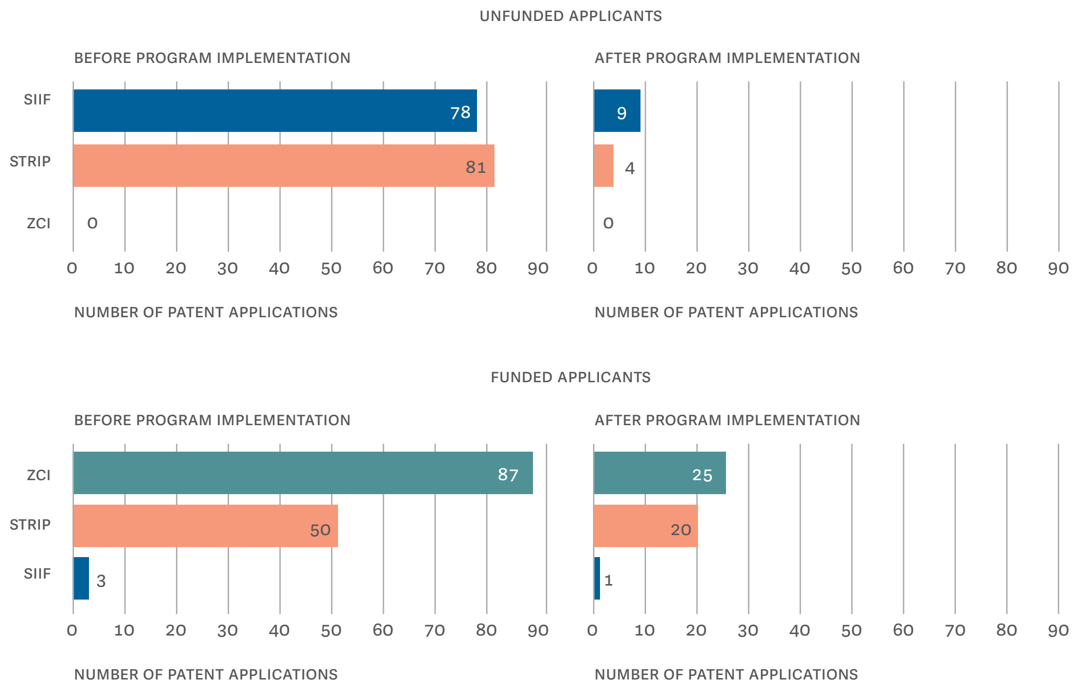


Source: CROSBI.

Patents

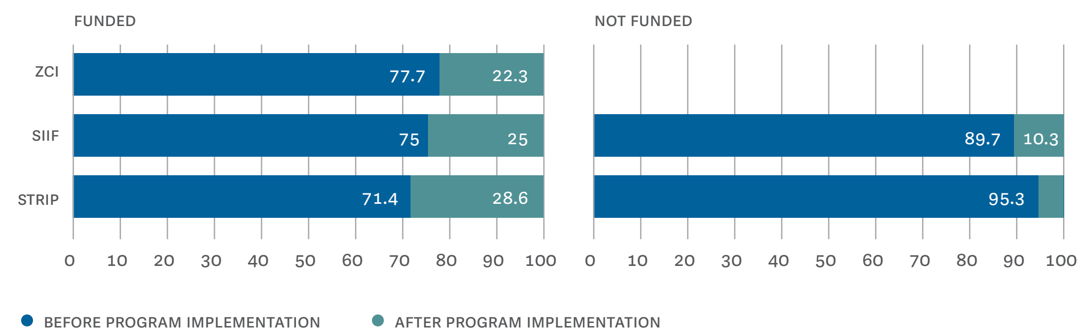
Unfunded researchers had more patent applications before the intervention, but patent applications among funded researchers grew faster. Before the programs were implemented, researchers associated with non-funded projects submitted a higher number of patent applications compared to those from funded projects. Specifically, the STRIP program had the highest number of patent applications before its initiation, totaling 131. Out of these, 62 percent were filed by team members from non-funded projects. Similarly, nearly all patent applications submitted by researchers associated with SIIF before program implementation originated from non-funded researchers, accounting for over 96 percent. However, the number of patent applications grew at a higher rate among funded applicants (Figure 3.9). After program implementation, unfunded applicants had only 13 patent applications, whereas funded applicants had 46.

Figure 3.9 Applicants from unfunded projects have a stronger starting position in terms of patent applications



Source: Patstat.

Figure 3.10 Share of patent applications after the program was implemented in total number of patent applications

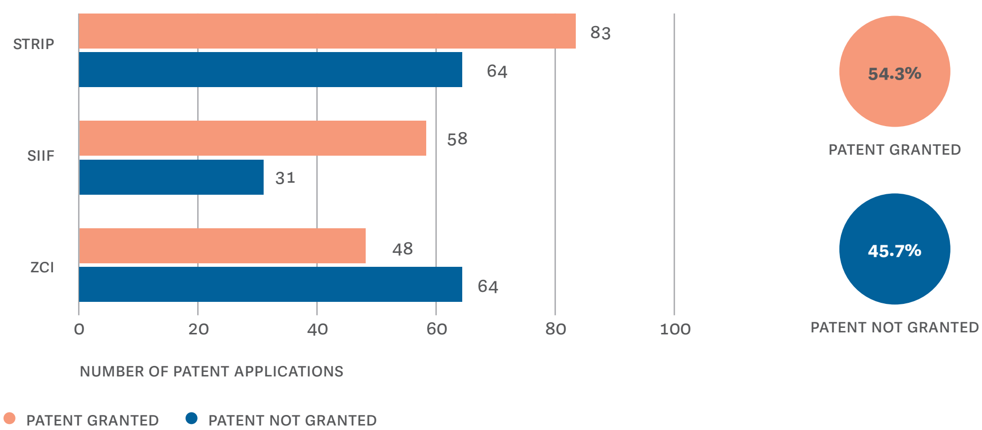


Source: Patstat.

Similarly, unfunded researchers have a higher baseline of granted patents, but funded researchers increased granted patents by a higher margin after program implementation. Although non-funded applicants have a much stronger starting position, in percent terms the improvement for funded research is substantially larger. The percentage change in the number of patent applications shows a two to three-fold increase for funded researchers, whereas for unfunded researchers, the change is very modest (Figure 3.10).

Applicants to the STRIP program had the most granted patents, whereas SIIF applicants had the highest success rate. All applicants submitted 348 patent applications, with 189 (or 54.3 percent) being granted and 159 (or 45.7 percent) not granted (Figure 3.11). Researchers funded under the STRIP program recorded the most patent applications (147), with over 56 percent of these applications being successful. Researchers that applied for the SIIF program filed fewer of patent applications (89) but had a higher success rate (over 65 percent). Finally, researchers that implement ZCI programs filed 112 patents, 48 (or 43 percent) of which were granted.

Figure 3.11 A larger share of patent applications filed by program applicants has been granted

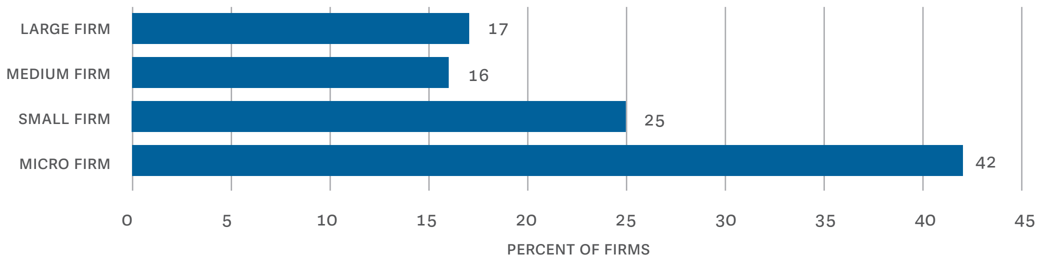


Source: Patstat.

Collaboration with firms

Regarding collaboration with the private sector, research organizations in the STRIP program mainly partnered with micro and small firms. Although there are other programs which allow for collaboration between researchers and firms, the analysis refers only to the STRIP program, since it is the only program where partnerships were mandatory and for which sufficiently granular data was available. Over two-thirds of partners in STRIP program applications are micro and small firms (Figure 3.12).

Figure 3.12 Partner size on the STRIP program



Source: Staff elaboration.

There is evidence of significant concentration of collaborative networks among few research organizations. To better understand the connections among applicants, we used a network diagram. A network diagram is a special representation of entities which have relationships among themselves (see Box 3.1). A partial segment of the network diagram for the STRIP program (Figure 3.13) shows there are applicants with a relatively developed collaboration network (indicated with nodes with high centrality), suggesting a concentration of collaborative projects among a few research organizations and firms. Some of these more prolific applicants share a limited number of partners. Although this may be a function of the small number of firms with the capacity and willingness to engage in R&D, it may also indicate difficulties for new entrants to become part of these established networks.

Box 3.1 Interpreting network diagrams

The diagram in this box is a visual representation of the network created by one institution. The red circle (or node) represents the main applicant. The 10 green nodes linked to the applicant denote 10 projects for which the applicant sought financing. The thicker connections (edges) between red and green nodes indicate funded projects (six in this example), whereas thin connections indicate unfunded applications. Partners are marked with lighter teal nodes. This applicant has up to two partners per project, and funded projects had more partners on average. Among the funded projects, half had two partners, but only one out of every four non-funded projects featured a partnership.

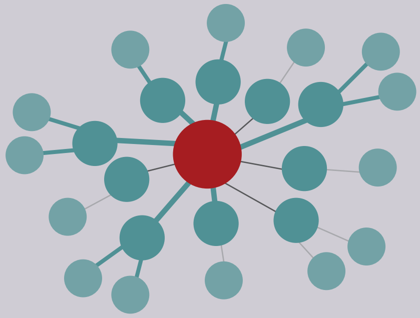
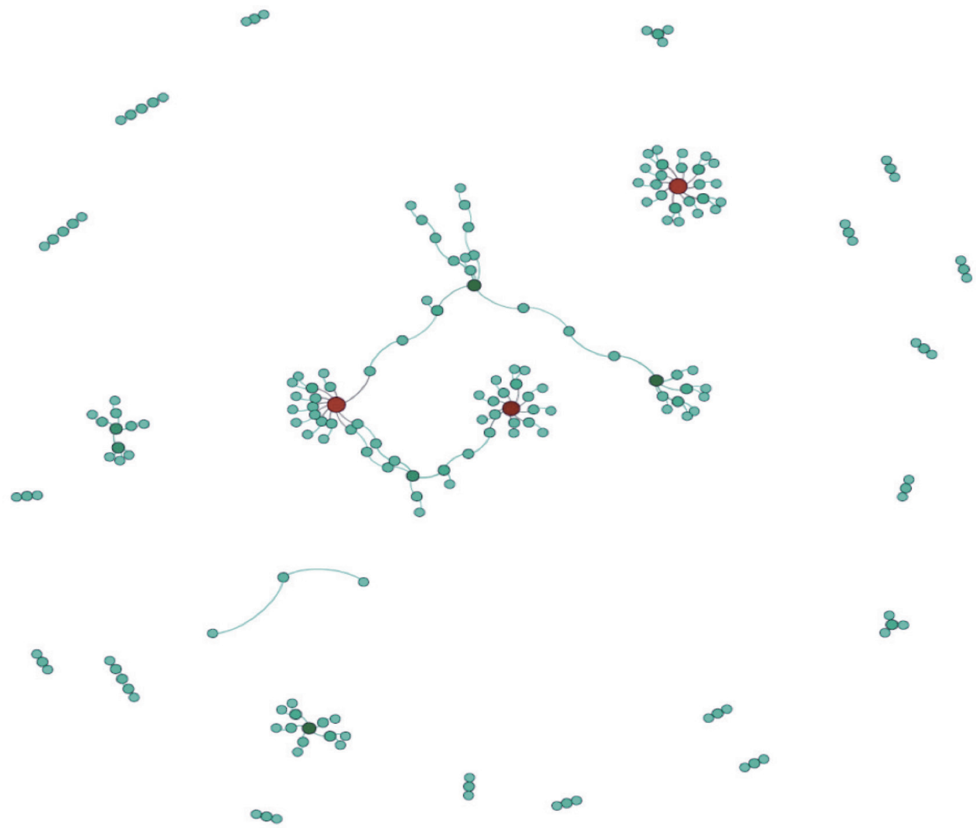


Figure 3.13 Network diagram segment of collaborative relationships in the STRIP project



Note: The figure shows a partial segment of the network diagram. Red node= applicant, green node=project, teal nodes=partners, thick connections (edges)=funded projects, thin connections (edges) unfunded projects. The groups of densely interconnected nodes reveal sub-networks or communities within the larger network, highlighting the groups of entities that tend to collaborate more closely among themselves.

Source: Staff elaboration.

3.3 Program impacts on quantity and quality of publications

The impact of SIIF and STRIP programs on researchers' publications is measured through publication quantity and quality. The quality of citations was estimated using different measures scraped from Google Scholar: the total number of citations, citations per paper, H-index, and I10 index.[11] We then also calculate the number of citations per paper as an

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11 These three key metrics have been scraped for each researcher we have information on through the application file from Google Scholar. These metrics encompass the current number of citations as of November 2023, the number of citations up to 2018 (we consider this as the pre-program), the H-index, and the i10-index (again as of November 2023 and up to 2018).

additional outcome. Box 3.2 provides definitions and explanations for all four measures used. The impact on publication output is measured using DiD estimation methods. We incorporate researcher fixed effects for the DiD analysis to control for any unobserved heterogeneity between the group and to reduce the risk of bias in our estimates.

Box 3.2 Measures of publication quality

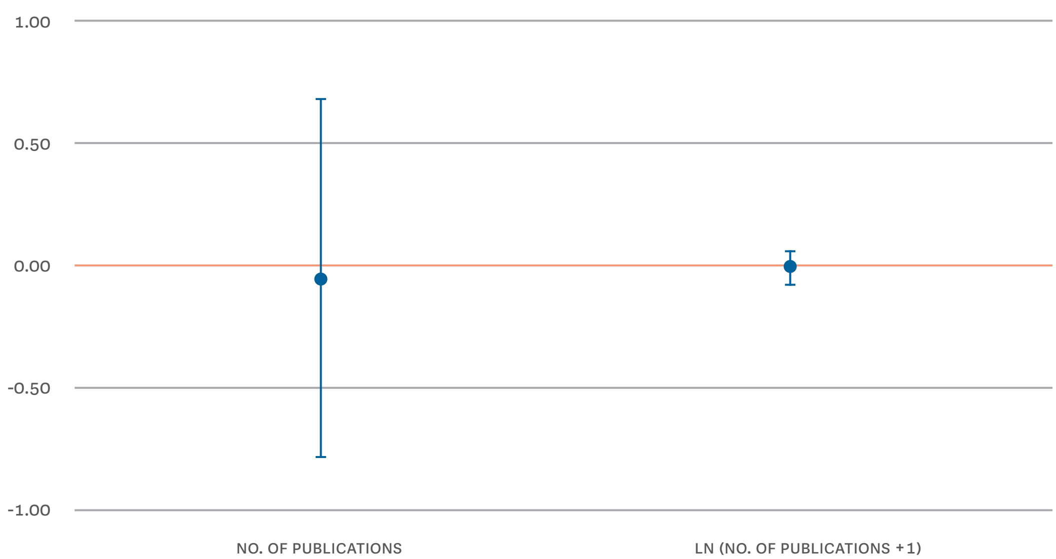
The analysis in this section is based on four complementary measures of the quality of publications:

- Total citations – the total count of citations that a published item has received since its publication date. Although this measure is straightforward to interpret, it penalizes more recent publications that have not yet had enough time to be cited.
- Average number citations per paper citations – the number of citations divided by number of publications.
- Hirsch index (H-index) – The H-index is an aggregate measure that combines data on citation and publication quantity. The H-index is defined as the maximum value of h such that an author has published h papers that have each been cited at least h times. For example, an author who has three papers, each cited only once, has an H-index of 1. However, an author who has three papers, where the first paper is cited 10 times, the second paper is cited five times, and the third is cited once, has an H-index of 2 (i.e., the author has two publications that have been cited two times or more). The H-index can vary across fields due to their particular publishing and citing frequencies.
- I10 index – the number of publications with at least 10 citations.

At the time of the impact evaluation, the programs had no effect in increasing the quantity of publications among beneficiaries, which is expected given that publications take some time to produce and not all projects are completed. The analysis considers publications by 895 researchers identified in CROSBI, both beneficiaries and non-beneficiaries. On average, all researchers authored six publications per person. The analysis reveals no statistically significant difference in the number of publications between those applicants who received support and those who did not. Since research papers may take two years to prepare and publish, it can be reasonably expected that this result may change over the next couple of years. Projects in the SIIF and STRIP programs started in December 2019 and December 2020, respectively, and some are still ongoing at the time of writing of this report. Figure 3.14 shows that: (i) the estimated differences between funded and unfunded researchers in terms of publications are close to zero (circles in the chart indicate the estimated difference values); and (ii) the estimates are not statistically significant at

95 percent level of confidence (as the confidence interval illustrated by the vertical line crosses the zero line). In simpler words, the analysis finds neither statistically nor economically significant effects of receiving a grant on the quantity of publications produced.

Figure 3.14 Program impact on publication quantity



Note: Point estimates (circles) and 95 percent confidence intervals (vertical error bar). Variables with confidence intervals that do not cross zero are considered statistically significant at 5 percent level of significance. The estimates for log-transformed dependent variable measure the percentage change in the dependent variable.

Source: Staff elaboration based on CROSBI data.

Although the average number of citations per paper appears to be very high, it is inflated by a few highly collaborative projects typical for certain scientific fields. The results in Table 3.1 show that, on average, researchers in the sample have almost 1250 citations, with 331 citations per paper. The average H-index is 13.8 and the average I10 index is 24.1, respectively. However, these results are distorted by the fact that a few authors have between 10,000 and 100,000 citations and high H-indices. The average number of citations is largely inflated by highly collaborative articles, particularly in disciplines such as physics or medicine. For example, extensive co-authorship is specific to certain physics subsectors, such as high-energy physics, where the complexity of research projects requires extensive collaboration within large teams and all team members are listed as authors. The literature argues that substantial collaboration is highly correlated with publication impact, measured by the number of citations received by their peers (Franceschet & Costantin 2010).

Table 3.1 DiD results for different quality measurements of scientific bibliography

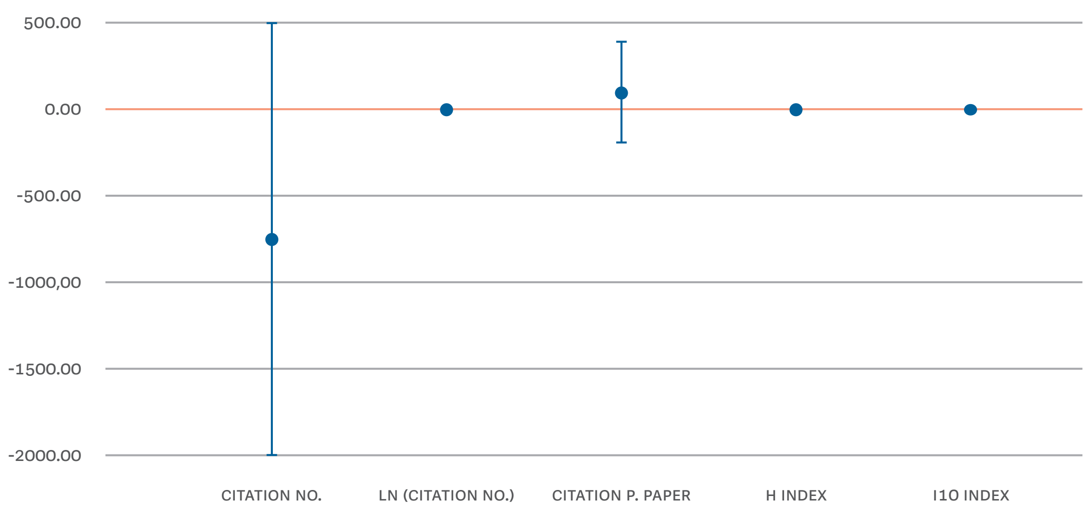
	(1) Citation no.	(2) ln(citation no.)	(3) citation p. paper	(4) H index	(5) I10 index
TREATMENT	-751.7 (638.5)	0.0917 (0.110)	101.3 (148.7)	-0.372 (0.442)	-2.127 (2.136)
OBSERVATIONS	794	773	801	794	794
ADJUSTED R^2	-1.439	0.217	-1.612 330.8	-0.631	-1.173
MEAN OF DEP. VARIABLE	1236.7	5.615		13.82	24.12

Standard errors in parentheses
*p < 0.10, **p < 0.05, ***p < 0.01

Source: Staff elaboration based on Google Scholar data.

The programs seem to have had no effects on raising the quality of publications noting that this may change because publications usually accumulate citations over a long period. The analysis considers around 800 researchers who have at least one citation. None of the results for the beneficiaries are statistically significant, so no effect of the programs on the quality of publications has been detected. This result comes with the same caveat as publication quality: projects started relatively recently and may need more time to accumulate citations. Figure 3.15 shows the results of the analysis in graphic form. The estimate for the difference in the number of citations between funded and unfunded firms is around negative 750, whereas the estimates for the difference in other citation measures (citation growth, citations per paper, H-index and i10 index) are close to zero. The figure also shows that the 95 percent confidence intervals for the estimates cross the zero line, meaning they are not statistically significant.

Figure 3.15 Program impact on publication quality



Note: Point estimates (circles) and 95 percent confidence intervals (vertical error bar). Variables with confidence intervals that do not cross zero are considered statistically significant at 5 percent level of significance.

Source: Staff elaboration based on Google Scholar data.

3.4 Program impacts on patent applications

Developing and obtaining a patent takes a long time, limiting the impact analysis to patent applications. For example, a 2022 study of grants funded by the European Research Council shows it takes an average of 3.7 years for new knowledge based on fundamental research to be cited in a patent application, whereas some papers are cited up to 10 or even 12 years after they are first published (ERC 2022). Further, the European patent approval procedure takes three to five years according to the EPO. The analysis therefore focuses on patent applications rather than granted patents, due to the limited sample size.

Two-period, two group DiD was applied to understand the effect of project implementation on patent applications. As we do not have a proper time series of the patents data, we propose a simple two-period, two-group DiD. Fixed effects for the researchers have been included in the regression to account for any unobserved heterogeneity between the groups. The time dimension in this study is determined by whether the patent application predates or postdates the project implementation. This creates a two-period panel structure, where each period consists of two groups (treatment and control). The limited sample size for this part of the analysis is a challenge, as we had to manually match researchers in the database and application file, which are only available for MSE programs.

The analysis suggests a positive impact of the programs on patent applications, but this should be taken with caution due to the small sample size. Patent applications were observed among 67 researchers which appear in the Patstat database (both beneficiaries and non-beneficiaries), and on average they had four applications each. Figure 3.16 shows a positive and statistically significant difference between funded and unfunded beneficiaries both in absolute terms (left bar) and a percent change (right bar). Both bars on the chart, representing 95 percent confidence intervals for the point estimates, stay above the zero line, which signifies that the estimates are statistically significant. The analyzed programs resulted in about 70 percent more patent applications compared to non-beneficiaries,[12] and this result is statistically significant with a level of confidence of 99 percent. Nevertheless, the magnitude of the impact should be interpreted with caution as the analyzed sample has only 67 observations.

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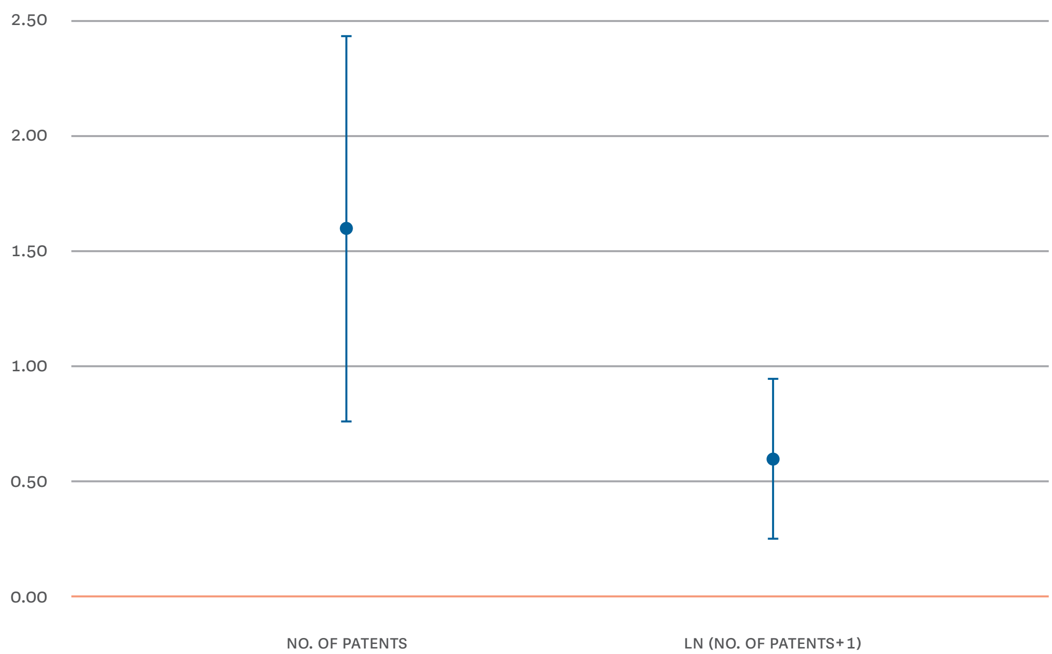
12 The estimated coefficient shows an increase in the number of patent applications of 1.6 over an average of 3.97 (between treatment and controls), which is about 70 percent increase over the control mean.

Figure 3.16 Program impact on patent applications, DiD



Note: Point estimates (circles) and 95 percent confidence intervals (vertical error bar). Variables with confidence intervals that do not cross zero are considered statistically significant at 5 percent level of significance. The estimates for log-transformed dependent variable measure percentage change in the dependent variable.

Source: Staff elaboration based on Patstat data.

4 Analysis of firms' outcomes

4. Analysis of firms' outcomes

The analysis of S3 instruments on firm innovation outcomes is based on descriptive analysis of survey data, data from publicly available databases, and a counterfactual impact evaluation for selected outcomes. The analysis considers outcomes achieved by firms funded under five programs: IRI, KIP, Startup Innovation, Inno-vouchers, and STRIP. The analysis includes a before-and-after and program-level analysis of firms' outcomes based on financial statement data, a survey of applicants,[13] and an impact evaluation for selected outcomes.

Lack of data limits the analysis. Data from project applications would have allowed for much richer analysis, especially since MESD programs generally have a sizable applicant population. However, the MESD was willing to provide only data on applicant names, IDs, partner names, where applicable, and application status. This severely limited the analysis that could be conducted. Lack of application data for projects to firms also precluded bibliography analysis for firms and researchers that collaborated with firms (e.g., on the IRI program).

4.1 Survey results

Over half of the surveyed firms completed their projects fully or partially. Over a quarter of firms reported having fully completed projects, whereas 43 percent were partially complete (Figure 4.1). Twenty-nine percent of firms indicated they did not (even partially) complete their project. A significant share of projects were completed despite not receiving funding (see Annex 2). For firms, this may indicate that they have alternative means to finance their projects.

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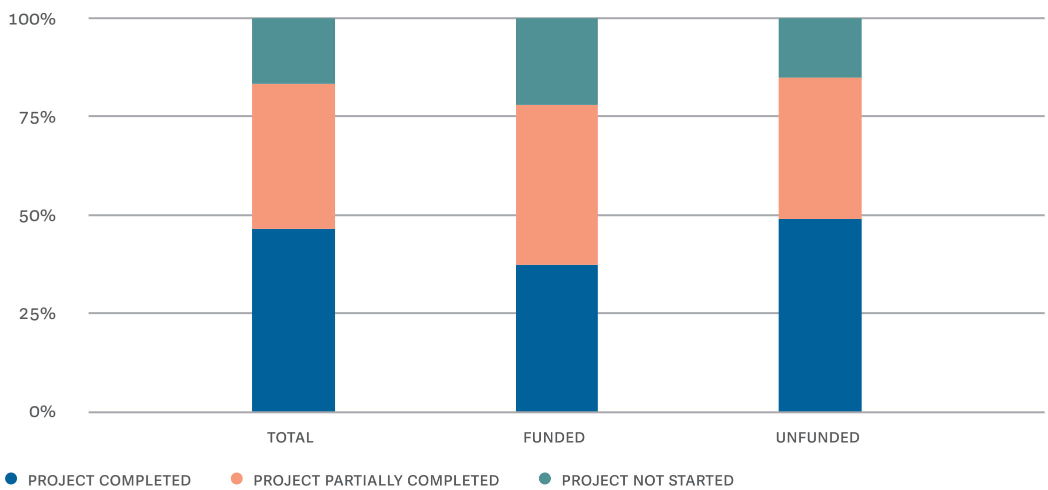
13 The results of the survey are presented here for informational purposes, but they are not representative of the applicant population, and should be interpreted with caution. Due to the low response rate, the results cannot be extrapolated to the whole researcher applicant population. Nevertheless, the survey provides some interesting insights that, in some cases, are in line with the findings of previous analytical work.

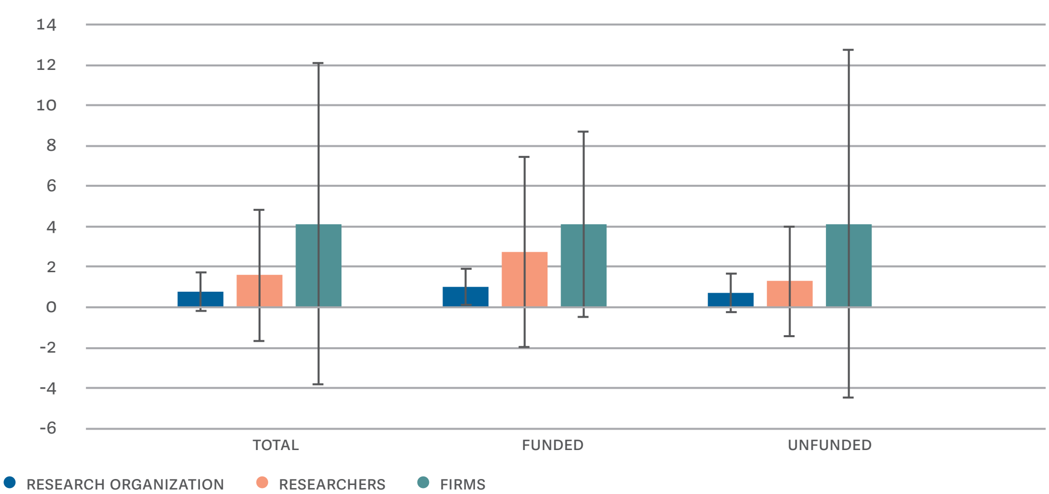
Figure 4.1 Project completion status of firm survey respondents



Source: Staff elaboration.

Firms report very few collaborations and tend to gravitate toward other firms as opposed to research organizations or researchers. Firms reported an average of one collaboration with other companies, whereas many had no collaborations with research organizations or researchers in general (Figure 4.2). On one hand, this result is not surprising given that the majority of analyzed programs did not require mandatory partnership. On the other hand, the STRIP program included mandatory partnerships, whereas the Inno-vouchers program (which had many applicants and beneficiaries) and the IRI program (the largest in terms of overall budget) also supported industry-science collaboration. Collaboration schemes are notoriously difficult to structure due to more complex state aid implications. Nevertheless, it will be important for both MSE and MESD to join forces in focusing on expanding collaboration networks between researchers and firms.

Figure 4.2 Average number of collaborations (firms)



Note: The vertical lines (error bars) represent 95 percent confidence intervals.

Source: Staff elaboration.

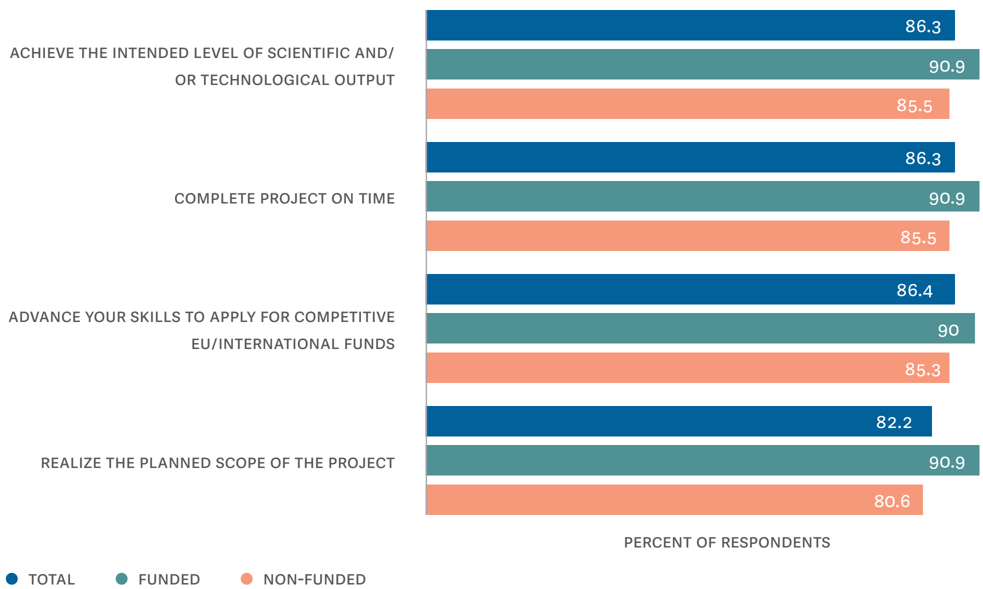
Firms report developing and commercializing their innovations as a result of implementing their project but rarely seek to protect their IPR. Firms mostly reported developing product innovations, followed by design and process innovations (Figure 4.3, panel A). Firms commercialize about half of the developed innovations and sought IPR only for 29 percent of them. Many of the developed innovations (65 percent of them) were reported to be green or sustainable. On average, firms developed close 1.4 product or service innovations on average, whereas process innovation and design innovation was reported around once per firm (Figure 4.3, panel B). The light-shaded portions of the bars in Figure 4.3, panel A represent the results for funded firms while the darker shaded portions of the bar represent all firms. Interestingly, unfunded firms reported developing, commercializing and protecting more innovations than funded firms.

Figure 4.3 Reported innovations in firms

Note: Light coloured portions of the bar in panel A represent funded applicants.
Source: Staff elaboration.

Most respondents report additional benefits of applying for funding. Over 80 percent of firms stated that they built up their skills to apply for other competitive EU or international funds, realized the planned scope of the project, and completed their project on time (Figure 4.4). A slightly higher share of respondents (88 percent) stated that they achieved the intended level of scientific or technological output.

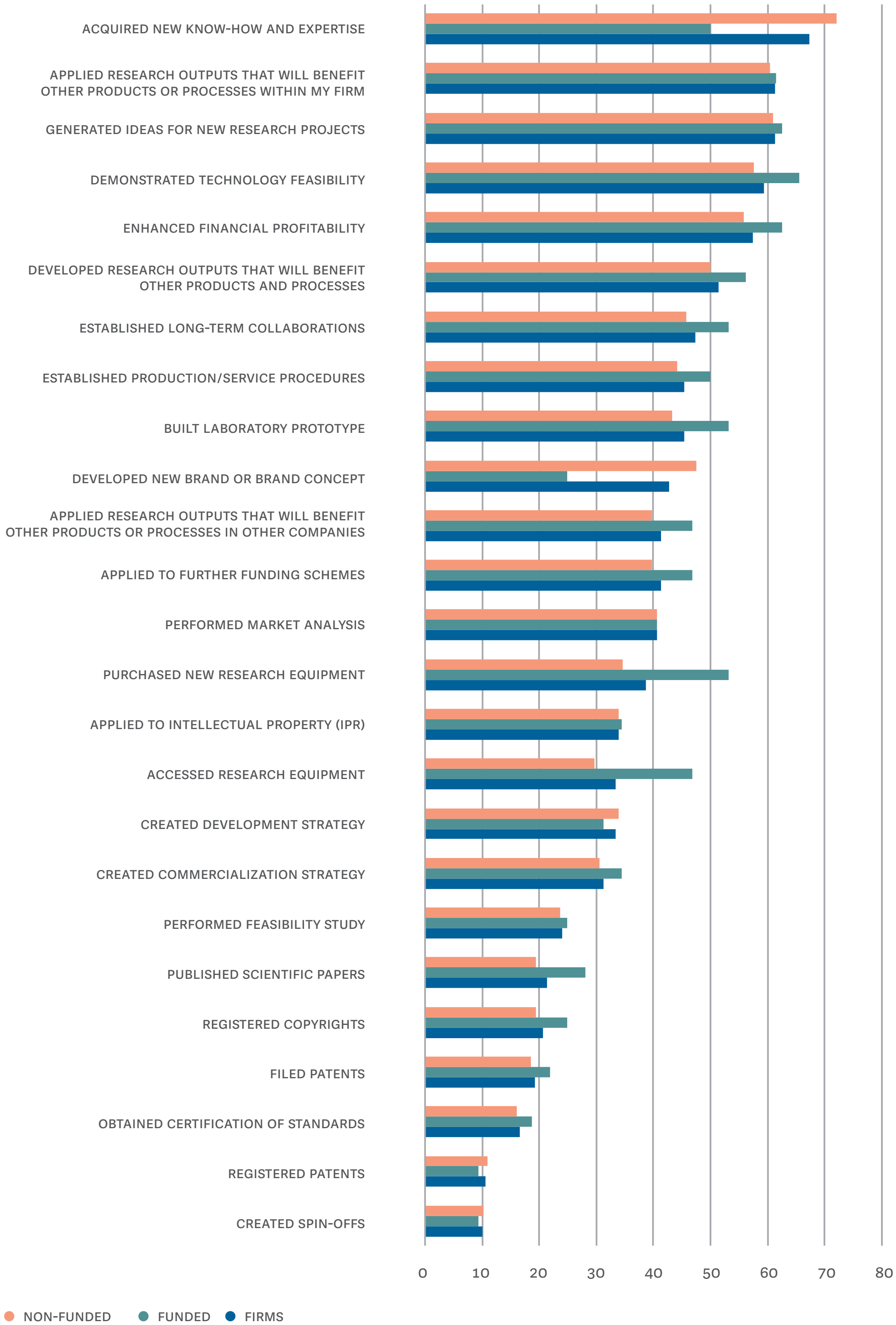
Figure 4.4 Benefits of applying, percent of firm respondents



Source: Staff elaboration.

Firms mostly report project outcomes related to generating new knowledge, whereas outcomes that would be close to the market are scarce. Over 60 percent of survey respondents reported outcomes that could be associated with early stages of innovation, such as acquiring new knowledge, generating applied research outputs and ideas for new research projects (Figure 4.5). Few firms reported intellectual property protection and technology transfer outcomes, as well as outcomes related to preparation for market entry.

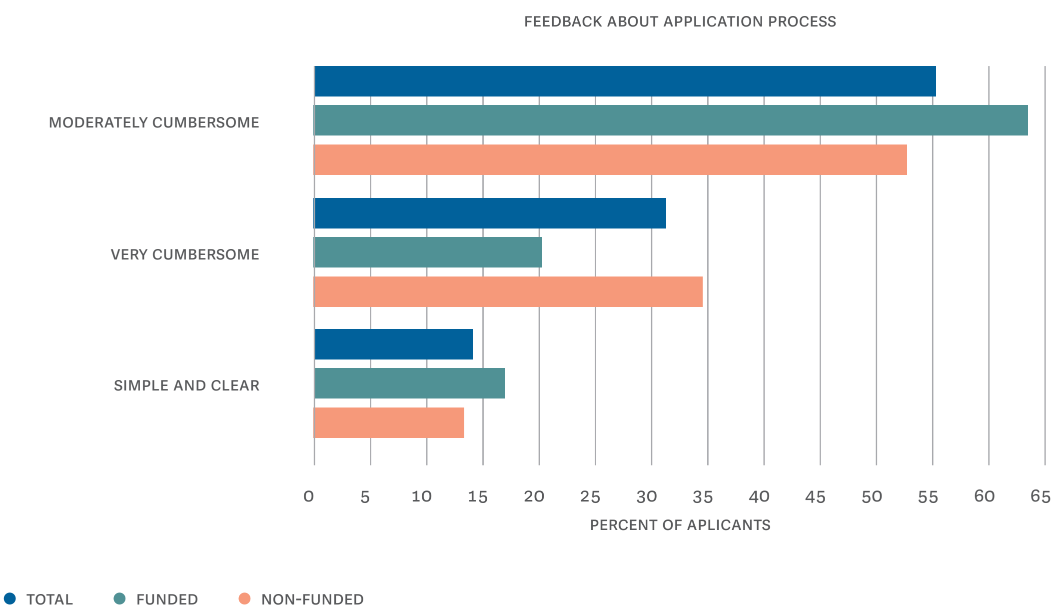
Figure 4.5 Reported project outcomes (firms)



Source: Staff elaboration.

Most firms found the application process moderately to very cumbersome. A majority of surveyed firms (around 56 percent) found the process to be moderately cumbersome, whereas around 29 percent stated it was very cumbersome (Figure 4.6). This result is consistent with the data gathered from researchers (see section 3.1). The centralized nature of application and selection process design does not allow for the flexibility necessary to simplify the application and selection processes more substantially.

Figure 4.6 Feedback on the application process, percent of firm respondents



Source: Staff elaboration.

4.2 Intangible assets and innovation spillovers

Funded firms had stronger innovation output, financial performance, and employment levels even before receiving any funding. Results in Table 4.1 show that, before the programs were introduced, funded firms were already stronger with respect to innovation performance (measured by the value of intangible assets) and had higher revenues and more employees. Except for intangible assets, all variables show a statistically significant difference in favor of funded firms, both in absolute terms and as log-transformations.[14] The difference in intangible assets is statistically significant in its log-transformation

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14 Log transformation mitigates the impact of extreme values, which were somewhat pronounced in the sample.

form. The same conclusions hold for KIP, IRI, and to some extent the Startup Innovation program. However, for Inno-vouchers, these differences are in favor of unfunded firms, i.e., funded firms are typically smaller, and are not statistically significantly different from unfunded firms.

Table 4.1 Supported firms had better financial performance and employment level before program start

	(1) Not Funded		(2) Funded		(1)-(2) Pairwise t-test	
VARIABLE	N	Mean/(SE)	N	Mean/(SE)	N	Mean difference
REVENUE, MILLION EUROS	533	4.100 (1.786)	579	14.632 (5.848)	1112	-10.532*
LOG REVENUE, MILION EUROS	497	11.155 (0.115)	562	12.495 (0.120)	1059	-1.340***
COGS (COST OF GOODS SOLD), MILLION EUROS	533	1.853 (0.585)	579	10.093 (4.275)	1112	-8.240*
LOG COGS (COST OF GOODS SOLD), MILLION EUROS	517	10.125 (0.120)	571	11.632 (0.125)	1088	-1.506***
OPEX (OPERATING EXPENSE), MILLION EUROS	533	3.610 (1.436)	579	13.770 (5.561)	1112	-10.160*
LOG OPEX (OPERATING EXPENSE), MILLION EUROS	530	10.739 (0.116)	576	12.245 (0.118)	1106	-1.506***
I.ASSETS (INTANGIBLE ASSETS), MILLION EUROS	533	0.434 (0.299)	579	0.758 (0.321)	1112	-0.324
LOG I.ASSETS (INTANGIBLE ASSETS), MILLION EUROS	250	8.503 (0.151)	400	9.612 (0.119)	650	-1.109***
NO.EE (NUMBER OF EMPLOYEE)	533	27.887 (9.694)	579	81.381 (20.143)	1112	-53.494**
LOG NO.EE (NUMBER OF EMPLOYEE)	466	1.309 (0.069)	552	2.123 (0.078)	1018	-0.814***
F-test of joint significance (F-stat)						4.479***
F-test, number of observations						613

Note: This is a balance test for firm's grant applicants. As common in impact evaluation, balance tests are run with both absolute and logarithmic values, to ensure rigorous assessment of comparability between treatment and control (i.e., funded and unfunded firms). Differences in the pre-program outcome average values have been tested using pairwise t-test (*p-values ***p < 0.01, **p < 0.05, *p < 0.10).*

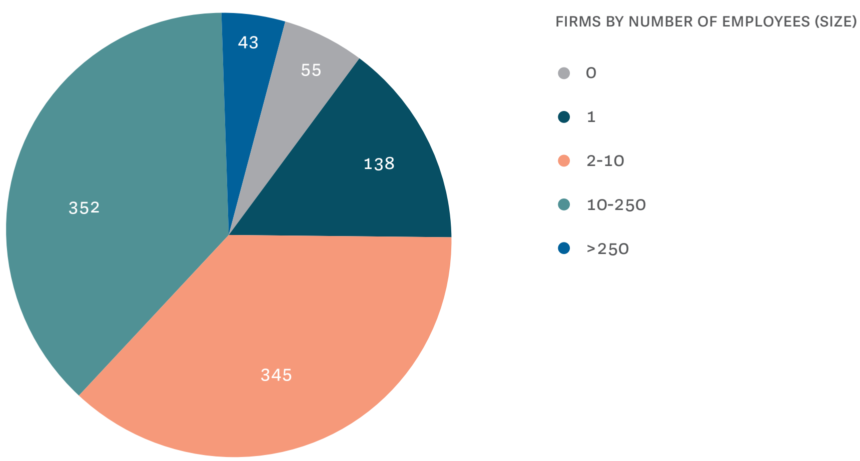
Source: Staff elaboration.

These results indicate that firms with lower financial capacities may face barriers to public financing for innovation. The fact that funded firms had more valuable innovation assets and financial position even before receiving funding suggests that the programs explicitly or implicitly selected for those characteristics. This may result from the selection criteria placing a strong emphasis on implementation capacities, but may also reflect the overall complexity inherent in the application process. Indeed, the disparity between funded and unfunded firms is not as clear in the Inno-vouchers program, which had a much simpler application process. The extensive capacity needed to participate in solicitations for grants supporting innovation has been well documented through earlier analyses (see World Bank 2020b). Excessive program and application complexity and rigid selection frameworks will create barriers for new firms at initial stages of development.

However, those are precisely the firms with the strongest argument for receiving public support, as they face many market and system failures and have the strongest potential for productivity gains as a result of R&D investment (World Bank 2019).

The majority of active firms are micro firms, with 10 or fewer employees. These micro firms constitute 58 percent of all active firms in the sample, followed by the SMEs. Within the category of micro- firms, 193 firms operate with zero or one employees. This is over half of the active micro firms, and 20.7 percent of all active firms. By contrast, 43 firms (or 4.6 percent of the sample) are categorized as large firms (Figure 4.7).

Figure 4.7 Applicant structure by firm size



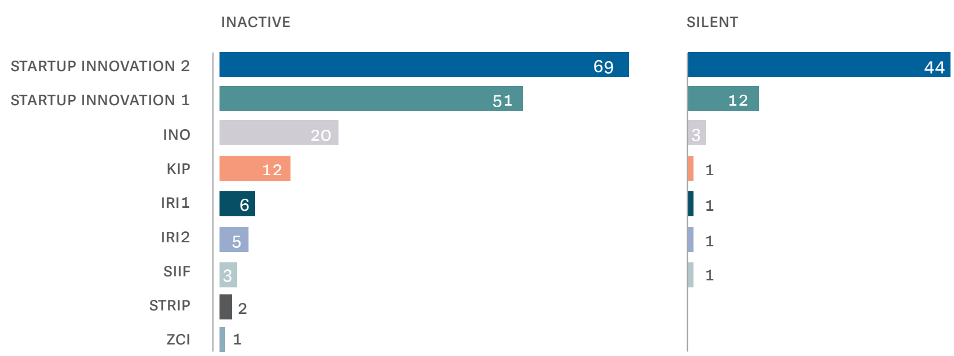
Source: Staff elaboration.

There is a non-negligible share of inactive and "dormant" firms among the applicants. These firms were identified during the survey data cleaning process, which involved cross-referencing applicants with an administrative database to check their activity status. During the verification, 165 companies were found to have ceased operation and deleted from the relevant registries. Such firms are treated as inactive and are excluded from the sample and further analysis. Moreover, when active firms were further analyzed by revenues and number of employees, we found that 60 active firms reported zero or one employee and zero revenues. Such entities are often called "silent" or "dormant" firms.

There is a concern that "dormant" firms were created with the sole purpose to apply for grant funding. The analysis reveals that several firms were created or moved out of an inactive state specifically at the time of application. Although some grant programs can serve as an avenue for firm creation, there is a worry that these newly established firms may be unprepared to manage large grants and their creation could end up being a dispersion of resources.

There is a relatively high number of inactive and dormant firms in the Inno-vouchers and Startup Innovation programs. A deeper analysis of firms' status by type of instrument reveals several key findings about inactive firms. First, a significant portion of inactive firms (around 72 percent) originates from Startup Innovation programs, followed by Inno-vouchers at 10 percent. It is somewhat expected that the programs supporting start-ups had the highest share of currently inactive or dormant applicants, considering that the survival rates for start-ups are generally lower than for established enterprises. Second, a majority (74 percent) of these inactive firms received no funding. Interestingly, Inno-vouchers is the only program where a higher proportion of inactive firms received funding. Furthermore, 44 percent of firms in Startup Innovation 1 and 35.5 percent of firms in Startup Innovation 2 were inactive, underscoring a relatively high level of inactivity in these early stages of development. Finally, almost all firms which are regarded as dormant in 2022 have applied for participation in the Startup Innovation programs.

Figure 4.8 Number of inactive and dormant firms per program



Source: Staff elaboration.

4.3 Program impacts on innovation and spillover outcomes

The impact analysis considers financial statement data as proxies for innovation and spillover outcomes relevant for the programs. Furthermore, the responses collected from the applicant survey were not sufficient to collect data on other innovation outcomes such as innovations introduced, sales from innovative products and services, and similar. The analysis focuses on five important outcomes that were part of the objectives of different programs and are available from administrative records:

1. Sales revenue and other operating income (Revenue);
2. Costs of raw materials, direct labor costs, and material expenses (Cost of goods sold);
3. Total operating expenses (Operating Expenses);
4. Value of intangible assets (Intangible Assets);
5. Number of employees.

Unfortunately, no specific innovation outcome would be available with administrative level data, but intangible assets can be regarded as its proxy as it contains items linked to innovation as the value of patents, concessions, licenses, trademarks, software, and other rights. Other variables in data set used as a control variable provide a rich and detailed framework for our analysis, allowing us to account for various factors that may influence the outcomes we are studying.

Multiple methods have been used to analyze observational data. Given the non-random assignment of grants, unclear assignment rules, and small sample size, we employed multiple methods for analyzing observational data, each relying on different identifying assumptions. Since there were only a few applicants and beneficiaries, we pooled programs run by the MESD. While acknowledging heterogeneity in the programs and participants, we recognize that analyzing at the program level would be underpowered. Furthermore, all the programs are dedicated to grants for innovation activities with similar scope but distinct rules and sizes as elaborated in section 1.1. However, we also report results based on different aggregations of the firms' programs but call for cautiousness in results interpretation due to limitations primarily related to small sample size.

The analysis uses different estimation techniques to overcome methodological challenges and verify the robustness of the results. In the analysis, we first present the results of the novel Callaway and Sant'Anna (2021) estimator (CS-DiD) for dynamic treatment effects, which is suited to our scenario, because we have a staggered design when considering all the programs at once (the first treatment year is 2016 and the last 2019). We limit the post and pre-program differences to a few leads and lags because we can observe at most three leads for all programs. (this is due to our data availability up to 2022 whereas the youngest program starts in 2019.) We use as a control group applicants who were not funded. However, issues related to the lack of a random design require testing the validity of results with an alternative estimation method. The primary concern with the present assessment is the absence of a randomized design, necessitating a cautious interpretation of the results. One possible way to address the reasonable concerns about the validity of the results is to provide additional evidence based on alternative identification assumptions. The CS-DiD results are therefore complemented by standard DiD and DDML methods (see Box 4.1 for more technical details on the implemented methodologies).

Box 4.1 Standard DiD and DDML technical specifications

Standard DiD and DDML were the methods used to probe the robustness of the main results. The main differences between the standard DiD and the dynamic treatment effects' approach boils down to the way the experiments are aggregated, and the fact that Callaway and Sant'Anna reweigh the observations so the treatment and control groups are rebalanced.

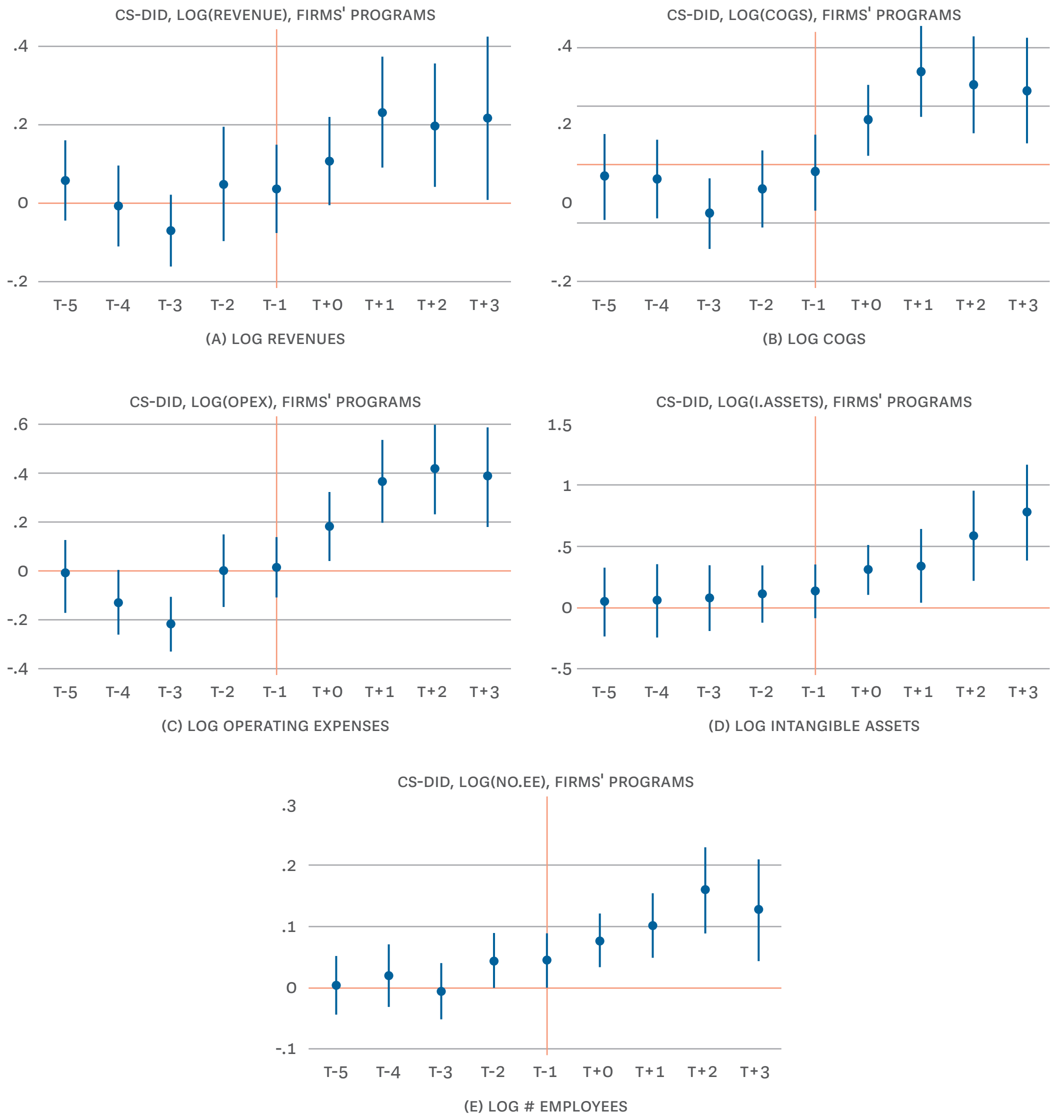
A different identification idea underlies the DDML, the assumption is that the treatment effect is identified conditional on a set of controls at baseline selected with a machine learning tool, so the ultimate differences between treatment and control units rest on the treatment status. A set of control variables has been included in the model to account for important factors that, in addition to treatment, can greatly affect a firm's performance. These variables include baseline outcomes and baseline variables such as firm location, sector, and international market share larger than 0 (used as a proxy for market presence). Additionally, two other variables are included: number of employees (for labor input) and asset size (for capital). Finally, the year fixed effects and cluster standard errors by firms have been included for our analysis. Note that in DDML we have employed a cross-sectional structure of the data, averaging variables over time and by unit. Specifically, for non-categorical controls, we calculate the pre-program implementation means. For categorical controls, we select the value occurring one year before the first treatment year for a program. To tailor our DDML analysis to five outcomes, we construct five sets of potential baseline control variables. These sets vary depending on the outcome, as some control variables show high correlations and could introduce bias. For instance, we exclude sales revenue as a control when estimating its impact on overall revenue. (More technical details on DDML are available in the background technical report). Both outcomes and non-categorical control variables undergo logarithmic transformation. To address many zero values among the control variables, we apply a log transformation of log (x + 1) to prevent significant missing values that would otherwise result from the zero entries. Exceptions are made when control variables can assume negative values, in which case logarithmic transformations are omitted.

Pre-program outcomes appear to be balanced, which allows the use of the CS-DiD methodology. Figure 4.9 shows the results of the impact analysis for all firms' programs pooled, using the CS-DiD methodology. The blue dots represent the estimated difference in outcomes between funded and unfunded applicants, for five years before the program start (T−5) and up to three years after program start (T+3). Each chart presents the results for one observed outcome. It is reassuring to observe that the pre-program outcomes are rather balanced for almost all outcomes, perhaps except for operating expenses. This means that in years prior to treatment, there are essentially no differences between treatment and control group units.

The programs had a positive and statistically significant impact on firm innovation, measured as the value of intangible assets and revenues. Figure 4.9 shows that a growing difference between funded and unfunded applicants in the years following program launch, as illustrated by the blue dots. The vertical lines crossing the blue dots represent the confidence interval for the estimated difference; if the vertical does not cross zero the result is considered statistically significant. As our best proxy for innovation, we see an increase in intangible assets of about 60 percent overall, with a balanced pre-program profile and sustained upward effect in later years following application year (Figure 4.9).

Compared to the control group, the revenue of funded firms tends to increase by about 20 percent in the aftermath of the project implementation. Controlling for program fixed effects[15] returns the same results (Annex 3).

Figure 4.9 Program impacts on firm outcomes, CS-DiD estimates



Note: Point estimates (circles) and 95 percent confidence intervals (vertical error bar). The pre-program periods are up to T-1. Point estimates with confidence intervals that do not cross zero are considered statistically significant at the 5 percent level of significance.

Source: Staff elaboration.

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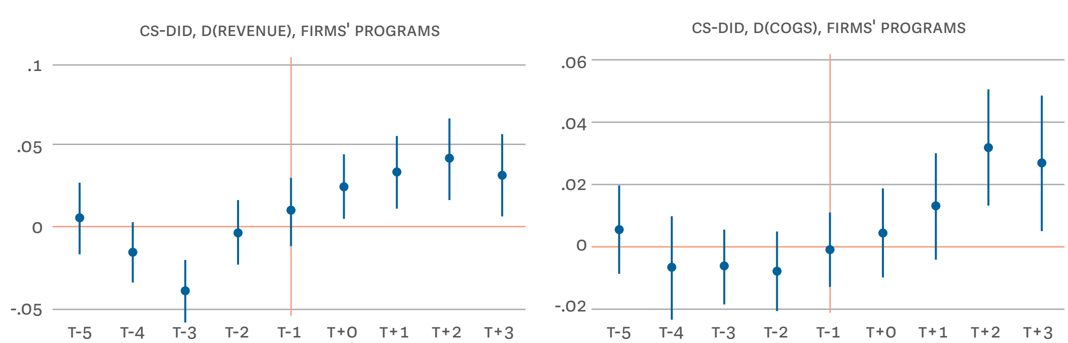
15 Fixed effects analysis is used to account for any differences inherent in programs that may affect the results of the analysis.

However, the programs also appear to have had an effect on increasing costs and number of employees, which may have ambiguous implications. Before the analysis, we hypothesized that the programs may lead to a reduction in costs of goods sold and operational costs through efficiency gains associated with innovation. In the analyzed programs we see the opposite: the programs had a large effect on increasing the cost of goods sold (by about 25 percent) and operating expenses (up to 40 percent). The number of employees also increased among beneficiaries by about 15 percent. Controlling for program fixed effects returns the same results (Annex 3). As efficiency gains may take a while to materialize, this may not necessarily be conclusive evidence of inefficiency among grant recipients. Nevertheless, it is an interesting finding that would be worth examining more closely.

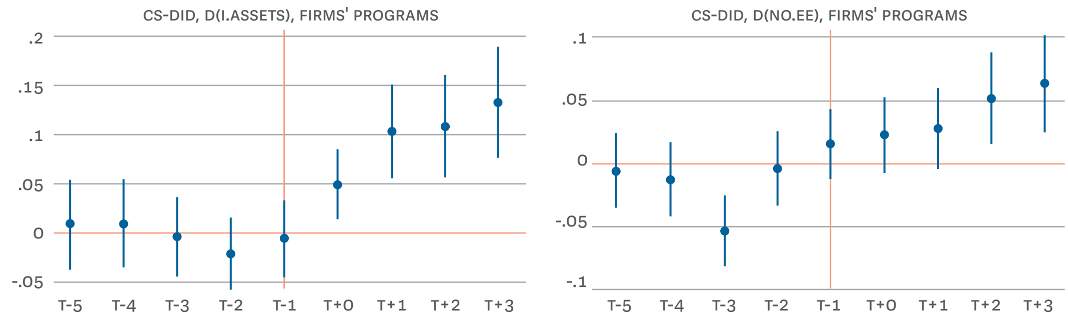
The analysis also shows positive effects of programs on expanding the range of outcomes achieved by firms. A significant portion of firms (44 percent) had no recorded value of intangible assets before the start of the program, about 10 percent had no employees, 4 percent had no revenues, and 2 percent had recorded no costs of goods sold. We therefore analyzed how the program affects the likelihood of having a positive (non-zero) outcome value (i.e., the effects at the extensive margin). The blue dots in Figure 4.10 show the estimated differences in the likelihood of recording a positive outcome value between funded and unfunded firms for each year, five years before the start of the program (T−5) up to three years after the start of the program (T+3). The vertical bars represent confidence intervals for the estimate; if the vertical bar crosses zero, the estimate is not statistically significant. In the pre-program period the differences are rather balanced and not statistically significant. However, in the post-program period, the likelihood of funded firms recording a positive outcome value increases by roughly 2–15 percentage points relative to unfunded firms.

Figure 4.10 Program impacts at the extensive margin, CS-DiD estimates



(A) DUMMY REVENUES

(B) DUMMY COGS



(C) DUMMY INTANGIBLE ASSETS

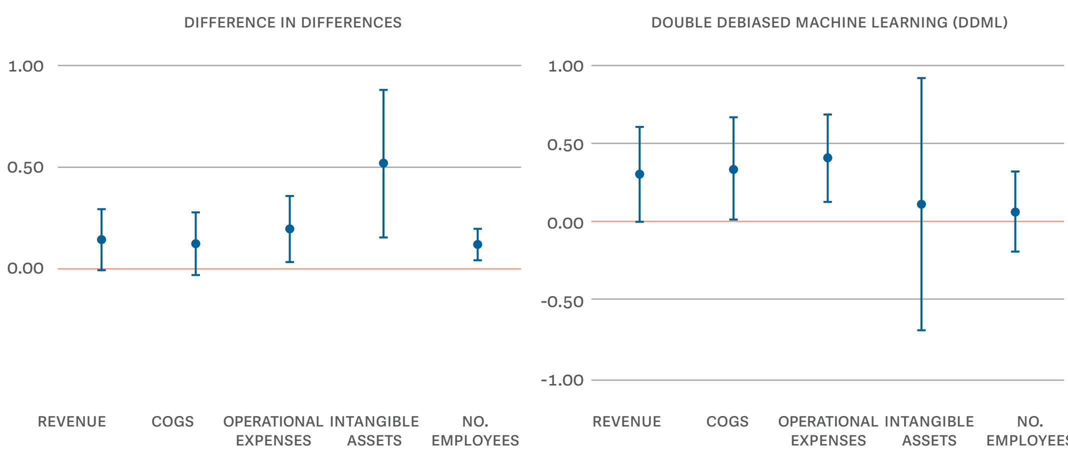
(D) DUMMY # EMPLOYEES

Note: Point estimates (circles) and 95 percent confidence intervals (vertical error bar). The pre-program periods are up to T−1. Point estimates with confidence intervals that do not cross zero are considered statistically significant at 5 percent level of significance. Operational expenses were recorded in 99.5 percent of firms, so it was excluded from this analysis.

Source: Staff elaboration.

Other methods yield largely consistent results. Analyzing data from all firms, both standard DiD and DDML estimates indicate that programs exert a positive impact on all analyzed outcomes. The blue dots in Figure 4.11 show the estimated differences between funded and unfunded applicants for all five observed outcomes. The vertical bars represent confidence intervals for the estimate; if the vertical bar crosses zero, the estimate is not statistically significant. As shown in the figure, DiD estimates for costs of goods sold just fail to pass the conventional level of significance (the left-hand panel in Figure 4.11), whereas the DDML method reports no statistically significant effect on intangible assets and number of employees (the right-hand panel in Figure 4.11). Although not statistically significant at conventional levels, in terms of sign, they are not different from those that are significant.

Figure 4.11 The robustness analysis (DiD and DDML estimates) report similar results



Note: Point estimates (circles) and 95 percent confidence intervals (vertical error bar). Variables with confidence intervals that do not cross zero are considered statistically significant at 5 percent level of significance.

Source: Staff elaboration.

4.4 Program-level analysis

Program-level impact analysis must be interpreted with caution as the sample sizes are small and therefore statistical power is limited for those estimates. As noted in section 1.2, the analyzed programs and participants had to be pooled for the impact estimates to be statistically reliable. However, the individual programs, especially those managed by the MESD, are heterogeneous, and estimating their individual impact could provide interesting information for policymakers. This section repeats the impact analysis by reviewing results for each program separately (combining, however, different editions of the same program such as IRI1 and 2 and Startup Innovation 1 and 2). Although this section reports program-level results, the small sample size and a lack of a random design require very cautious interpretation, as analyzing the impact at the program level may be underpowered. Table 4.2 reports the sample size for the analyzed programs (split by calls, where applicable).

Table 4.2 Sample split by program

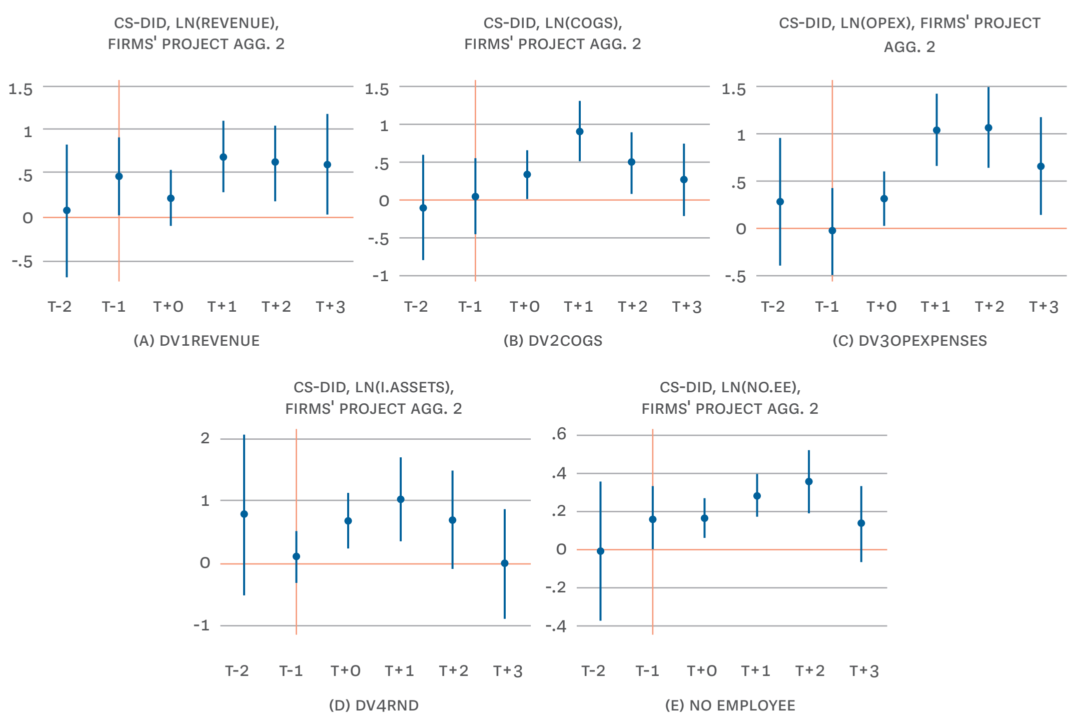
Program	Implementor	Not Funded	Funded	Total
STRIP	MSE	22	24	46
KIP	MESD	39	15	54
Startup Innovation 1	MESD	117	56	173
Startup Innovation 2	MESD	183	116	299
Inno-vouchers	MESD	21	111	132
IRI1	MESD	33	73	106
IRI2	MESD	140	208	348
Total		555	603	1,158

Source: Staff elaboration.

The first phase of the Startup Innovation program is the only call where projects were completed before the latest date of financial data. The Startup Innovation programs are specifically designed to stimulate and support innovation within recently established firms, defined as those in operation for no more than 36 months before the application date. The allocated funding is earmarked for initiatives focused on either introducing innovative products or services or improvement of novel goods and services. This strategic allocation of resources aims to foster innovation among newly established firms, thus enhancing the competitive edge of these emerging enterprises. The program was implemented in two phases. The Startup Innovation program (phase 1) is the only program in the evaluation mix for which the official end date of program funding (2021) precedes the latest financial and employment data (2022). Although this does not mean that the full effect of grants has already been observed, it does mean that fund disbursement would have finished, and beneficiaries were supposed to have completed all the operations they put forth in the application.

The Startup Innovation programs seem to affect increasing revenues, costs, intangible assets, and employment. For these programs, there are at most two pre-program periods as this program targets firms younger than 36 months. The blue dots in Figure 4.12 show the estimated differences in outcomes for funded and unfunded applicants starting from two years before program start (T−2), up to three years after (T+3). The vertical lines crossing the blue dots represent the confidence interval for the estimated difference; if the vertical line crosses zero the result is not statistically significant. The figure shows that the program seems to increase the value of intangible assets and revenues, but also operational expenses, costs of goods sold and the number of employees in newly established companies. The fact that costs and employees are higher among funded applicants is not an unexpected result for this program: the grants likely supported the expansion of operations in newly established SMEs, which had an effect on increasing both revenues and expenses. The effect is not statically significant for the last period in the case of cost of goods sold, intangible assets, and number of employees. However, the full effects of grants are not necessarily observed at the time of the impact evaluation.

Figure 4.12 Effects of Startup Innovation program grants (phases 1 and 2)

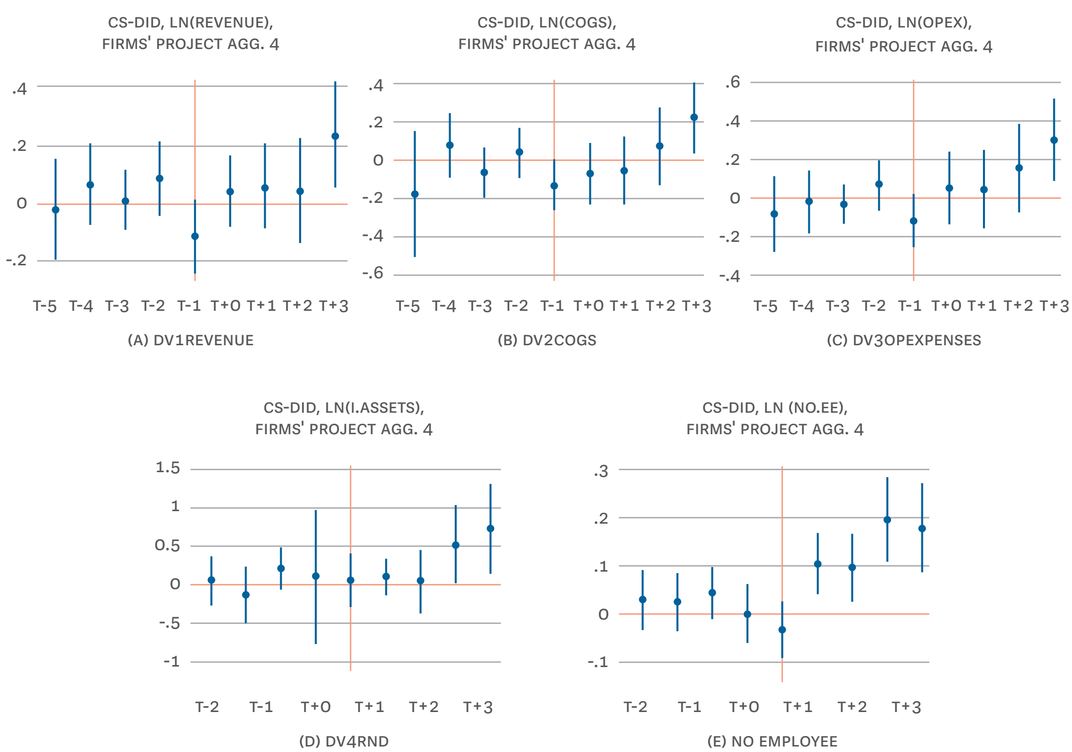


Note: Point estimates (circles) and 90 percent confidence intervals (error bar) (90 percent confidence intervals presented to recognize the smaller sample size). The pre-program periods are up to T-1. Variables with confidence intervals that do not cross zero are considered statistically significant at 10 percent level of significance. Control for program's wave included.

Source: Staff elaboration.

IRI, the most generous program in terms of grant value, seems to have an impact increasing the value of all observed financial and employment variables, but this is statistically significant only three years after the start of the intervention. Like the Startup Innovation program, IRI was also implemented in two calls with slight differences. The IRI program (1 and 2) supports R&D projects aiming at developing new products and technologies. The funds cover investment in tangible and intangible assets. Note that most firms came from IRI 2, which only started their projects in December 2019, and the projects will be in implementation until the end of 2023. The blue dots in Figure 4.13 show the estimated difference in outcomes between funded and unfunded firms. The vertical lines crossing the blue dots represent the confidence interval for the estimated difference; if the vertical line crosses zero the result is not statistically significant. The estimated results for IRI appear to have a significant impact on increasing the value of all observed outcomes, at least starting from three years after the start of program.

Figure 4.13 Effects of IRI program grants (both phases 1 and 2)

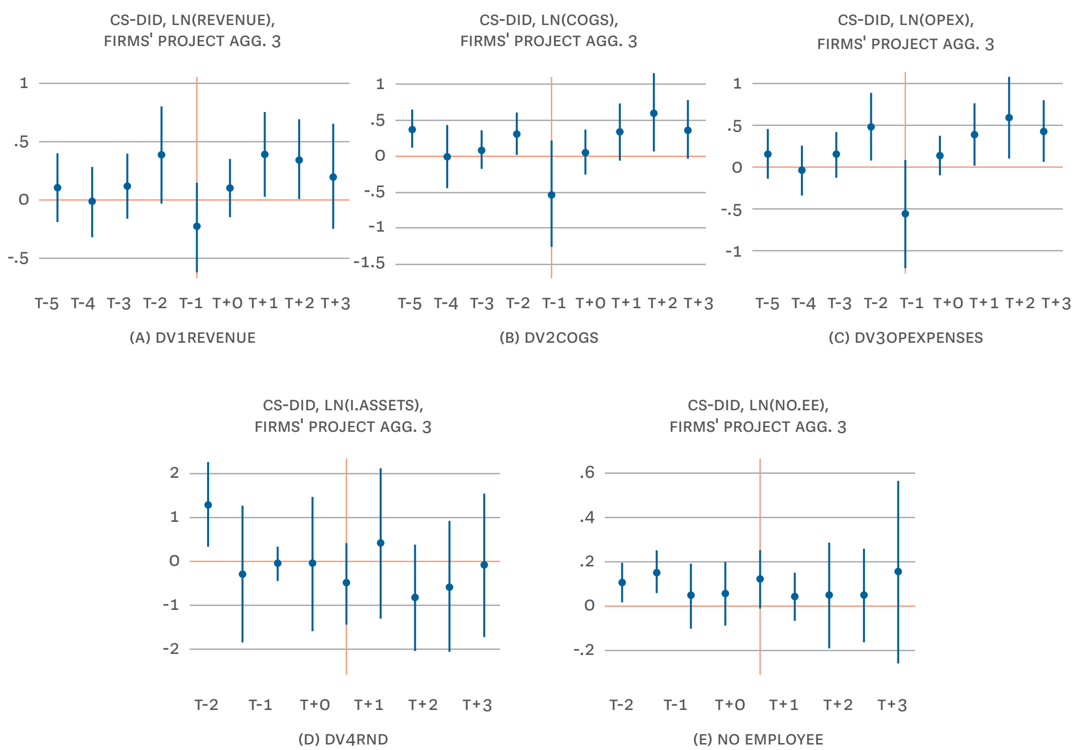


Note: Point estimates (circles) and 90 percent confidence intervals (vertical error bar) (90 percent confidence intervals presented to recognize the smaller sample size). The pre-program periods are up to T−1. Variables with confidence intervals that do not cross zero are considered statistically significant at 10 percent level of significance. Control for program's wave included.

Source: Staff elaboration.

The smallest program in terms of grant value, Inno-vouchers, appears to have no effect on employment and intangible assets, and some effect on increasing revenues and costs, though estimates are not precise. Inno-vouchers is a program for SMEs that aims to facilitate procuring services from research labs for testing, designing, prototyping, etc. of new products or processes. The Inno-vouchers program is specific as it is the only program in the evaluation mix where funded firms are typically smaller, and not statistically significantly distinguishable from non-funded firms. The blue dots in Figure 4.14 show the estimated difference in outcomes between funded and unfunded firms five years before (T−5) and three years after the start of the intervention (T+3). The vertical lines crossing the blue dots represent the confidence interval for the estimated difference; if the vertical line crosses zero the result is not statistically significant. The estimated results in Figure 4.14 shows that the Inno-vouchers program has no effect (understandably) on employment and intangible assets, and some (imprecisely estimated) effects on increasing revenues, operating expenses, and costs of goods sold.

Figure 4.14 Effects of Inno-vouchers program grants

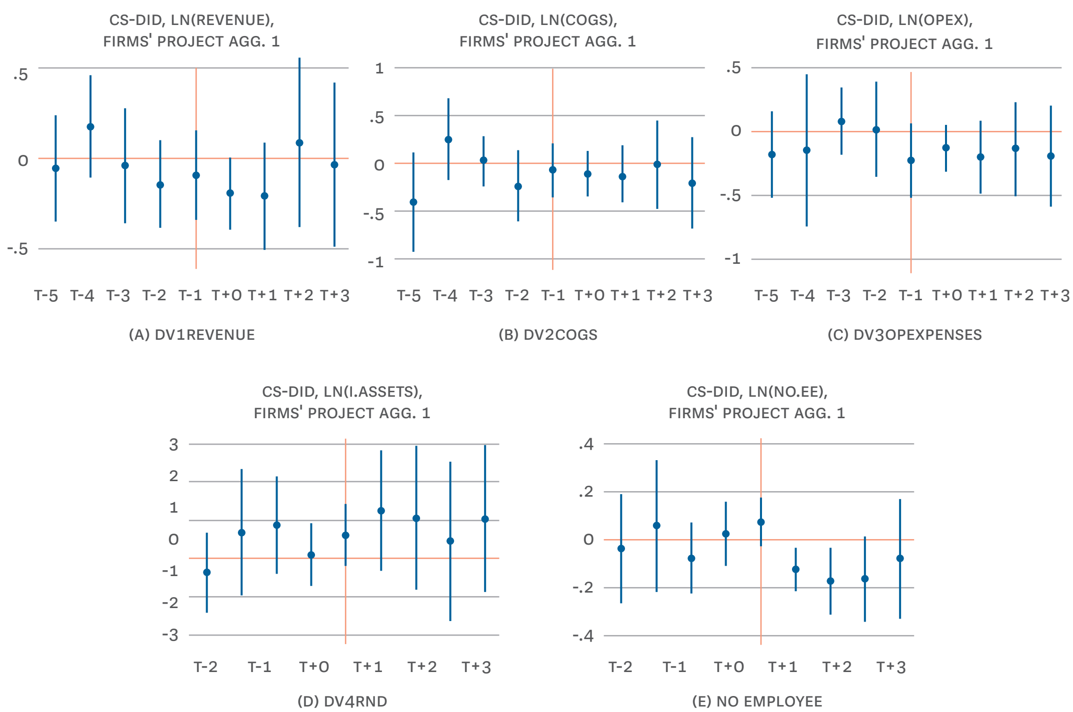


Note: Point estimates (circles) and 90 percent confidence intervals (error bar) (90 percent confidence intervals presented to recognize the smaller sample size). The pre-program periods are up to T−1. Variables with confidence intervals that do not cross zero are considered statistically significant at 10 percent level of significance.

Source: Staff elaboration.

The impact analysis detects no significant effect of the KIP program on the observed variables, although the sample size is very limited. KIP is dedicated to supporting SMEs in the production and commercialization of RDI products or processes. The grants were awarded to 20 applicants with an average size of just over 250,000 EUR, but our financial data can only recover information on 15 funded firms (and 39 controls). The blue dots in Figure 4.15 show the estimated difference in outcomes between funded and unfunded firms five years before (T–5) and three years after the start of the intervention (T+3). The vertical lines crossing the blue dots represent the confidence interval for the estimated difference; if the vertical line crosses zero the result is not statistically significant. The estimated effect of grants on the KIP program (Figure 4.15) shows no statistically significant effects, except for a negative effect on employees. Here and for all other programs, we need to exercise caution in the interpretation of the findings, due to limited sample size.

Figure 4.15 Effects of KIP program grants

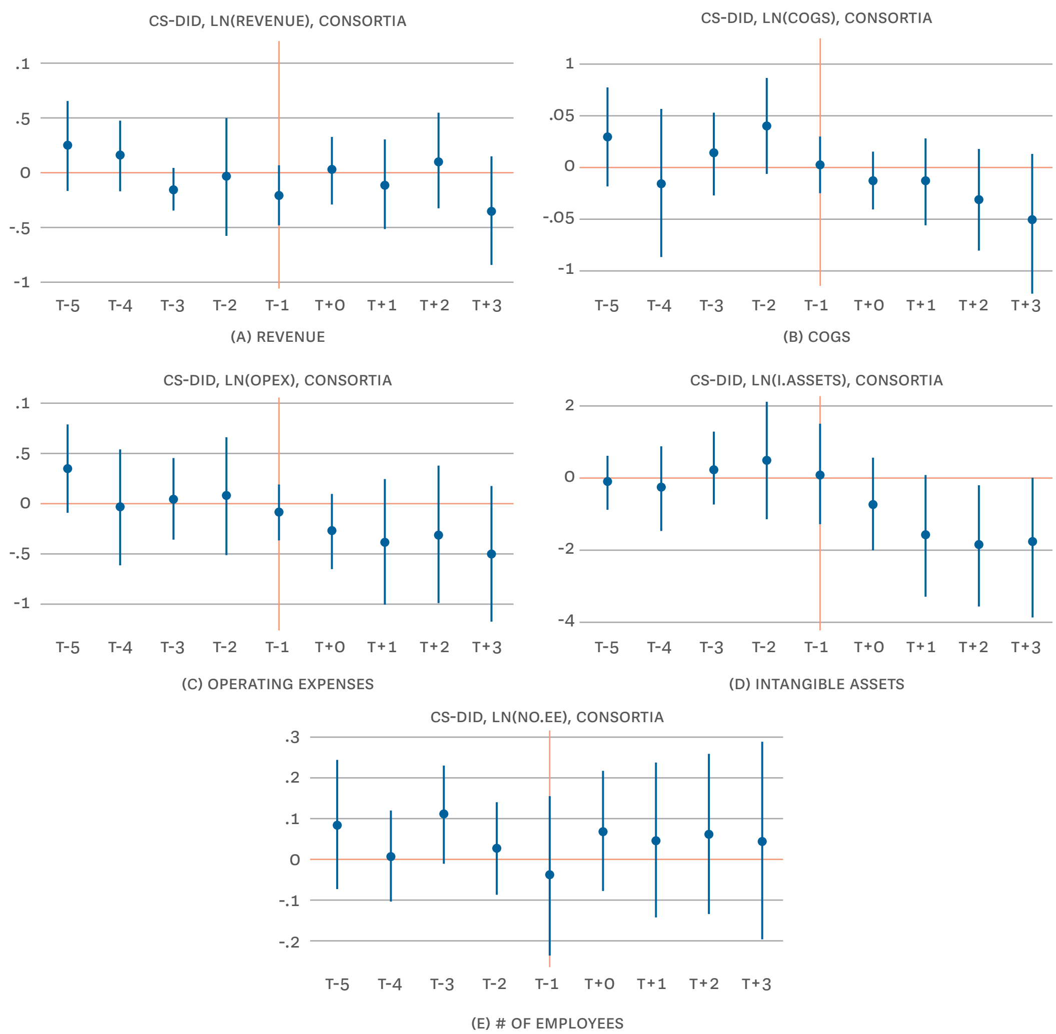


Note: Point estimates (circles) and 90 percent confidence intervals (error bar) (90 percent confidence intervals presented to recognize the smaller sample size). The pre-program periods are up to T-1. Variables with confidence intervals that do not cross zero are considered statistically significant at 10 percent level of significance.

Source: Staff elaboration.

The analysis detects no significant effects of the STRIP program on firm outcomes, though the analysis is limited by a small sample size. Being the only program dedicated to collaborations between researchers and businesses, STRIP, had a small sample of applications, and we can recover most firms that are part of the consortium in the financial data (about 85 percent; missing nine firms overall, of which eight were unfunded). Unfortunately, the sample size for this program consists of only 46 firms. To ensure a comprehensive analysis, and considering the unique characteristics of this program, we report a preliminary estimate of its impact on financial results in Figure 416. The blue dots in the figure show the estimated difference in outcomes between funded and unfunded firms five years before (T−5) and three years after the start of the intervention (T+3). The vertical lines crossing the blue dots represent the confidence interval for the estimated difference; if the vertical line crosses zero the result is not statistically significant. No significant effects have been detected. Indeed, a few variables exhibit unexpectedly adverse effects, yet they lack statistical significance. Due to the limited sample size, we are unable from offering a more detailed analysis of the results.

Figure 4.16 Effects of grants on STRIP (partners only)



Note: Point estimates (circles) and 90 percent confidence intervals (error bar) (90 percent confidence intervals presented to recognize the smaller sample size). The pre-program periods are up to T−1. Variables with confidence intervals that do not cross zero are considered statistically significant at 10 percent level of significance.

Source: Staff elaboration.

Part 2

Analysis of the S3 monitoring indicators and governance system

5 Assessment of S3 monitoring results

Assessment of S3 monitoring results

This section presents data collected from S3 managers in accordance with S3 objectives and indicators, but does not assume a causal relationship between S3 instruments and reported results. As part of the midterm S3 evaluation, data was previously collected for purposes of the analysis of the S3 intervention logic and midterm assessment of indicator achievement (World Bank 2021). This data covered results up to 2020. This report follows the same approach and presents the latest data available, as of September 2023. Most of the presented data has been collected from the relevant S3 institutions involved in S3 monitoring, namely MSE, MESD, and the S3 Technical Secretariat. Part of the data was collected from publicly available sources. For a significant share of indicators, data for 2023 is not yet available, due to projects being still in implementation, or the timeframe for indicator measurement extending in the post-implementation period, or the required data has not yet been published by relevant authorities and databases (e.g., Eurostat). As 2023 is the target year for the majority of outcome indicators, it remains to be seen whether there will be some additional recorded progress toward the set targets. This section does not provide a causal attribution analysis of the reported values of indicators.

The analysis considers both the M&E framework originally introduced in the officially adopted S3 and the revised framework informally introduced in 2019. The officially adopted S3 comprises an M&E including a set of output, outcome, and impact indicators, along with targets defined on S3 level. Furthermore, the framework includes context indicators for both the overall strategy, and ones connected with individual TPAs. As part of the S3 Action Plan 2019–2020 adopted by the National Innovation Council (NIC), the M&E framework was revised by the policy makers, with an expanded set of output and outcome indicators detailed on instrument level. Additionally, the S3 objectives were revised, with the six original S3 specific objectives translated into three main S3 objectives, each of which were paired with several output and outcome indicators, labeled as Key S3 Indicators. The revised M&E framework, however, does not introduce revised or new quantified targets for the indicators tracked for the expanded policy mix. The report thus first looks at current results compared to the target values set in the S3 document, and then analyzes the recorded values of all indicators from the revised framework.

5.1 Achievement of original S3 targets

This section presents achievements in accordance with the original S3 M&E framework, based on S3 specific objectives (SOs) and TPAs. Outputs and outcomes are presented for each SO, along with their target values. Achievements are shown as cumulative values, up to the cutoff dates (in most cases 2020 and September 2023, unless otherwise noted), subject to data availability. They are also linked to particular delivery instruments planned to achieve them. TPA progress is shown as a separate overview for indicators for which TPA disaggregation is applicable and where TPA data is available. Finally, context indicators and Key S3 Indicators from the revised M&E framework are presented.

Table 5.1 List of S3 SOs

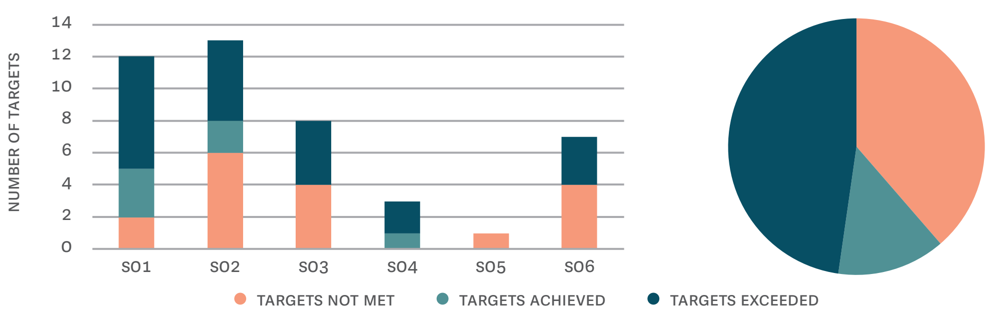
S3 SPECIFIC OBJECTIVE
SO1 – Increased capacities of RDI sector to perform excellent research and to serve the needs of the economy
SO2 – Overcoming the fragmentation of innovation value chain and the gap between research and business sector
SO3 – Modernizing and diversifying Croatian economy through increasing private investments into RDI
SO4 – Upgrading in global value chain and promoting internationalization of Croatian enterprises
SO5 – Working in partnership to develop social innovations
SO6 – Development of smart skills – upgrading the qualifications of existing and new work force for smart specialization

Source: S3 2016–20.

Summary of overall target achievement for all specific objectives

Overall, 62 percent of S3 target outputs have been reached or exceeded, with the most favorable achievement ratios in SO1 and SO2. Figure 5.1 summarizes the achievement of targets for output indicators per each SO and shows the number of targets that have been fully achieved, as well as those that have been under- and overachieved. In all SOs, 62 percent of the 44 targets in total have been reached or exceeded. The least share of targets with under-performance is recorded for SO1, SO2, and SO4. Aside from SO5 that has been de facto excluded from the S3 policy mix during implementation and records no progress, underachievement is clear for SO6 where more than half of the targets have not been met, whereas the data for SO3 indicates that half of the targets have not been met, and the other half met or overachieved.

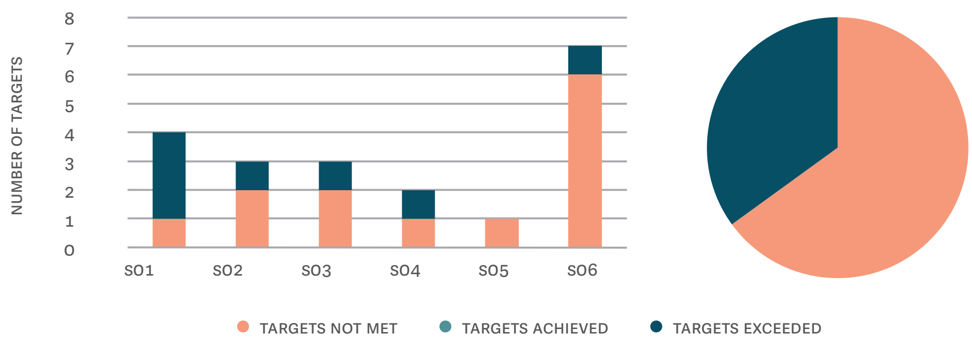
Figure 5.1 Number of output targets achieved for all SOs



Source: S3 2016–20; staff elaboration based on data provided by S3 institutions.

Most outcomes are yet to be met, or the achievement is not fully clear. Summary data for outcomes is presented in Figure 5.2. Out of 20 targets, 65 percent of the target values have not yet been reached, or the outcome is unclear due to missing data. Out of these indicators, SO6 holds the largest share of targets not met or data not available (not counting SO5, for which the data is not tracked anymore). By contrast, SO1 accounts for the least number of underachieved targets, and SO4 has an equal number of under- and overachieved targets.

Figure 5.2 Number of outcome targets achieved for all SOs



Note: In this overview, indicators for which data is not available, progress is not tracked, or the achieved value is unclear, are included under targets not met.

Source: Staff elaboration based on data provided by S3 institutions.

SO1 – Increased capacities of RDI sector to perform excellent research and to serve the needs of the economy

SO1 seeks to enhance the capacities of Croatian research organizations to produce excellent research results relevant to market needs. This entails upgrading the legal framework and funding conditions for Croatian research organizations and directing their activities toward solutions that could lead to commercial applications. The delivery instruments within this SO provide funding for applied R&D projects, including collaborations, and upgrading research infrastructure. The SO consists of the following delivery instruments:

a. Strengthening research excellence by supporting ZCI and enabling synergies with ERC grants

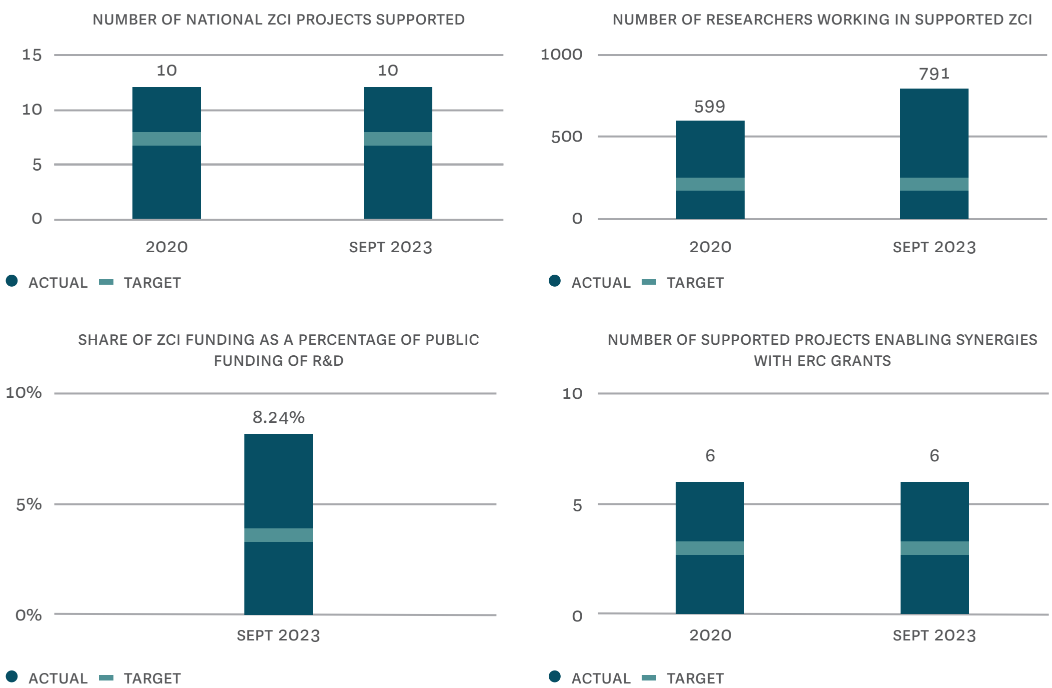
b. Increase R&D ability for conducting top quality research and cooperation on national and international levels

c. Support to research organizations conducting R&D projects directed toward the needs of economy

d. Strategic Project 'Science and Technology Foresight'

The research excellence instrument surpassed all targets. The initiative to support National Centers of Research Excellence had already made substantial progress by 2020, with 10 projects being supported, which exceeded the target of 6 (Figure 5.3). This achievement was sustained until 2023, as the funded projects have continued to be supported and are expected to be fully implemented by end of 2023. Similarly, the number of researchers in supported ZCI witnessed a significant rise, from 599 in 2020 to 791 in 2023, compared to the target of 210 researchers. At the same time, the share of ZCI funding also surpassed its target by more than double, with the funding reaching 8.2 percent in 2023, compared to the target of 3.6 percent.

Figure 5.3 Outputs under the "Strengthening research excellence by supporting ZCI and enabling synergies with ERC grants" instrument



Source: Staff elaboration based on data provided by S3 institutions.

The instrument supporting the increase of R&D ability for conducting top quality research and cooperation on national and international levels met two out of three targets. By 2020, the instrument had already funded 32 infrastructure projects, surpassing the target of six by over five times (Figure 5.4).[16] The number of researchers (measured as full-time

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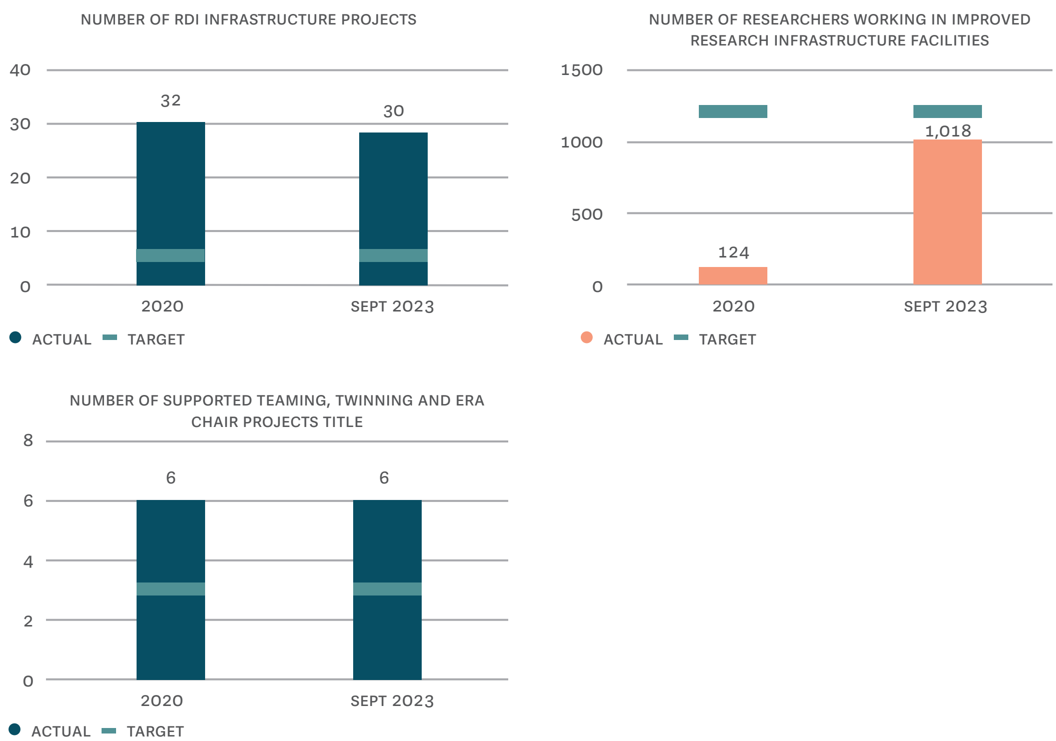
16 The result in 2023 declined compared to 2020 since two projects (Children Center for Translational Medicine at the Children's Hospital Srebrnjak and Open scientific infrastructural platforms for innovative applications in economy and society – O-ZIP), that had initially planned to be completed until the end of the reference period, were restructured and phased. The implementation of the projects is planned to continue beyond 2023 and are therefore not counted as completed yet.

equivalent, FTE) working in enhanced research infrastructure facilities showed modest progress of 123.5 in 2020, but has reached 1,017.5 researchers by September 2023, inching closer to the 1,215 target. Additionally, this delivery instrument provided more support to the projects that have already been funded via centralized EU programs (ERC grants, and Horizon 2020 Teaming, Twinning, and ERA chair projects). The target for this activity was already met in 2020 and remains unchanged as of September 2023.

Figure 5.4 Outputs under the "Increased R&D ability for conducting top quality research and cooperation on national and international levels" instrument



Source: Staff elaboration based on data provided by S3 institutions.

The instrument supporting research organizations conducting R&D projects directed toward the needs of economy is yet to reach one out of two output targets, but this is expected to change by the end of 2023. This instrument, comprising two applied research grant scheme programs,[17] overperformed in the number of enterprises supported, but underperformed when it comes to the total number of conducted projects (Figure 5.5). The delayed implementation of projects funded through SIIF and STRIP means that, as of September 2023, the number of completed RDI projects is short of the target by 53 projects. Although a portion of projects is expected to reach completion by the end of 2023, this target likely will not be met because SIIF and STRIP in total supported less than 75 projects.

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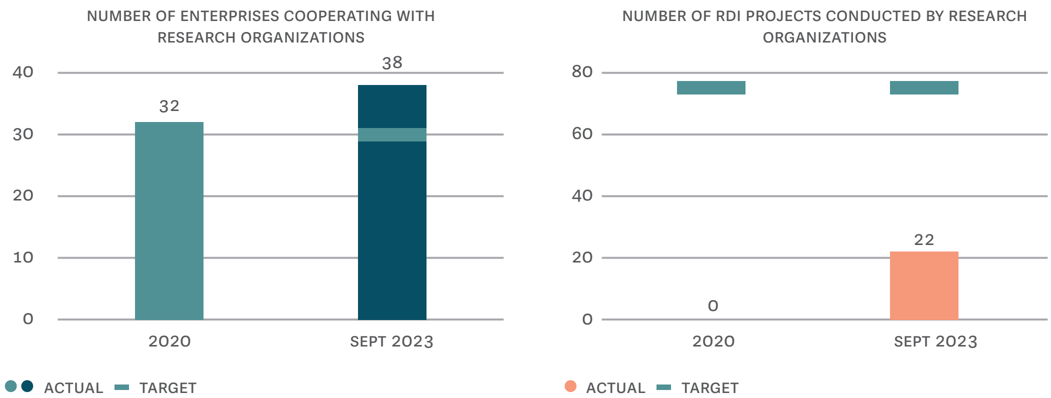
17 SIIF, supporting applied research projects of PROs, and STRIP, supporting collaborative R&D projects of PROs and enterprises.

Figure 5.5 Outputs under the "Support to research organizations conducting R&D projects directed toward the needs of economy" instrument

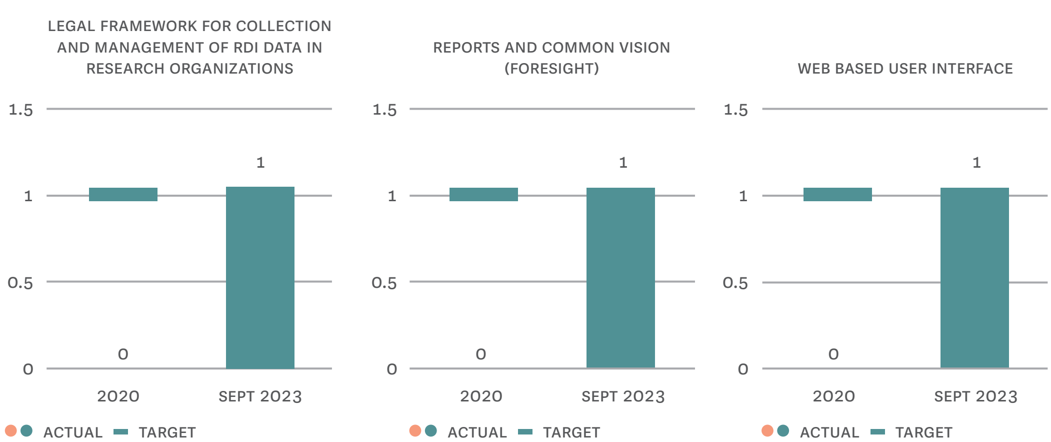


Note: Number of RDI projects conducted by research organizations - refers only to projects completed up to the cut-off date.

Source: Staff elaboration based on data provided by S3 institutions.

The delivery instrument "Strategic Project Science and Technology Foresight" met its output targets. Compared to the other instruments that are grant scheme programs, this instrument refers to a project of developing a foresight to cater S3 TPAs to strategize their future development. The output targets associated with this instrument have fully been met in 2023 (Figure 5.6). Policy makers report that the legal framework for collecting and managing RDI data in research organizations has been established, reports with a unified foresight vision haven been formulated, and a web-based user interface for input, management and analysis of data has been developed, together with maps and visualization of defined research disciplines and technology areas.

Figure 5.6 Outputs under the "Strategic Project Science and Technology Foresight" instrument

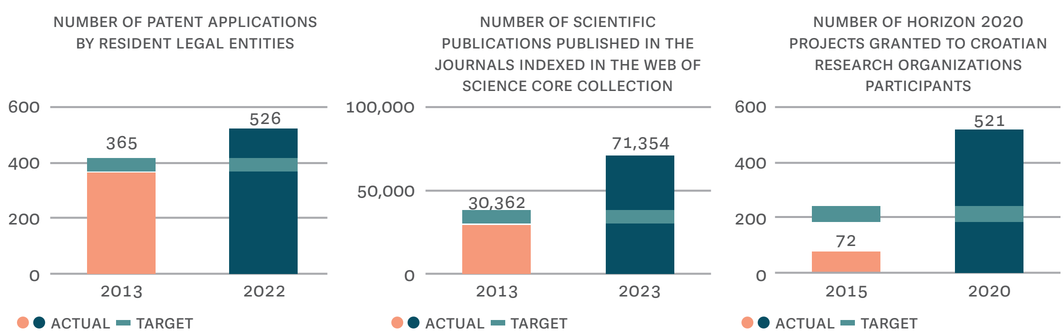


Source: Staff elaboration based on data provided by S3 institutions.

The delivery instruments under SO1 reached most output targets, with more progress expected to be logged at the end of implementation. Although most targets have been reached or even significantly overperformed, the only significant underachievement is related to the number of completed applied R&D projects. As previously noted, the value of this indicator will be updated to take into account all funded projects that will be completed until 2023, however, the target is still likely to be missed.

Outcomes connected with SO1 were significantly overachieved, apart from one outcome which is expected materialize in 2024. Figure 5.7 presents three out of four outcomes connected with SO1.[18] The achieved values show that Croatia overperformed significantly regarding patent applications, scientific publications, and Horizon 2020 projects awarded. Publications in the Web of Science Core Collection have surged, reaching 71,354, exceeding the target of 36,430. Croatian research organizations received 521 Horizon 2020 projects, surpassing the target of 213 by a significant margin. Similarly, the number of patent applications by resident legal entities exceeded the target, registering 526 in 2022 compared to the intended 392. It should be noted, however, that these values are not connected exclusively with the delivery instruments under this SO but refer to overall national performance instead. The fourth outcome not shown in the figure—creation of a priority setting system for scientific R&D policy in Croatia—is expected in 2024. The priority setting system is planned to be established based on the Croatian Research Information System (CroRIS), developed as part of the Strategic Project Science and Technology Foresight.

Figure 5.7 Outcomes under SO1



Note: The fourth outcome "Creating a priority setting system for scientific R&D policy in Croatia" is not shown because it does not have a quantitative target. However, the outcome is expected to be achieved in 2024 (one year after completion of the Strategic Project "Science and Technology Foresight").

Source: Staff elaboration based on data provided by S3 institutions.

18 The fourth outcome—Creating a priority setting system for Scientific R&D policy in Croatia—does not have a quantitative target and therefore not shown.

SO2 – Overcoming the fragmentation of innovation value chain and the gap between research and business sector

SO2 aims to bridge the gap between research and commercialization and strengthen collaboration between the research and business sectors. As there is an identified persistent challenge related to translating research results of Croatian research organizations toward commercialization, this SO planned several instruments to fund investments in technology infrastructure that would offer services to enterprises or provide a platform for joint research activities and investments. Delivery instruments under this SO include:

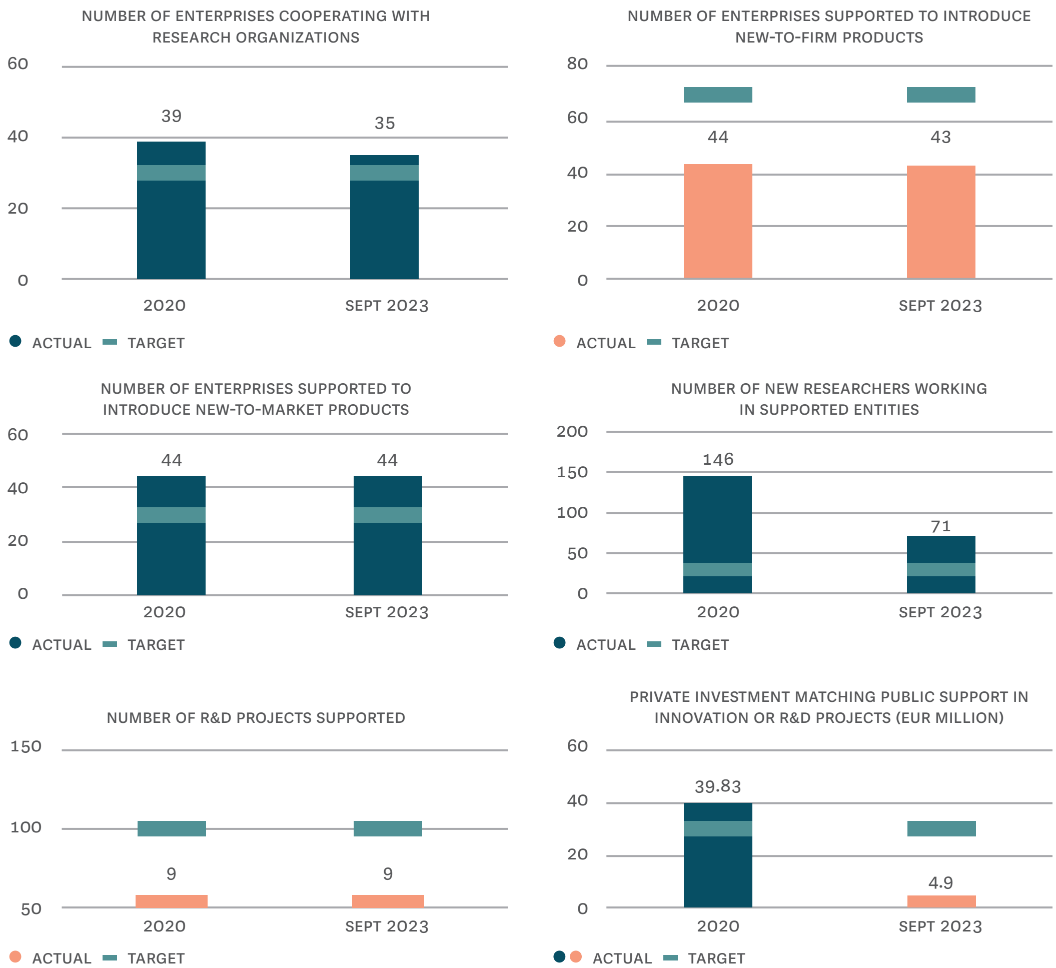
a. Support to the development of Centers of Competence

b. Strategic Project for Support to Establishment of the Innovation Network for the Industry and Thematic Innovation Platforms

c. Strengthening links between scientific and business sector by supporting technology transfer offices and science-technology parks

Although initially facing challenges and delays, the support to the development of Centers of Competence reached half of the targets set. In terms of allocated funding, Centers of Competence have been designated as the flagship instrument to disburse grants for industry-science collaboration and technology infrastructure projects under SO2. However, as noted in the Analysis of the Quality and Coherence of the Policy Mix (World Bank 2019), the program featured a complex design and faced a critical delay in the project selection phase. Consequently, the start of implementation of the contracted projects was significantly delayed. Despite the delays, the instrument provided support to 35 enterprises collaborating with research organizations, exceeding the initial target for 2023 (Figure 5.8). A total of 44 enterprises were supported for development of new-to-firm and new-to-market products. Centers of Competence ended up employing more researchers than first expected, with 146 researchers employed in 2020. This number decreased, however, to 70 researchers employed as of 2023, remaining more than double compared to the initial target value. For the indicator tracking private investments in R&D, the progress will be logged upon project completion. Due to the late implementation start, projects are still underway, so final achievement is not yet known. The contracted amount (noted for 2020), however, exceeds the target value, so it can be expected that the final achievement will be in line with the target.

Figure 5.8 Outputs under the "Support to the Development of Centers of Competence" instrument



Note: *Number of enterprises supported to introduce new-to-firm products and Number of enterprises cooperating with research organizations:* Achievement in September 2023 corrected downward due to one cancelled project. *Private investment matching public support in innovation or R&D projects (EUR million):* The 2020 value refers to the contracted amount for all projects supported. Actual achieved values are logged upon completion of each project. The September 2023 value thus refers only to the investments in projects that completed implementation until the cut-off date. Since other projects are still being implemented until the end of 2023, the final achievement will be known in 2024.

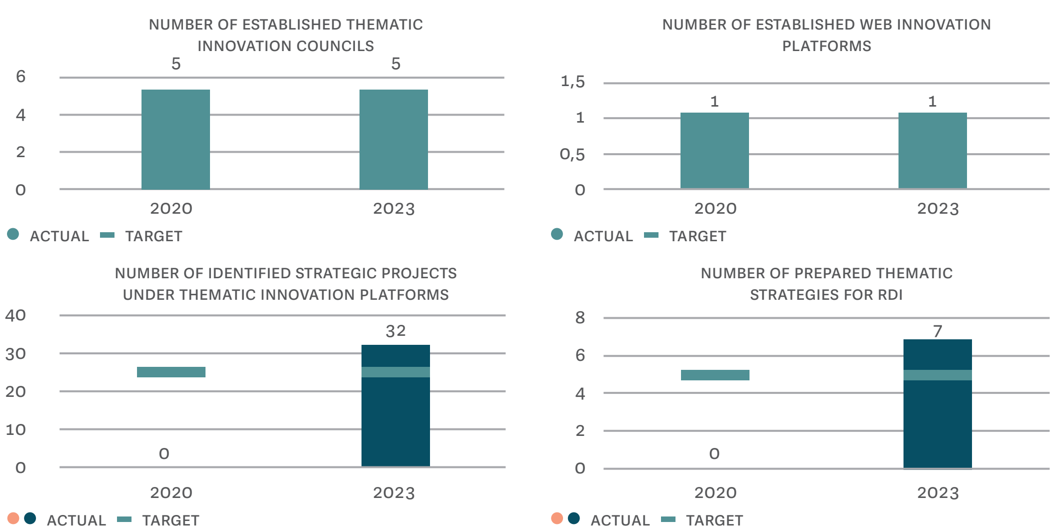
Source: Staff elaboration based on data provided by S3 institutions.

Lack of clarity in the definition of number of R&D projects supported resulted in significant underachievement for this indicator. Centers of Competence significantly underperformed regarding the number of research projects supported. According to program managers, this is due to differing definitions of the indicator when the target was set, as compared to implementation. In the instrument design stage (i.e., when setting the target value), each research project within the established Centers of Competence was planned to be counted under this indicator. In other words, a single Center of Competence may conduct multiple R&D projects, each of which would be counted toward the indicator. During project implementation, however, they could only count the established Center of

Competence as a single project resulting in a total of nine projects (corresponding to nine Centers of Competence), significantly below the initial target of 100 projects. Despite this shift in the definition of the indicator, there was no process in place to adjust the target.

The Strategic Project for Support to the Establishment of the Innovation Network for the Industry and Thematic Innovation Platforms met all set targets. This instrument differs from grant scheme programs, as it refers to a project implemented by S3 institutions, supporting the governance of S3 and functioning of the structures intended to carry the entrepreneurial discovery process. As analyzed in midterm evaluation of S3 governance (World Bank 2021a), the project initially faced significant delays and challenges in producing the designated project outputs. However, in the last years of S3 implementation, the project reached the quantified targets set. As planned, five Thematic Innovation Councils were established and supported through the project. The project also generated an innovation web platform aiming to connect the stakeholders within the Thematic Innovation Councils and beyond. This delivery instrument was initially lagging regarding identified strategic projects and developed RDI strategies for the S3 TPAs, and no progress in these areas was recorded in 2020. However, by 2023 the project exceeded targets for both indicators (Figure 5.9). A total of 32 strategic projects were identified, compared to the target of 25, and RDI strategies have been developed for seven instead of five S3 TPAs.[19] When it comes to supporting the Thematic Innovation Councils, additional complementary support has been provided by other instruments.[20]

Figure 5.9 Outputs under the "Strategic Project for Support to Establishment of the Innovation Network for the Industry and Thematic Innovation Platforms"



Source: Staff elaboration based on data provided by S3 institutions.

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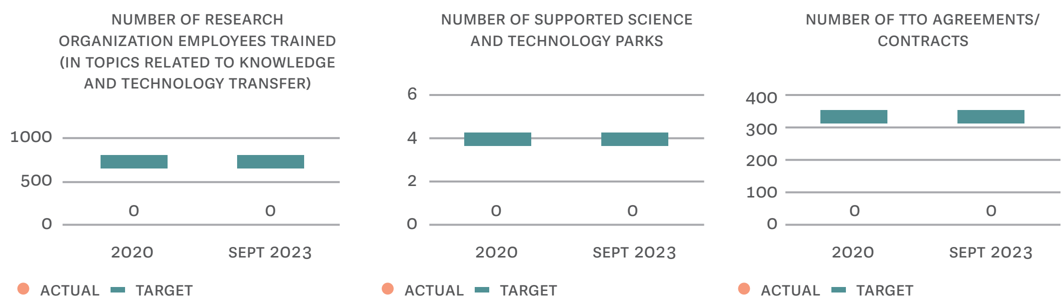
19 The initial plan was to develop one strategy for each of the five S3 TPA. In the end, two separate strategies were developed within the TPA Food and Bioeconomy, and the seventh strategy was developed for an additional TPA Digital products and platforms.

20 See section 6.2 for more detail on the activities of Thematic Innovation Councils and the additional support provided.

The instrument "Strengthening the ties between the scientific and business sectors via supporting technology transfer offices and science-technology parks" was never launched. Outputs related to the instrument record no progress toward the target set in the S3 (Figure 5.10), as the instrument intended to support technology transfer offices and science-technology parks was never launched in the analyzed period. If this instrument was abandoned during implementation, there is no record of the process through which this was done. Although S3 is meant to be a flexible strategy, in practice there was no process for making and documenting adjustments during implementation.

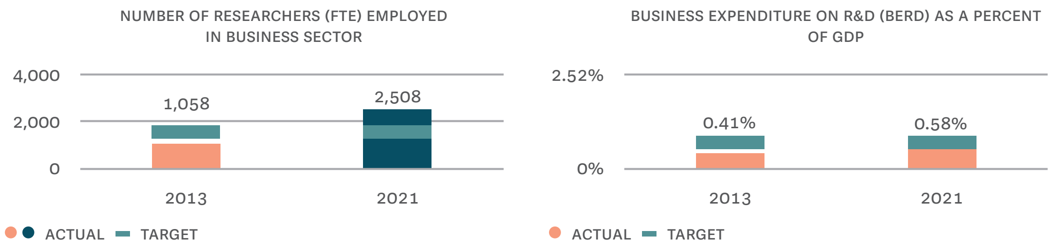
Figure 5.10 Outputs under the "Strengthening Links Between Scientific and Business Sector by Supporting Technology Transfer Offices and Science-Technology Parks" instrument



Source: Authors based on data provided by S3 institutions.

Regarding outcomes for SO2, Croatia overperformed in the number of researchers engaged in the business sector, whereas it slightly underperformed for business sector R&D investments. The available outcome indicators paired with SO2 are shown in Figure 5.11. According to the latest data (2021), R&D employment and R&D investments in the business sector are moving in a positive direction. However, although the former surpassed the target value over 1.5 times, the latter has not yet reached the designated value of 0.7 percent of GDP. Nonetheless, it remains to be seen whether the targets have been met, when the 2023 data becomes available. The third indicator, concerning the number of spin-off/spin-out companies, is not tracked, as it was connected with the Technology Transfer Offices and Science-Technology Parks programs, which have not been launched. Its baseline and target values were supposed to be set upon the completion of the Science and Technology Foresight project.

Figure 5.11 Outcomes under SO2



Note: This SO is linked to a third outcome, "Number of spin-off/spin-out companies," which has no associated baseline and target value. The baseline and target values were supposed to be set after the completion of the 'Science and Technology Foresight' project.

Source: Staff elaboration based on data provided by S3 institutions.

SO3 – Modernizing and diversifying Croatian economy through increasing private investments into RDI

SO3 focuses on fostering private sector investments into RDI and introducing new products on the market. The delivery instruments under SO3 are programs supporting R&D projects of enterprises, their collaborations with research organizations, and their efforts in commercialization of new innovative products.[21] Delivery instruments within SO3 include:

a. Support to business investments in RDI

b. Support to strengthening SMEs' capacities to innovate.

Support to business investments in RDI has seen encouraging progress, but four out of six targets remain to be achieved. Figure 5.12 shows the results for all outputs under this delivery instrument. The number of enterprises collaborating with research organizations has far surpassed its target for 2023, with 250 enterprises engaged as of September 2023 against a target of 100. Furthermore, although the initial goal for 2023 aimed at 400 enterprises receiving grants, the current standing is at 92, indicating there is still a way to go. This progress does not include enterprises still implementing the projects, hence the final result is yet to transpire. Progress in supporting enterprises to introduce new products to the firm is nearing its target, with 307 out of the projected 330. Similarly, those introducing new products to the market show a positive trend, with 300 enterprises achieving this against a target of 70. Regarding R&D projects supported, the results are still lagging with

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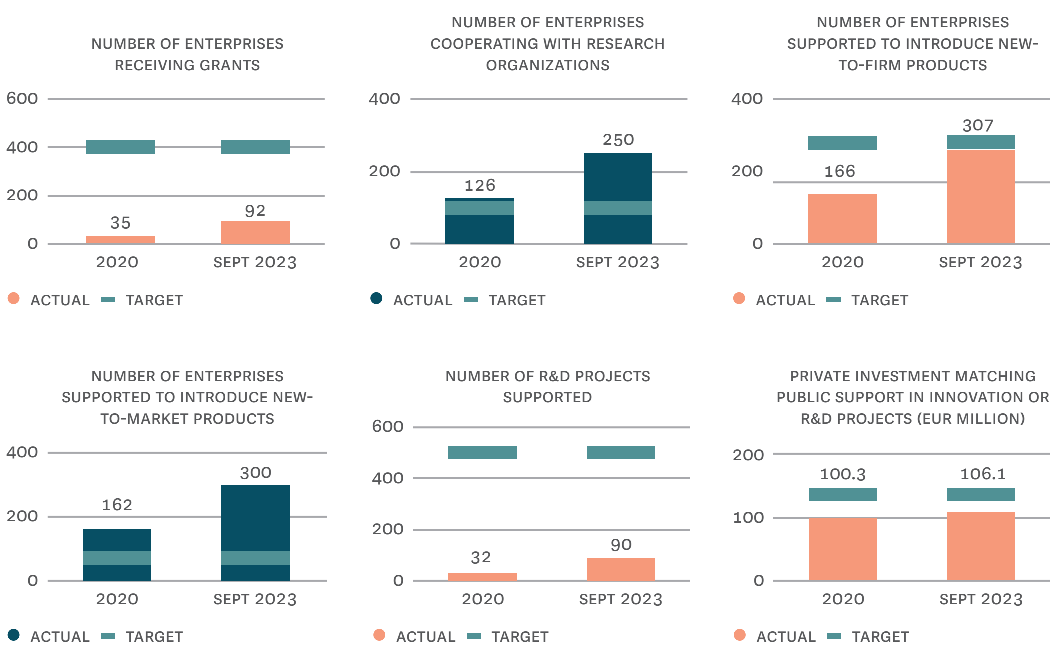
21 The delivery instrument "Support to business investments in RDI" refers to two editions of the program "Support to development of new products/services resulting from R&D activities-IRI" (Phase I & Phase II), providing funding for applied R&D projects of enterprises of all sizes, and their collaborations with ROs. The delivery instrument "Support to strengthening SMEs' capacities to innovate" refers to multiple programs targeting innovative SMEs: "Commercialization of innovation in entrepreneurship," "Innovation vouchers," "Innovations in S3 areas," "Innovations of newly established SMEs" (Phase I & Phase II), and "Integrator."

only 90 out of the targeted 500 projects being supported as of September 2023, but the final result will be known in 2024. Private investment matching public support in innovation or R&D projects stands at EUR 106.1 million, which is close but still shy of the EUR 136.67 million target. As with several other indicators, the full scope of investments pursued will be known upon completion of all projects receiving support through the instrument.

Figure 5.12 Outputs under the "Support to business investments in RDI" instrument

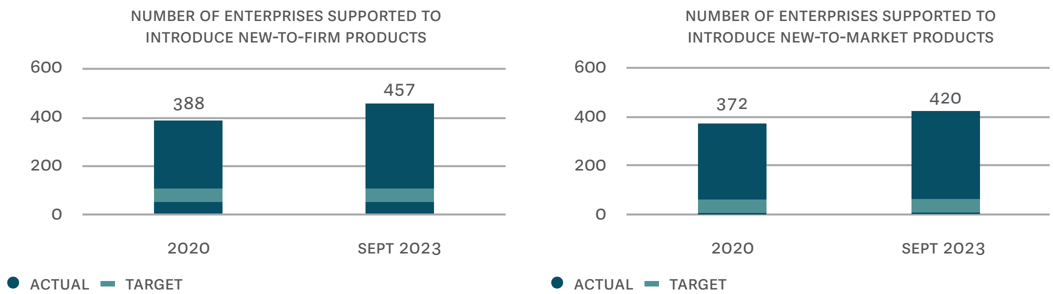


Note: Number of enterprises receiving grants and Number of R&D projects: Refers only to projects completed up to the cut-off date. Achievements from projects still in implementation are not included in the values shown.

Source: Staff elaboration based on data provided by S3 institutions.

For the delivery instrument of supporting SMEs' capacities to innovate, the outputs produced have significantly exceeded the initial expectations. (See Figure 5.13.) Enterprises supported to introduce new to the firm products have reached 457, vastly outstripping the target of 83. Moreover, the number of enterprises launching new products to the market has also surpassed its target, with 420 enterprises, against the goal of 36.

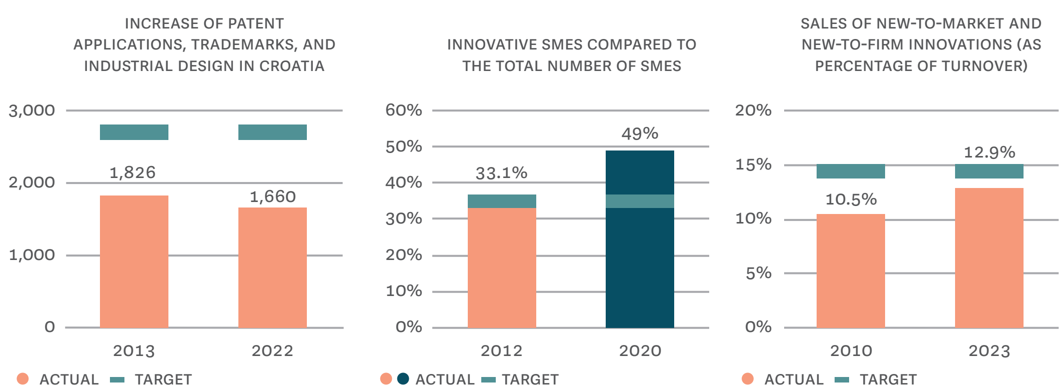
Figure 5.13 Outputs under the "Support to strengthening SMEs' capacities to innovate" instrument



Source: Staff elaboration based on data provided by S3 institutions.

Although Croatia excelled when it comes to the share of SMEs that innovate and showed progress in the share of turnover from innovations, intellectual property applications remain low. The three outcomes connected to SO3 are shown in Figure 5.14. Croatia increased the number of SMEs that innovate which in 2020 (latest data available) surpassed the 2023 target. The share of turnover from innovations increased to 12.9 percent in 2023, which is slightly below the target of 14.4. However, the number of patent applications, trademark, and industrial design was 1,660 in 2022, which is well below the 2023 target of 2,700, but also below the baseline value of 1,826 in 2013.

Figure 5.14 Outcomes for SO3



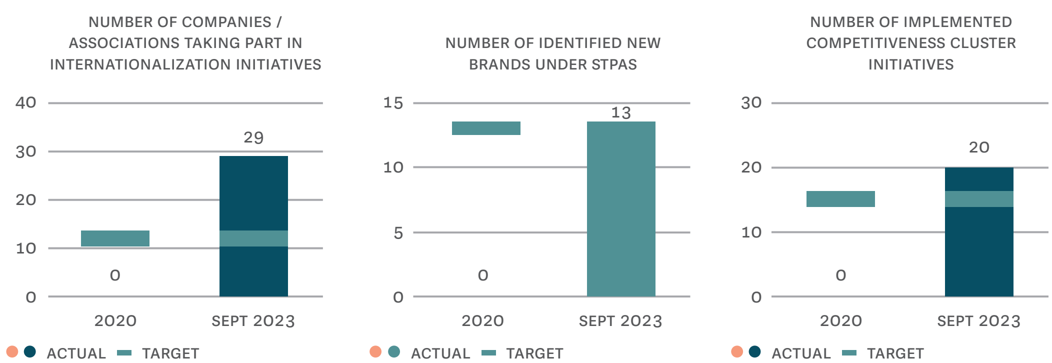
Source: Staff elaboration based on data provided by S3 institutions.

SO4 – Upgrading in global value chain and promoting internationalization of Croatian enterprises

SO4 refers to a single delivery instrument supporting clusters in value chain integration and internationalization. This SO did not entail grant scheme programs, but instead focused on supporting the initiatives of Competitiveness Clusters through analytical and advisory work. This was the only delivery instrument under SO4.

The "Strategic Project for Support to Competitiveness Clusters Initiatives" has reached all its targets. Figure 5.15 presents the three outputs associated with this delivery instrument. As with the Strategic Project for Support to Establishment of the Innovation Network for the Industry and Thematic Innovation Platforms under SO2, the instrument refers to an institutional project intended to support cluster initiatives under the S3. Program managers report that the project reached 29 companies and associations with internationalization support, compared to the initial plan of 12. As originally planned, the project supported the identification of 13 new brands connected with the Sub-Thematic Priority Areas (STPAs) of the S3. Finally, program managers recorded 20 competitiveness cluster initiatives implemented, whereas the target was 15.

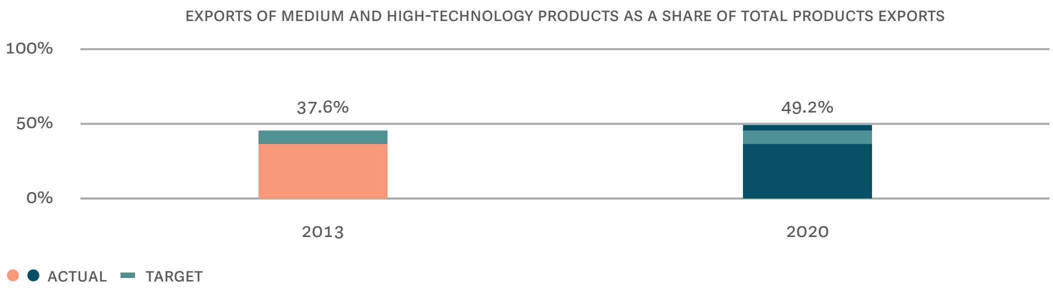
Figure 5.15 Outputs under the "Strategic Project for Support to Competitiveness Clusters Initiatives"



Source: Staff elaboration based on data provided by S3 institutions.

Croatian exports of medium and high-technology products, calculated as a share of total products exports, have surpassed the original target, but the dynamics of cluster membership is unknown. SO4 is associated with two outcomes: the share of exports of medium and high-technology products, and the number of Competitiveness Clusters members. S3 institutions have no data on the status of the latter, so this outcome is omitted from Figure 5.16. According to the World Bank data, Croatian medium and high-tech exports (as a share of manufactured exports) have increased significantly, reaching 49.2 percent in 2020, which is beyond the target of 41.3 percent in 2023. It remains to be seen whether the positive trend has continued up to 2023.

Figure 5.16 Outcomes under SO4



Note: Institutions provided no data for the second outcome associated with SO4 (number of Competitiveness Clusters members), hence this outcome is not shown in the figure. The baseline value for this indicator was 350 and the target is 500.

Source: Staff elaboration based on World Bank data.

S3 Specific Objective SO5 – Working in partnership to develop social innovations

SO5 was introduced in the S3 to refer to the planned efforts toward addressing societal challenges, but the objective has been discontinued to be tracked during S3 implementation. SO5 was initially envisaged to tackle societal challenges, however, no progress has been recorded regarding the delivery instrument supporting social innovation. No such instruments have been included in the S3 Action Plan 2019–2020 nor implemented in the period 2020–23. Tables 5-2 and 5-3 present the indicators that were set in the S3 document in relation to this SO and the envisaged delivery instrument. As there was no instrument launched, there have been no achievements connected to this SO, and the outcome indicator is not tracked.

Table 5.2 Outputs under SO5

DELIVERY INSTRUMENT	INDICATOR (OUTPUT)	TARGET VALUE (2023)	ACHIEVED VALUE (2020)	ACHIEVED VALUE (SEPT 2023)	SHARE OF TARGET ACHIEVED
Support to social innovation	Number of social innovation projects	3	0	0	0%

Note: Baseline value (2016) is zero.

Source: S3 document; staff elaboration based on data provided by S3 institutions.

Table 5.3 Outcomes under SO5

INDICATOR (OUTCOME)	BASELINE VALUE	TARGET VALUE (2023)	ACHIEVED VALUE	SHARE OF TARGET ACHIEVED
Increased number of PCT patent applications in societal challenges per billion GDP (PPS EUR)	0.22 (2011)	0.35	n/a	n/a

Note: PCT = Patent Cooperation Treaty, GDP = gross domestic product, PPS = purchasing power standards, EUR = euro currency.

Source: S3 document; staff elaboration based on data provided by S3 institutions.

SO6 – Development of smart skills – upgrading the qualifications of existing and new work force for smart specialization

SO6 is related to developing smart skills and upgrading work force qualifications in line with smart specialization needs. The SO comprises several delivery instruments referring to the establishment of skills-related infrastructure, development of new education programs and qualification standards, and sectoral curricula in relation to smart specialization. This SO includes the following delivery instruments:

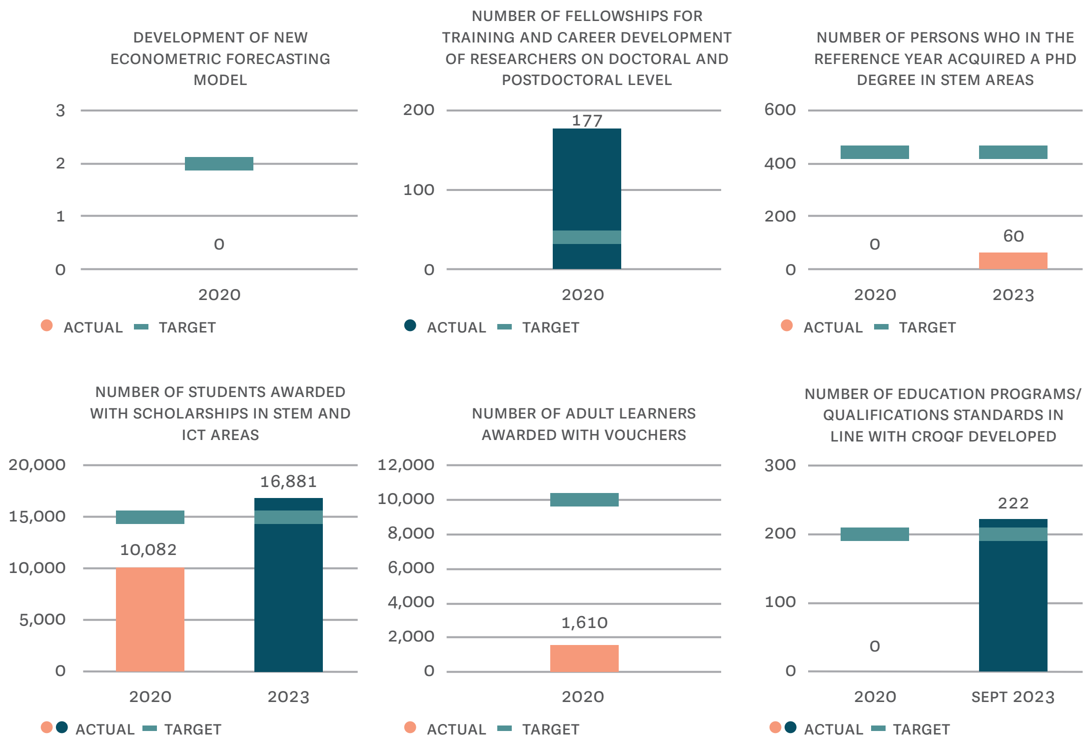
a. Establishing infrastructure for smart skills policies

b. Additional instruments put in place for assessing medium-term skill needs

c. Implementing the Croatian Qualification Framework mechanism for delivering timely and standardized training programs based on future and medium-term skill needs.

SO4 achieved half of its set output targets, with certain achievements not yet clear (Figure 5.17). The SO overperformed regarding supported students in science, technology, engineering, and mathematics (STEM) areas, by awarding over 16.8 thousand scholarships (the target value was 15 thousand). The fellowships awarded to PhD candidates and postdoctoral researchers also excelled with 177 in 2020, which is over four times the initial target. Furthermore, 222 education programs and qualifications standards have been developed in line with Croatian Qualifications Framework (CROQF). The SO underperformed regarding PhD completion, awarding vouchers to adult learners, and developing sectoral curricula. However, the most recent data for several indicators under this SO is not available, so it is unclear whether the final values at the end of 2023 will differ from the current ones.

Figure 5.17 Outputs under SO6

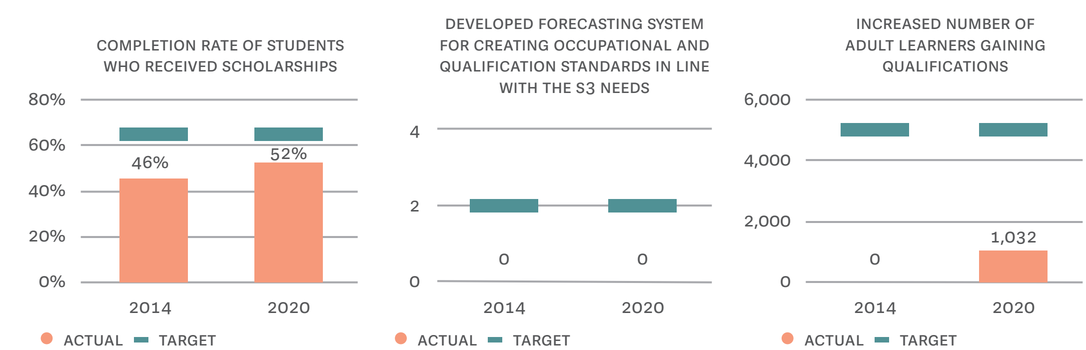


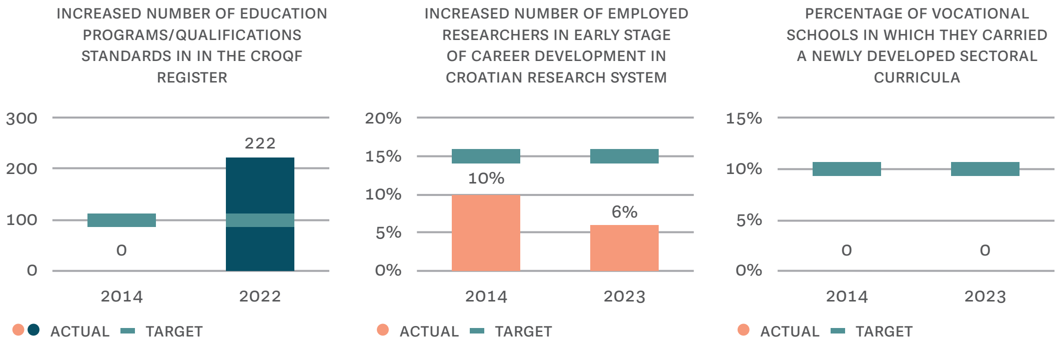
Note: Baseline value (2016) is zero for all indicators, except for the Number of persons who in the reference year acquired a PhD degree in STEM areas (Baseline value (2016) = 405)

Source: Staff elaboration based on data provided by S3 institutions.

SO6 achieved only one out of six outcome targets, with part of the data not available. Figure 5.18 provides an overview of the outcomes assigned to SO6. Although the number of education programs and qualifications standards in the CROQF Register surpassed the original 2023 target by more than twice in 2022, the other indicators have either underperformed, or the data is not (yet) available.

Figure 5.18 Outcomes under SO6





Note: Project completion deadline has been postponed to November 30, 2023, so final achievements are not yet known.
Source: Staff elaboration based on data provided by S3 institutions.

Overview of TPA progress

The analysis of results at TPA level is limited by data availability. The S3 identified five TPAs that represent priority areas for R&D investments of the S3 delivery instruments. Although there are no TPA-specific objectives, indicators, or targets, the S3 monitoring framework envisages the measurement of output indicators by TPA. (The S3 foresees no TPA-specific outcome indicators). Results at TPA level are estimated by mapping each supported project to one or more TPAs (in terms of percentage contribution), and then deriving TPA results from total results. Midterm S3 evaluation showed challenges in relation to tracking TPA progress and data availability in the first years of S3 implementation (World Bank 2021c). In recent years, however, there have been notable improvements regarding the number of instruments for which TPA disaggregation has been made available. This also includes instruments that were not limited to funding S3 areas, such as support programs for innovative SMEs, which have been analyzed ex post by the program managers to identify projects and results that could be attributed to particular TPAs.

Although TPA Energy and Sustainable Environment seems to dominate in most indicators, other TPAs also show relative strengths; however, lack of baseline TPA data and estimations and targets impede more accurate conclusions. Table 5.4 looks at TPA-level achievements as of September 2023. TPA1 (Health and Quality of Life) exhibits notable results in several areas with a strong emphasis on research (SO1), particularly when it comes to supporting ZCIs and investing in RDI infrastructure. Half of ZCI engagement falls under TPA1, with the same area dominating in number of researchers employed in ZCIs. This TPA also has the second highest number of RDI infrastructure projects supported and the most researchers that work in the upgraded facilities. But TPA2 (Energy and Sustainable Environment) seems to dominate regarding cooperation of enterprises with research organizations and supporting enterprises to introduce new products. TPA3 (Transport and Mobility), however, records a significantly higher recorded value for financial contribution of the private sector matching funds compared to other TPAs. TPA4 (Security) and TPA5 (Food and Bioeconomy) seem to perform less compared to other TPAs, although TPA5 also tops several indicators. The S3 did not quantify any targets that would be assigned to outputs and outcomes of any individual TPAs, however. Hence, it is difficult to assess whether these achievements are satisfactory or not. Moreover, there is no detailed data on which stakeholders or sectors a particular TPA covers, which would also be a relevant information for comparing TPA progress.

Table 5.4 TPA-level achievements in outputs as of September 2023

INDICATOR (OUTPUT)	TPA 1	TPA 2	TPA 3	TPA 4	TPA 5
Number of enterprises cooperating with research organizations	55.43	120.92	75.58	36.95	34.12
Number of RDI projects conducted by research organizations	4.50	7.50	0.83	0.83	8.33
Number of National CoREs projects supported	5	1.58	0.50	1	1.92
Number of researchers working in supported CoREs	418	109.25	28.17	85.5	150.08
Number of supported projects enabling synergies with ERC grants	1	1.83	0.33	0.83	2
Number of RDI infrastructure projects	10.37	10.66	1.96	2.10	4.91
Number of researchers working in improved research infrastructure facilities	472.67	340.79	62.76	37.98	103.31
Number of supported Teaming, Twinning, and ERA chair projects	1	1.83	0.33	0.83	2
Number of new researchers working in supported entities	27	0	21	13	10
Number of established Thematic Innovation Councils	1	1	1	1	1
Number of identified strategic projects under Thematic Innovation Platforms	5	14	6	5	2
Number of prepared Thematic Strategies for RDI	1	1	1	1	2
Number of enterprises receiving grants	16	29	25	15	7
Number of enterprises supported to introduce new-to-firm products	72	170	116	79	55
Number of enterprises supported to introduce new-to-market products	72	161	113	76	52
Number of R&D projects supported	15	30	26	16	12
Private investment matching public support in innovation or R&D projects (million EUR)	13.96	16.37	60.55	9.44	10.64

Note: TPA 1 = Health and Quality of Life; TPA 2 = Energy and Sustainable Environment; TPA 3 = Transport and Mobility; TPA 4 = Security; TPA 5 = Food and Bioeconomy. Cell color indicates where the cell value falls within the color gradient within each row (i.e., for each indicator, top performing TPA is marked with the darkest color). In case of indicators that repeat for multiple SOs, the TPA data shows consolidated values across all instruments for which data is available. Values that are not whole numbers indicate that, in cases of projects contributing to multiple TPAs, the approximation of contribution to each TPA has been made, resulting with progress from a single project being split into multiple areas.

Source: S3 document; authors based on data provided by S3 institutions.

TPA progress is difficult to contextualize, however, due to lack of more detailed data on TPA scope and TPA-specific objectives and targets. The achievements in Table 5.4 provide insights on the relative performance of the TPAs in the context of support provided and results achieved. It needs to be noted again, however, that for an accurate comparison across TPAs, TPA size approximation would be beneficial (e.g., how many stakeholders are active within a particular TPA, their baseline capacities, etc.), but such data is not available. Furthermore, to compare achieved with planned values, quantified TPA-level targets are needed, but none were set in the S3 document.

5.2 Monitoring results per revised S3 framework

The S3 M&E Framework was revised in 2019 to track progress in a more comprehensive results framework for an extended set of policy instruments. With adoption of the S3 Action Plan 2019–2020, the S3 policy mix was expanded to include not only new instruments that had previously not been planned, but also some previously implemented instruments for which the progress had not yet been tracked as part of the S3. Furthermore, the list of indicators was expanded significantly, providing a clearer link between the delivery instruments and achievements (World Bank 2021c).

There are no quantified targets, however, for indicators in the revised framework. The revised S3 framework reflects a more comprehensive and expanded set of instruments and indicators. However, the new framework does not refer to any quantified S3 targets in accordance with the revised policy mix. Because the policy mix was expanded to include additional ESIF and national budget programs, and considering a significant share of indicators were not tracked previously, there is no full comparability with the targets in the original S3.

The revised framework introduced three S3 main objectives (MOs), that were derived from the six previous S3 SOs, and assigned them with key output and outcome indicators. Table 5.5 shows how the original SOs map to the new MOs. Each MO is associated with several output and outcome indicators, designated as "key S3 indicators." The rest of this section presents progress in key indicators achieved per each MO. Annex II presents recorded achieved values of all indicators from the revised framework, with reference to instruments contributing to their achievement.

Table 5.5 Main S3 objectives according to S3 Action Plan 2019–2020

MAIN OBJECTIVE	SPECIFIC OBJECTIVES
MO1 – Improving capacity, performance, and skills for excellent and relevant research in the public sector	SO1, SO6
MO2 – Bridging the gap between the research and business sector	SO1, SO2
MO3 – Increasing research, development, and innovation efficiency and skills in the business sector	SO3, SO4

Note: SO1 = Increased capacities of RDI sector to perform excellent research and to serve the needs of the economy; SO2 = Overcoming the fragmentation of innovation value chain and the gap between research and business sector; SO3 = Modernizing and diversifying Croatian economy through increasing private investments into RDI; SO4 = Upgrading in global value chain and promoting internationalization of Croatian enterprises; SO6 = Development of smart skills – upgrading the qualifications of existing and new work force for smart specialization. SO5 (Working in partnership to develop social innovations) is not covered by the revised policy mix.

Source: S3 Action Plan 2019–2020.

MO1 – Improving capacity, performance, and skills for excellent and relevant research in the public sector

MO1 strives toward contributing to improved capacities, skills, and results of the Croatian public research sector. Table 5.6 lists output and outcome indicators assigned to MO1. In terms of outputs, the indicators track new RDI infrastructure projects, fellowships awarded to PhD candidates and postdoctoral researchers, and on outcome level, new PhD graduates. On the outcomes side, the indicators track scientific publications produced, new funding attracted from EU centralized programs, and new collaborations of Croatian organizations with foreign partners.

Table 5.6 Outputs and outcomes under S3 Main Objective MO1 – Improving capacity, performance, and skills for excellent and relevant research in the public sector; achievements as of September 2023

INDICATOR TYPE	INDICATOR	TOTAL	TPA 1	TPA 2	TPA 3	TPA 4	TPA 5
Output	Number of RDI infrastructural projects	**30**	10.37	10.67	1.95	2.09	4.90
Output	Number of fellowships for training and career development of researchers on doctoral and postdoctoral level	**169**	n/a	n/a	n/a	n/a	n/a
Outcome	Number of scientific publications published in journals indexed in the Web of Science core collection	**4,717**	1,651.23	1,285.49	551.43	517.67	709.17

INDICATOR TYPE	INDICATOR	TOTAL	TPA 1	TPA 2	TPA 3	TPA 4	TPA 5
Outcome	Total contracted amount for RDI funding from centralized EU funds (attracted by beneficiaries) (EUR thousand)	**15.13**	n/a	n/a	n/a	n/a	n/a
Outcome	Number of collaborative contracted projects (by beneficiaries in HEIs and PRO) with foreign HEI and PRO institutions	**2**	n/a	n/a	n/a	n/a	n/a
Outcome	Number of young researchers who gained doctoral (PhD) degree	**90**	n/a	n/a	n/a	n/a	n/a

Note: TPA 1 = Health and Quality of Life; TPA 2 = Energy and Sustainable Environment; TPA 3 = Transport and Mobility; TPA 4 = Security; TPA 5 = Food and Bioeconomy, HEIs = higher education institutions, PRO = public research organization.

Source: S3 Action Plan 2019–2020; authors based on data provided by S3 institutions.

For most indicators, the progress shown refers to a very limited set of programs, and the complete data will be available up to five years after project completion. For MO1, the most notable results concern RDI infrastructure. The 30 projects recorded include flagship infrastructure projects of Center for advanced laser techniques (CALT), Croatian Scientific and Educational Cloud (HR-ZOO), as well as the projects supported under programs "Investment into organizational reform and infrastructure of RDI sector" and "Development and strengthening synergies with Horizon 2020 horizontal activities: Twinning and ERA chairs." Furthermore, the program supporting "Career development of young researchers (PhD education)" reached 169 fellowships, leading to 90 new PhD graduates. The progress in new publications refers to both to the entities benefiting from the improved RDI infrastructure and beneficiaries of other grant scheme programs. Both in terms of infrastructure projects supported and the publications produced, TPA1 (Health and Quality of Life) and TPA2 (Energy and Sustainable Environment) seem to lead compared to other TPAs. The outcomes referring to additional funding attracted and new international collaborations are tracked for a broad set of programs (see Annex II); however, the modest progress recorded at the moment refers to a single program, whereas, the rest of the data is not yet available.

MO2 – Bridging the gap between the research and business sector

MO2 aims to support and sustain cooperation activities between the research and business sector. Regarding collaborative research activities, the indicators track the number of enterprises supported to engage in such collaborations, the number of projects supported, and the collaborative projects contracted to continue research upon completion of the supported projects. Furthermore, the MO includes indicators on usage of public infrastructure by enterprises, and the amount of funding contracted by the ROs, from private sector entities. The indicators and the achieved values (as of September 2023) are listed in Table 5.7.

Table 5.7 Outputs and outcomes under S3 Main Objective MO2 – Bridging the gap between the research and business sector; achievements as of September 2023

INDICATOR TYPE	INDICATOR	TOTAL	TPA 1	TPA 2	TPA 3	TPA 4	TPA 5
Output	Number of enterprises cooperating with research organizations	**341**	55.43	120.92	75.58	36.95	34.12
Output	Number of supported collaborative projects of the scientific research and business sector	**210**	28	76	38	28	22
Outcome	Rate of public infrastructure usage by enterprises	**n/a**	n/a	n/a	n/a	n/a	n/a
Outcome	Number of collaborative contracted projects between companies and HEIs/PROs after the end of supported projects	**31**	0	4	3	2	2
Outcome	Total contracted amount for R&D funding from private sector attracted by PROs /HEIs beneficiaries (EUR thousand)	**264.85**	n/a	n/a	n/a	n/a	n/a

Note: TPA 1 = Health and Quality of Life; TPA 2 = Energy and Sustainable Environment; TPA 3 = Transport and Mobility; TPA 4 = Security; TPA 5 = Food and Bioeconomy.

Source: S3 Action Plan 2019–2020; authors based on data provided by S3 institutions.

Although data on enterprises and projects supported is available for all instruments, the data on outcomes achieved within MO2 is limited. The instruments supported 341 enterprises in collaborating with ROs in 210 projects, funded through the following programs: "Strengthening capacities for research, development and innovation (STRIP)," "Research infrastructure usage and researchers' services for SMEs (IRCRO)," "Supporting development of Centers of Competence," and "Support to Development of New Products/Services Resulting from R&D Activities-IRI" (Phases I and II). Regarding collaborations supported, the largest share of both enterprises and projects supported is attributed to TPA 2 (Energy and Sustainable Environment) and TPA 3 (Transport and Mobility). The data on new collaborations after the end of supported projects and the total contracted amount from private sources is, however, tracked up to five years after project completion, and thus available for a limited set of projects only. Furthermore, the data on the rate of public infrastructure usage by enterprises will be available five years after completion of the Strategic Project "Science and Technology Foresight," with the project ending in 2023.

MO3 – Increasing research, development, and innovation efficiency and skills in the business sector

MO3 focuses on boosting RDI skills and performance in the business sector. The MO concerns support provided to enterprises to introduce new, innovative products in their portfolios, while investing their own complementary R&D funding on top of grants provided. On the outcome level, the MO refers to the share of the turnover generated by the sales of products introduced in total turnover, the new R&D job positions created in enterprises, and the number of innovative products, services, processes, and technologies resulting from the supported projects. The indicators and achieved values for MO3 are listed in Table 5.8.

Table 5.8 Outputs and outcomes under S3 Main Objective MO3 – Increasing research, development, and innovation efficiency and skills in the business sector; achievements as of September 2023

INDICATOR TYPE	INDICATOR	TOTAL	TPA 1	TPA 2	TPA 3	TPA 4	TPA 5
Output	Number of enterprises supported to introduce new-to-firm products	**856**	72	170	116	79	55
Output	Private investment matching public support in innovation or R&D projects (EUR million)	**205.28**	30.03	40.68	71.10	18.47	17.82
Outcome	Sales of new-to-firm innovation (as percentage of turnover)	**14.41**	n/a	n/a	n/a	n/a	n/a
Outcome	Number of job positions in R&D created in enterprises by RDI projects after the end of funded project	**158**	9	9	46	21	26
Outcome	Number of new innovative products/services/processes/ technologies	**252**	11	40	16	6	2

Note: TPA 1 = Health and Quality of Life; TPA 2 = Energy and Sustainable Environment; TPA 3 = Transport and Mobility; TPA 4 = Security; TPA 5 = Food and Bioeconomy.

Source: S3 Action Plan 2019–2020; authors based on data provided by S3 institutions.

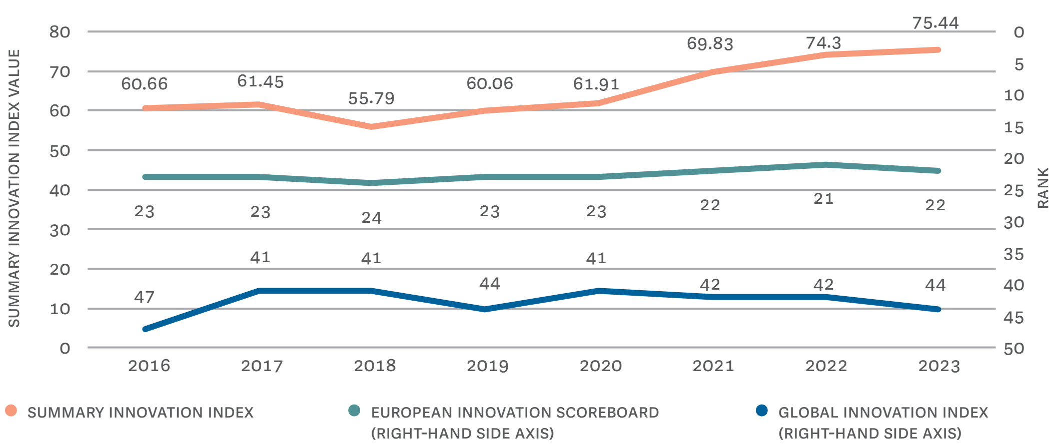
The progress under MO3 already reflects progress in outputs and outcomes for most programs, but the data will be complemented in years to come. The support programs under this MO, concerning mostly grant schemes supporting SMEs, reached 856 enterprises seeking to introduce new products, and investing more than EUR 205 million. TPA 2 (Energy and Sustainable Environment), and particularly TPA 3 (Transport and Mobility), hold most results among all TPAs. It should be noted, however, that the information on TPA progress refers to a limited sub-set of programs only where such data is available. For the supported enterprises, on average 14.4 percent of turnover share is approximated to be attributed to the innovations developed within the projects. As of September 2023, 252 new innovative products, services, processes, and technologies were recorded as resulting from the projects implemented, and the value will continue to be tracked and revised up to five years after completion of all projects supported.

Context indicators

There has been improvement in the recorded values for all context indicators, compared to the values at the beginning of the S3 implementation. Although output and outcome indicators from the revised framework directly refer to supported projects and beneficiaries, context indicators are used to track the progress of Croatia's innovation system. Context indicators were part of the original S3, but without setting any targets. The revised S3 framework also includes a revised set of context indicators. Although improvements are clear when looking at Croatia in isolation, the monitoring framework set no specific targets or comparisons to the EU average. It is therefore difficult to judge whether these improvements are contributing to catching up to EU innovation leaders or peers.

Composite measures of national innovation performance have slightly improved. Compared to 2016, Croatia improved its ranking in the Summary Innovation Index (from 23rd to 22nd) and the Global Innovation Index (from 47th to 44th). Summary Innovation Index shows more improvement and has reached 75 percent of the EU average in 2023, compared to 61 percent in 2016.

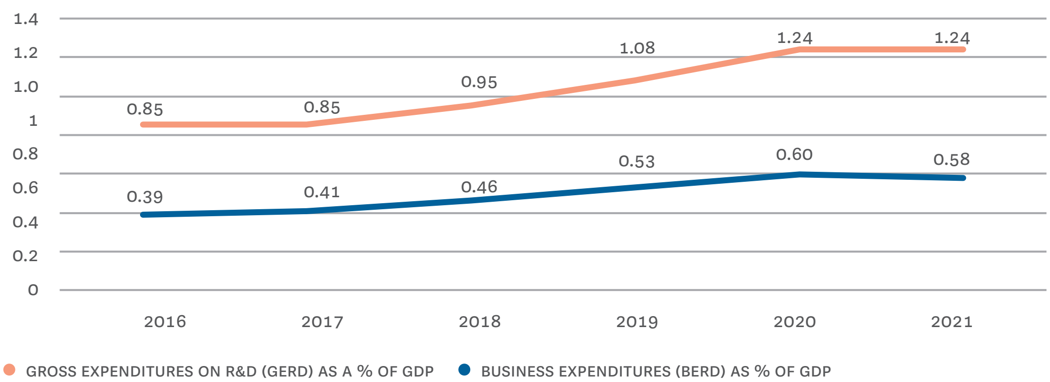
Figure 5.19 Composite innovation performance measures



Source: Staff elaboration based on European Innovation Scoreboard (online interactive tool) and World Intellectual Property Organization.

Investments in R&D have almost doubled, though remain below the EU average. Both gross expenditures on R&D (GERD)and business expenditures as a percent of GDP (BERD) have gone up (Figure 5.20). GERD started at 0.85 percent of GDP in 2016, and reached 1.24 percent in 2021, whereas in the same period BERD increased from 0.39 percent of GDP to 0.58 percent.

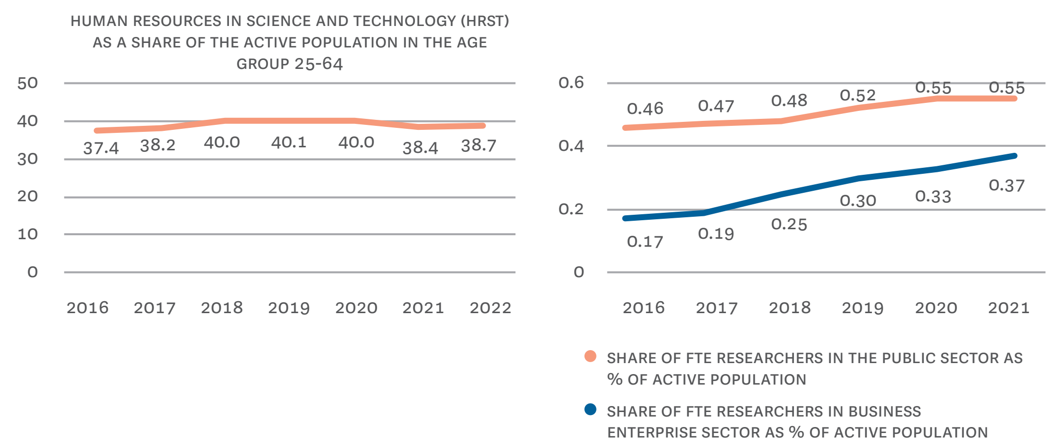
Figure 5.20 GERD and BERD as a percentage of GDP



Source: Staff elaboration based on Eurostat.

Human resources in R&D have grown, especially in the business sector. The share of human resources in the active population remained relatively stable. However, the share of FTE researchers in the active population employed in the business sector has grown from 0.17 percent to 0.37 percent in 2021 (Figure 5.21).

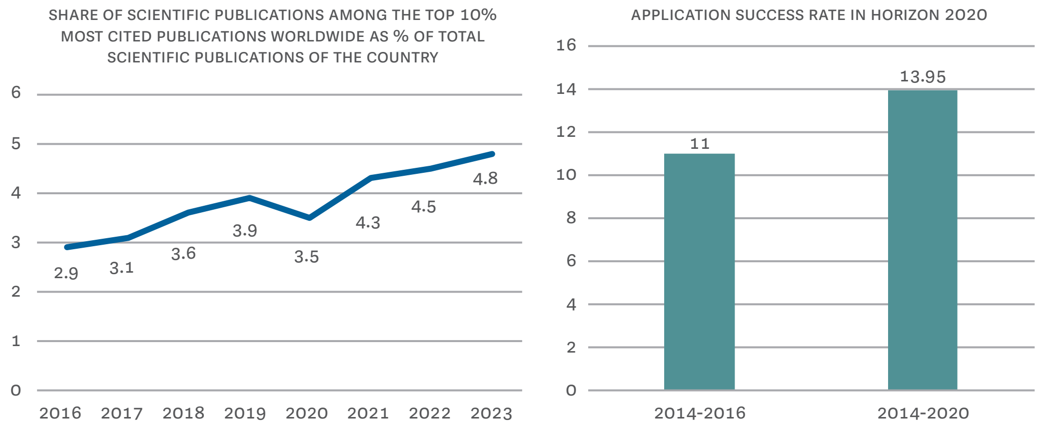
Figure 5.21 Human resources in R&D



Source: Staff elaboration based on Eurostat and European Innovation Scoreboard.

The publications of Croatian researchers and applications to competitive international schemes are becoming more relevant. The share of scientific publications among the top 10 percent most cited publications worldwide has almost doubled since 2016, reaching 4.8 percent in 2023, whereas the application success rate in Horizon 2020 stands at a higher-than-EU-average 13.95 percent (Figure 5.22).

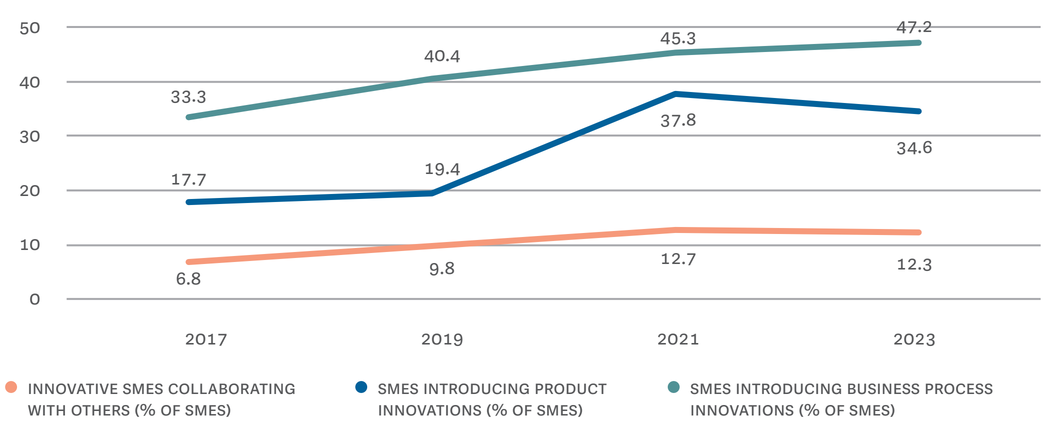
Figure 5.22 Research outcomes



Source: Staff elaboration based on Horizon 2020 Dashboard and European Innovation Scoreboard.

SME innovation metrics have also improved. More SMEs are introducing product and process innovations, and collaboration with other entities is increasing (Figure 5.23).

Figure 5.23 SME innovation measures



Source: Staff elaboration based on European Innovation Scoreboard.

6 S3 governance evolution and quality

S3 governance evolution and quality

This section reviews the developments in S3 governance in the period 2020–23 and ex post conclusions for the overall S3 implementation period. The assessment of Croatian S3 governance involves reviewing the institutions engaged in designing, managing, and implementing the S3, and their roles, responsibilities, and decision-making processes. The main source of information for the assessment is the available official documentation and information from the responsible policy makers. This section builds on the midterm evaluation findings and recommendations (World Bank 2021a), covering the period up to 2020, and follow up with the same analytical approach to assess any changes introduced, as well as those planned as part of the new S3 2029 strategy.

Previous analytical work was structured around three modes of governance seen in Croatia: policy governance, entrepreneurial discovery process governance, and implementation governance. The midterm evaluation (World Bank 2021a) distinguishes between three mutually intertwined hierarchical structures concerning the S3 policy cycle. Policy governance refers to policy design, adoption, and revision processes, strategic management, and M&E. In the S3 2016–20, this involved the NIC, supported by an Inter-ministerial Working Group, a Technical Secretariat, and three advisory councils.[22] Entrepreneurial discovery process governance refers to the structures and activities related to collective decision-making between governmental and non-governmental stakeholders, more precisely Croatian Competitiveness Clusters and Thematic Innovation Councils. Implementation governance refers to the structures and processes needed to implement S3 programs and projects, meaning the institutional management and control system for ESIF, and institutions and governance systems for other funding sources of S3 delivery instruments. This report follows the same analytical framework and provides the most recent developments regarding each governance layer.

This report also refers to the planned S3 governance which has been streamlined in the updated strategy. The S3 2029 details an updated structure presented in Figure 6.1. The new structure proposes a more streamlined plan in terms of role division and planned interaction of the S3 stakeholders, as opposed to the structure governing the S3 in the previous period. According to the S3 2029, the streamlined governance structure aims to "facilitate communication and decision-making between different stakeholders and create stronger linkages between policy governance and entrepreneurial discovery process (EDP) into policy co-creation and between policy governance and implementation governance."

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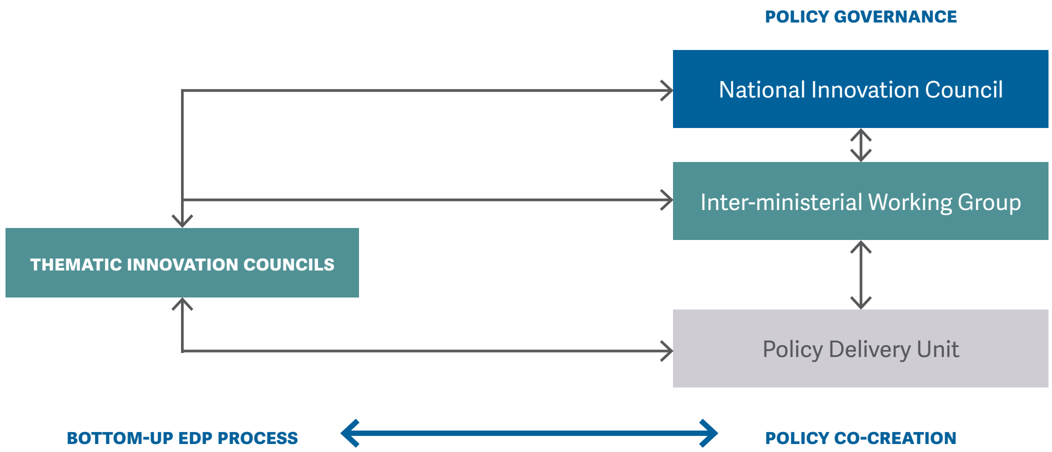
22 Innovation Council for Industry; National Council for Science, Higher Education and Technology Development; and National Council for Development of Human Potential.

The planned governance structure is a reference point regarding the assessment of the planned changes, although they remain to be implemented.[23] The rest of this section assesses the performance and plan regarding each of the three governance layers.

Figure 6.1 Planned governance structure from S3 2029)



Source: S3 2029.

6.1 Policy governance

S3 governance faced initial challenges created by the late establishment and overlaps in authority of the NIC. The NIC was envisaged as the central governance body of S3 governance. However, the NIC was established by government Decision in July 2018, over two years after the S3 adoption in 2016. The NIC overlapped with other strategic governance institutions, such as the Innovation Council for Industry, governing Croatian Innovation Strategy 2020. The key stakeholders of the innovation ecosystem were represented on both councils and governed policy mixes that overlapped to a significant extent, and with the Innovation Council for Industry being designated as one of the advisory councils of the NIC. Moreover, the presidents of the Thematic Innovation Councils, as the main entrepreneurial discovery structures, are members of both the Innovation Council for Industry and the NIC. The NIC is supported by an Inter-ministerial Working Group, a Technical Secretariat, and three advisory councils. Whereas the Inter-ministerial Working Group and the Technical Secretariat provided valuable contributions and continuity with regard to the functioning of the S3 governance and M&E processes, given the designated role and composition of these entities, they cannot replace the NIC as the main governance figure. The NIC top decision-makers, with representatives of the public administration bodies in charge of EU funds, economy, and science as co-chairs. The Inter-ministerial Working

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23 The Croatian government adopted the S3 2029 on December 13, 2023.

Group involves civil servants with limited decision-making authority. Furthermore, the Technical Secretariat had limited staff available to take on its support function.

Regarding overall policy governance, S3 midterm evaluation suggested strengthening further the role of the NIC and involvement in the entrepreneurial discovery process. The midterm evaluation recommendations included establishing an S3 policy delivery unit to strengthen the linkages between policy governance, entrepreneurial discovery process governance, and implementation governance (World Bank 2021a). Although the NIC would remain as the main policy-making body in the structure, the report argued that the S3 governance structure would benefit a body that can support steering the S3 at all stages of the policy cycle and ensure the implementation of the strategic decisions of the NIC. The policy development unit would be involved in M&E processes and detecting strategic and operational issues. Furthermore, a policy unit would discuss entrepreneurial discovery process results, perform M&E functions, provide analytical and expert support, and prepare materials for the Council's decision-making process. Upon adoption of NIC decisions and recommendations, the policy delivery unit would supervise and follow up on their implementation. To facilitate the process, the policy delivery unit would need to have authority over the bodies designated to implement NIC decisions and recommendations. At the same time, midterm evaluation argued that Croatia should reposition the NIC as a strategic council covering the overall national STI policy, absorbing the functions of the Innovation Council for Industry. This change was recommended to facilitate coordination of overall STI policy and enable better integration of S3 policy into STI policy while also creating the opportunity to streamline the governance structure, in particular when it comes to steering the entrepreneurial discovery process (World Bank 2021a).

Furthermore, the midterm recommendations included upgrading M&E processes and strengthening the capacities of the system and stakeholders involved. The midterm evaluation suggested that M&E capacities should be significantly strengthened, and the S3 M&E would benefit from strengthening TPA-level reporting and streamlining and harmonizing different M&E systems and information systems (S3, ESIF, and non-ESIF) (World Bank 2021a). Moreover, midterm evaluation suggested that efforts should be invested so the governance system operates in real time and that it features mechanisms for feedback, learning, and correction beyond regular reporting. The establishment of an S3 M&E network was suggested as one potential solution, to provide a mechanism for continuous and real-time adjustments based on available data and information. The network, consisting of S3 stakeholders, would detect issues in the entrepreneurial discovery process and in implementation as they emerge and try to resolve them directly through its members, or escalate to other S3 governance bodies as needed. Finally, midterm evaluation suggested that institutional capacity-building efforts should focus on improving policy design capacity and programming capacity, implementation management capacities, and M&E capacities. The areas that need institutional capacity building include job design, new employment (where necessary), staff retention, advanced training, work (re)organization, resource availability, and networking. Table 6.1 summarizes the progress made regarding each recommendation from the midterm evaluation.

Table 6.1 Summary of the progress on recommendations from the S3 midterm evaluation concerning policy governance

RECOMMENDATION	PROGRESS
1a: Establish an S3 policy delivery unit	**In progress.** The S3 2029 envisages the establishment of a policy delivery unit. The strategy was recently adopted (in December 2023), and the policy delivery unit is yet to be established.
1b: Strengthen the role of the NIC	**Pending.** Since 2020, the Council has met once. The S3 2029 was adopted in December 2023. The draft strategy envisages a revised governance structure and elevates the NIC to its recommended role, but the real test will be in the implementation.
1c: Involve the NIC more directly in strengthening entrepreneurial discovery process governance	**Pending.** There have been no activities related to this recommendation.
1d: Strengthen M&E reporting and utilization	**In progress.** There have been improvements with regard to the M&E processes (e.g., tracking progress on TPA level). An extensive M&E framework is being developed for the new S3 2029 and its delivery instruments.
1e: Establish a real-time monitoring and adjustment mechanism	**Pending.** There have been no initiatives of introducing a mechanism that would be designated to facilitate real-time learning.
1f: Strengthen institutional capacities	**In progress.** The MSE is working on raising the capacity of their staff through advisory support, especially to strenghten programming and M&E functions. Additional capacity building for policy design in the area of green and digital innovation is planned through a World Bank lending project.

Source: Staff elaboration based on Analysis of Design and Implementation of Croatian S3 Governance (World Bank 2021a) and S3 2029.

Although the NIC has been inactive in recent years, governance plans for S3 2029 spark some optimism; though the adoption of the strategy is once more delayed. The NIC's role has remained limited, and to this point, the last NIC meeting was held in 2020. During work stoppages brought on by the COVID-19 pandemic, the Inter-ministerial Working Group continued to play the most active role in S3 policy coordination and implementation. This remained the case as the institution supported the Strategy's most recent update by assisting with the entrepreneurial discovery process and strategy drafting. The S3 2029 presents an updated governance structure shown in Figure 6.1. In the updated S3, policy creators are planning to strengthen the coordinative role of the NIC to inform, discuss, and issue decisions and recommendations for institutions in the national innovation system to act within their domain related to the S3, S3 policy instruments, as well as broader research and innovation policy and their interaction with other policy domains. Moreover, per the S3 2029, policy makers are planning to establish an S3 Policy Delivery Unit to provide analytical and technical support to the coordination activities of the NIC.

However, as it was the case with the last policy cycle, the adoption process for the new S3 document has been prolonged, with the Strategy adopted by the Croatian government in December 2023. The policy delivery unit also remains to be established. It remains to be seen whether the planned improvements to the governance system and practices referenced in the S3 2029 will hold in practice.

The S3 M&E already exhibits some improvements, with an additional emphasis put on the M&E processes in the new governance structure planned. As argued in section 5.2 of this report, there have been improvements in the M&E processes, for example regarding data availability and tracking TPA progress. The Inter-ministerial Working Group and the Technical Secretariat remain active and operational regarding the M&E processes. The S3 2029 features an overall results framework and specific theories of change and metrics envisaged for the TPAs. The new RDI instruments launched by the MSE include the upgraded M&E frameworks and theories of change. Furthermore, the MSE is set to receive technical assistance through the Digital Innovation and Green Technology Project – a lending instrument of the World Bank – that will, among other actions, seek to improve internal capacities for RDI program M&E.

6.2 Entrepreneurial Discovery Process governance

Before 2020, the entrepreneurial discovery process experienced limitations in implementation. The S3 entrepreneurial discovery process involved many stakeholders and participants, and in that respect, it was relatively successful. However, the process had shortcomings regarding lack of clarity in the roles of different structures involved, overlapping authorities, and issues about coordination and efficiency of the entrepreneurial discovery process (World Bank 2021a). Furthermore, Croatia included several institutional instruments in the S3 policy mix that were expected to support the entrepreneurial discovery process by providing relevant analytical inputs for the work of entrepreneurial discovery process governance structures, and directly supporting coordination of such structures. However, due to delays and a variety of challenges, these mechanisms have had limited influence in the first years of S3 implementation.

The midterm evaluation suggested efforts toward strengthening the role of Thematic Innovation Councils, while minimizing administrative burden and micromanagement of the entrepreneurial discovery process governance structures. Midterm evaluation argued that Croatia should invest more efforts in increasing the involvement of the Thematic Innovation Councils in policy co-creation and developing RDI strategies and policy mixes for each S3 TPA. The 2021–2027 programming period presents an opportunity for Thematic Innovation Councils to be involved in designing TPA-specific RDI strategies and the pertaining policy mix. Designing TPA-specific support mechanisms involves developing tailored instruments for each thematic priority and accompanying goals, moving toward a specific portfolio of instruments and financial allocations for each TPA. The new programming period allows for an opportunity to significantly improve the entrepreneurial discovery process through which TPA-specific support mechanisms can be designed.

The role of the Thematic Innovation Councils could be increased further by involving the Thematic Innovation Councils to provide, for example, opinions on other strategic documents or draft legislation related to STI and sectoral policies connected with the S3. At the same time, policy makers should facilitate the bottom-up nature of the entrepreneurial discovery process through a careful balance between helping with the Thematic Innovation Councils' work with some procedures and general guidelines, and not creating unnecessary administrative burdens or making the process overly prescriptive. Table 6.2 presents the midterm recommendations and progress made in the period 2020–23.

Table 6.2 Summary of the progress on recommendations from the S3 midterm evaluation concerning entrepreneurial discovery governance

RECOMMENDATION	PROGRESS
2a: Facilitate the bottom-up approach in structuring the entrepreneurial discovery process	**In progress.** Thematic Innovation Councils have been supported by workshops with the purpose of involving the members in the S3 2029 preparation.
2b: Increase the involvement of the Thematic Innovation Councils in policy co-creation	**In progress.** Guidelines for continuous EDP have been adopted. It remains to be seen whether the Thematic Innovation Council will remain active upon the adoption of S3 2029.
2c: Engage Thematic Innovation Councils in developing RDI strategies and policy mixes for each thematic priority	**Complete.** Thematic Innovation Councils have provided inputs for developing TPA RDI strategies, which have been integrated into priorities of S3 2029.

Source: Staff elaboration based on Analysis of Design and Implementation of Croatian S3 Governance (World Bank 2021a) and S3 2029.

The reparation of S3 2029 gave new momentum for the involvement of the Thematic Innovation Councils, but the process remained limited to strategy preparation, and momentum seems to have stalled. The process of designing S3 2029 relied significantly on involvement of the Thematic Innovation Councils. Beginning in July 2021, the World Bank conducted surveys across Thematic Innovation Councils to help define key capacities, opportunities, challenges, and provisional transformational objectives for their respective priority areas. The survey had modules on capacities, opportunities, and potential project ideas of TPA stakeholders. The survey gathered 699 responses, which were analyzed and used in further entrepreneurial discovery activities. Furthermore, a Guidance Note for Steering Entrepreneurial Discovery Process (World Bank, 2022) was produced with the support of the World Bank, to facilitate the entrepreneurial discovery continuation upon S3 2029 adoption. However, the involvement of the Thematic Innovation Councils did not extend to other areas where their inputs might be relevant, such as instrument design.

Following the survey, two rounds of workshops were organized to discuss the transformational goals and start developing a transformational roadmap. Two rounds of workshops were organized with World Bank support. Workshop participants included representatives from business, academia, and public administration bodies responsible for S3 policy. A total of 160 participants participated in the first round of workshops, and 154 in the second round. The first round aimed to reach agreement among stakeholders about a common transformational goal for each thematic priority, based on inputs from the survey and other analytical evidence. The second round of workshops focused the discussions on proposing public interventions to reach the agreed transformational goal. The proposed interventions were mapped onto a grid based on how well they use a specific opportunity, and on the capacities of stakeholders to carry out such an intervention. The workshops resulted with the decision of stakeholders to continue pursuing TPA Food and Bioeconomy as two separate TPAs: TPA Sustainable Food Production and Processing and TPA Sustainable Wood Production and Processing. The workshops generated separate policy notes for each TPA and a Memo on policy instruments to be used in S3 for entrepreneurial discovery and building the transformational roadmap (Foray, Eichler, & Keller 2021a). The report "The Smart Specialization Strategy of Croatia: TPAs and STPAs – Ready for EDP?" (Foray, Eichler and Keller 2021b) assessed TPAs in terms of their feasibility as strategic priority areas for an impact-oriented entrepreneurial discovery process and suggested potential roadmaps for strategic orientation of each TPA. These outputs have been prepared with the support of the World Bank based on inputs provided in the workshops. Although the updated S3 incorporates feedback from the latest round of the entrepreneurial discovery workshops, it is understood that the S3 allows for course corrections throughout implementation. Therefore, Thematic Innovation Councils are expected to continue working on their transformational roadmaps and update them regularly in the period to come.

In parallel consultations, an additional TPA referring to information and communication technologies (ICT) emerged in S3 2029. Upon engaging the Thematic Innovation Councils for refinement of the existing TPAs, policy makers organized a survey among Croatian ICT stakeholders, with purpose of shaping an additional TPA in S3 2029 that would concern digital products and technologies. Based on inputs collected, the TPA Digital Products and Platforms was included in the S3 2029.

6.3 Implementation governance

The S3 instruments are managed by a multilayered structure of institutions managing ESIF and other funding sources, and the complexity of the system in place might impede efficiency. The majority of S3 instruments are funded through ESIF and managed by multiple institutions covering different phases of the program cycle. Functional and Governance Analysis (World Bank, 2020) and Analysis of Design and Implementation of Croatian S3 Governance (World Bank 2021a) argue that the multilayered system in place create coordination challenges among institutions. Certain phases of the program cycle, such as project selection, are done with parallel involvement of multiple institutions which might prolong process execution. Furthermore, non-ESIF programs are managed by different governance systems, adding more complexity to the setup in place and resulting in various M&E challenges on the overall policy level.

Midterm evaluation suggested options for streamlining implementation governance and organizing the policy implementation agenda around the stages of the innovation life cycle. The Analysis of Design and Implementation of Croatian S3 Governance (World Bank 2021a) argues that, in a system with a non-sectoral Managing Authority, the Managing Authority should focus primarily on ensuring procedural compliance of the Operational Program operations with national and EU regulations and harmonizing such procedures across different implementation areas, whereas sectoral policy authorities should lead in shaping the objectives and instruments of the support programs. An alternative could be more Operational Programs managed directly by the sectoral authorities, which might enable more flexibility and allow for customizing the program design and selection criteria instead of having a one-size-fits-all solution for different policy areas. Furthermore, the same report suggested a clearer organization of the policy authority based on the stages of the innovation life cycle, with MSE programs focusing on lower technology readiness levels (TRLs) and pre-commercial research, as well as facilitating the transition of public research organizations toward market-oriented projects and collaboration with the business sector, and the MESD managing highest TRL development activities and support for innovation capacities.

The midterm evaluation report provided further recommendations to enhance efficiency by reducing fragmentation in key implementation processes, modifying procedures, and reducing administrative requirements of program applicants. The report suggests reconsidering the roles and sequencing of steps in the grant award process to increase its efficiency. The least efficient solution appears to be switching back and forth between the institutions in the selection phases. Policy makers should also consider replacing the three-level structure with a two-tier system of institutions managing the project selection process, and defining a separate set of rules and procedures that would apply to RDI support instruments. Finally, the report argues that, for efficiency purposes, administrative requirements for program application should be minimized where possible (World Bank 2021a). The main recommendations regarding implementation governance, and the progress made, are noted in Table 6.3.

Table 6.3 Summary of the progress on recommendations from the S3 midterm evaluation concerning implementation governance

RECOMMENDATION	PROGRESS
3a: Streamline implementation governance	**In progress.** Although there are still multiple institutions involved in launching and implementing the calls, their roles are clearer and more streamlined, and the independence of the MSE as the sectoral authority in the program design is stronger. The MSE also plans to expand their capacities for applicant support.
3b: Organize the policy implementation agenda around the stages of the innovation life cycle	**Complete.** Under the S3 2029 policy mix, the MSE and the MESD cover the policy mix according to TRLs, with the former covering the earlier, and the latter covering the later stages of the innovation life cycle.
3c: Reduce fragmentation in key implementation processes	**In progress.** Although there are still multiple institutions involved in launching and implementing the calls, their roles are clearer and more streamlined, and the independence of the Ministry as the sectoral authority in the program design is stronger. The Ministry also plans to expand their capacities for applicant support.
3d: Introduce regulatory guillotine and tailor-made procedures for RDI projects	**In progress.** The MSE has reduced administrative and documentary requirements in calls for proposals (i.e., documentation required to be submitted as part of project proposal).

Source: Staff elaboration based on Analysis of Design and Implementation of Croatian S3 Governance (World Bank 2021a) and S3 2029.

Although the ESIF management structure remains unchanged, additional funding sources exhibit some streamlining of the program management structures. The ESIF system consists of three tiers: Managing Authority, Intermediate Bodies Level 1 (among which MSE and MESD), and Intermediate Bodies Level 2. However, the National Recovery and Resilience Program (NRRP) emerged as an additional funding source with a separate governance structure. This structure features a more streamlined two-tier level of implementation governance in the project selection process and a more independent engagement of sectoral authorities in all program management stages. This should not only facilitate implementation, but improve M&E and course correcting and ensure funding is directed effectively and disbursed efficiently. Furthermore, national budgetary funding is being planned for additional RDI instruments. It is likely that these too will be directly managed by the ministries and implemented independently or delegated to institutions such as the CSF.

Regarding the project selection phase, the MSE introduced certain organizational and administrative changes aiming to enhance efficiency of the process. More precisely, the Ministry has invested efforts in reducing the documentation needed to apply to the programs. This includes, for example, excluding the publicly available documents from requirements of the application pack. Moreover, for a part of the programs funded by the NRRP, the Ministry will execute the whole selection process, covering all phases of administrative and eligibility checks of applicants and their proposed projects and the quality assessment process.

However, the overall architecture of the application and selection process remains highly bureaucratic due to lack of flexibility in the design of the processes. Implementing bodies have limited influence over the general design of the application and selection process and there is little flexibility embedded in the regulations. Unless there is an agreement to provide more flexibility to implementing bodies around the design of application and selection processes, they will likely continue to be burdensome and highly bureaucratic to applicants.

Part 3

Conclusions and recommendations

7 Conclusions and recommendations

Conclusions and recommendations

In recent years, Croatian policymakers have been actively exploring ways to make public spending on science, technology, and innovation more effective. The performance of the country's research sector has been below expectations, with insufficient investments in R&D and limited progress in innovation. However, since joining the European Union, there has been a significant increase in the amount of public funds available for research and innovation. The S3 2016-20 was a significant funding initiative that provided access to the largest amount of funding for RDI projects in Croatia's history. The funding was made available through a range of instruments with the goal of improving knowledge and innovation capabilities to enhance economic competitiveness. This section summarizes the conclusions and proposes recommendations to address some emerging challenges in the upcoming strategy cycle.

7.1 Analysis of selected S3 instruments

The analysis of selected S3 interventions in Croatia shows promising early results. Although researchers remain focused on publication outcomes, they also appear to be making promising steps toward intellectual property protection. Among researchers, although sample size is an issue, the positive effects of two programs supporting applied and market-oriented research (SIIF and STRIP) increased patent applications. Researchers and firms both tend to develop collaborations within their sectors but not with each other. Researchers collaborate more with other researchers and research organizations, firms collaborate more with other firms, and there is little cross-pollination between them. Programs supporting firms overall have positively affected intangible assets, though spillover effects remain ambiguous. Programs positively impact intangible assets (a proxy for innovation), revenues, cost of goods sold, operational effects, and number of employees, with varying but economically relevant magnitudes across specifications. For example, although the effect on revenues has been positive, the programs also appear to have had a short-term impact on increasing operating expenses, costs of goods sold, and number of employees.

These results should be interpreted cautiously, considering the small sample size in certain programs and the considerable time needed for innovation outcomes to emerge. The sample sizes for the SIIF and STRIP programs are very small; therefore, a strict interpretation of the estimated parameters is not advisable. Further, innovation outcomes typically take a long time to materialize. Finally, some programs are technically still under implementation, and the estimated impacts at this stage may not be the final ones.

Analysis of research excellence and collaboration outcomes

Based on early results, the MSE seems to have been justified in setting a clearer distinction between research excellence and applied research and market-oriented outcomes in recent programs. Programs like SIIF and STRIP seem to have succeeded in spurring intellectual property protection efforts. This result is understandable, given the orientation of the programs on the needs of the economy (SIIF) and collaboration (STRIP). However, their impact on scientific outcomes has been less clear. Although this is a preliminary result and may change over time, it may suggest that similar programs should consider publications as secondary outcomes. The MSE has already added several new programs to its portfolio targeting research commercialization, and its theories of change typically do not include outcomes related to publications.[24] The lesson from the impact evaluation is that, when dealing with programs supporting applied and market-oriented research, the program monitoring frameworks should focus more on technology-transfer-based outcomes. Conversely, programs encouraging research excellence outcomes, such as quantity and quality of publications, should concentrate on excellence criteria rather than bundling them with market relevance.

Both MSE and MESD should invest more in supporting industry-science collaboration. Efforts to establish more intense connections between researchers and firms should be intensified. The MSE is already investing in several programs to support industry-science collaboration, such as the Targeted Scientific Research Program, Internships in the Economy, and similar. However, these programs require established collaborations. They should be complemented with programs to initiate collaborations. A pilot program for matchmaking between researchers and firms, supported by the World Bank, is underway. Other instruments that could be considered include innovation vouchers.

Analysis of firms' outcomes

Policymakers should carefully monitor the effect of grants on the operational efficiency of supported firms. Early indications are that grants to firms may increase operating costs at a higher rate than revenues. This may be an initial consequence of the grants providing financing to expand firm operations, thus increasing costs without necessarily having an immediate effect on revenues. Nevertheless, the long-term effects should be closely monitored to ensure that firms' operational efficiency does not decline.

Policymakers should create programs that are more accessible to all beneficiaries, but especially small and young firms. Some data suggests that firms with more resources had a better chance of receiving funding. In some cases, program design explicitly favors

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24 So far, publication outcomes are included in three programs (Researcher Mobility, Tenure Track, and Targeted Scientific Research).

incumbent firms by strongly emphasizing implementation capacities in the selection criteria. In other cases, the overall effort required to prepare the application and collect the necessary documentation strains the resources of smaller and younger firms. Policymakers should also have programs in their portfolios that are accessible to smaller and younger firms, with appropriate selection criteria for their capacity levels and simplified application and selection processes.

Conducting future impact evaluations

The impact evaluation presented in this report was one that was possible under the given time and data constraints, but it is not a substitute for more rigorous prospective methods. The lack of a randomized design limits the scope of questions that can be answered through the evaluation. Generally, ex-post impact evaluations such as that presented in this report rely on a number of assumptions (for example, DiD estimation requires that the difference in treatment and control groups is constant over time). The challenge is further exacerbated by inadequate data collection from the start and limited data sharing. The attempt to gather data through a survey instrument was not very successful. Hence, the evidence provided through the survey instrument has significant limitations. Using randomized control trials (RCTs) can overcome some of those challenges and help policymakers gain more insights into what interventions work, why and for whom (see Box 7.1).

Box 7.1 Using randomized controlled trials to evaluate policy effectiveness

RCTs are experiments that randomly assign an intervention (for example, funding) to participants to examine whether the intervention affected certain outcomes of interest. A crucial aspect of RCTs is that the assignment of the intervention must be random, because in that case any difference between average outcomes in the group that receive the policy intervention (the treatment group) and the group that do not receive it (the control unit) must be due to the intervention. The benefits of RCTs include elimination of selection bias, minimization of misleading results, and clarity in terms of the effectiveness of the intervention.

However, in the context of public funding, RCTs can be very challenging to implement, especially when the funding is subject to regulations which prescribe the manner of allocation of funds. For example, public funding for research and innovation in Croatia is highly regulated and leaves no room for random assignment. Furthermore, in the context of R&D grants, peer review is a generally accepted step of the selection process and there is concern over the acceptance of random assignment by interested stakeholders.

Some of these issues could be overcome with dedicated external funding for conducting RCTs. Another option could be partial randomization, that is, implementing randomization at some stage of the selection process. For example, some researchers have been suggesting that the award of R&D grants could be randomized after the peer review process, when peer review has reached its limits and all projects appear to be "equally good" (Bedessem 2020; Woods and Wilsdon 2021). In fact, some institutions such as the Swiss National Science Foundation, Austrian Research Council, and Health Research Council of New Zealand have introduced partial randomization in some of their programs at a small scale, with generally positive or neutral feedback from applicants (Bendiscioli, et al. 2022).

Policymakers should start collecting more and better-quality data, which will allow for more in-depth analysis to help improve program targeting and policy delivery. The quantity and quality of data provided did not allow for distinguishing between several potential mechanisms at play. As such, the analysis does not provide insights into improving the targeting and delivery of these policies. Since there are many types of applicants, collecting more data on their characteristics would allow for assessing the impact of programs on different subgroups of beneficiaries. This would help policymakers maximize the effectiveness of funding by targeting particular groups based on past evidence of higher returns. This targeted approach could lead to better outcomes with limited resources for future programs. To estimate the individual treatment effects of grants on innovation activities in different subgroups of firms and researchers, policymakers should consider using machine learning algorithms. These can help automate and rigorously identify subgroups of interest for investigation and provide more accurate estimates of treatment effects. Leveraging data-driven decision trees and forests (Athey and Imbens 2019; Lechner 2018; Wager and Athey 2018) can identify the most promising approach for this part of the analysis. Implementing this method may yield exciting insights into how treatment effects vary across different subgroups and inform future policy targeting to maximize returns. The MSE has already taken significant steps to build up the quality of data for future evaluations, including by introducing baseline surveys in their calls for proposals and working on building a comprehensive data collection and monitoring system.

The long-term effects of programs on innovation activities can only be captured by collecting data over a longer period. Doing so will enable the analysis to capture any potential long-term effects of the programs on innovation activities and provide a more nuanced understanding of their impact. It would be crucial to perform a later evaluation after the programs have ended for a reasonable period; the innovation process is potentially rather slow, and it is unlikely that we have captured the full effects at the time of writing. Support programs should incorporate a formal evaluation design, and data collection from the beginning of program implementation would enable a more informed and credible approach than the cumbersome path we had to follow in this study.

All institutions involved in the design, implementation, and oversight of innovation support programs need to define a clear protocol allowing the use of confidential data for impact evaluation purposes. A high-quality impact evaluation requires sufficient and detailed data. Research teams engaged on future evaluations should receive access to data from application forms, supporting documentation, and scoring results for all projects.

That the data may be used for impact evaluation purposes can be clearly stated in each call for proposals. Authorities may ask applicants to sign a consent statement to agree to data processing and to being contacted for future surveys. Box 7.2 provides proposed language that could be used to obtain consent for program evaluation purposes. MSE has already introduced this practice in their calls for proposals published under the National Recovery and Resilience Plan. The MESD, MRDEUF, CSF, HAMAG-BICRO, and others can easily replicate this approach. Research team members may sign non-disclosure agreements for an additional layer of security.

Box 7.2 Proposed language on consent to data use for program evaluation purposes

By applying to this call, the applicant *[and the partner]* consent to the use of the entire application documentation and data from the assessment of project proposals for program impact evaluation, regardless of whether the applicant [and the partner] will receive support or not. Access to the data will enable the impact evaluation to be carried out based on a comparison between the treatment and the control group, which includes funded and unfunded applicants. Consent is given by signing statements *[Insert Form Name]*.

When submitting the application form, applicants must complete a baseline survey via the link available *[Insert link location, e.g., Annex, section, etc.]*, which will collect data on the applicant's past achievements related to research and innovation activities and technology transfer. The responses collected by the survey will be used to evaluate the program's impact.

If the competent authorities decide to evaluate the program after completion and in the years after the implementation of the projects, surveys will be conducted to collect data on the results achieved by applicants and partners in relation to the situation reported when submitting the project. By applying to this call, the applicant and the partner undertake to participate in additional surveys, if the competent authorities decide to conduct them, and consent to the use of the collected data to evaluate the impact, regardless of whether they have received support. The competent authority will ensure that future surveys are not an administrative burden for respondents. Consent is given by signing the statement *[Insert Form Name]*.

7.2 S3 monitoring

Certain indicators and targets would benefit from clearer definitions and uniform measurement practices, which have, to some extent, been resolved in the revised M&E framework. Although the revised M&E framework significantly improves indicator definition and measurement, some indicators are still tracked using different practices across institutions and indicators. For example, some indicators tracking enterprises and projects supported record progress upon awarding the grants, whereas others record it upon completion of the supported projects. It would help streamline the M&E processes if connected and similar indicators applied consistent rules and definitions.

Policy makers should institute a clear and transparent process for updating the S3 regularly, including revising the monitoring framework when appropriate. According to data in section 5, a significant share of targets either significantly under- or overperformed, which was in many cases clear already during midterm evaluation. These misses may indicate that the original targets were not set appropriately and should have been reexamined and potentially updated. In some cases, the measurement methodology for certain indicators changed during instrument implementation, but the targets were not modified appropriately. This lapse resulted in a severe mismatch in the recorded value vis-à-vis the original target. Targets should be reexamined and revised when appropriate, for example, following any (and especially major) budget or policy mix revisions and when original targets appear mismatched with performance during implementation.

7.3 S3 governance

The implementation governance system should create more flexibility for implementing bodies to simplify the design of application and selection processes. Despite improvements in the functioning of implementation governance in the NRRP, many administrative obstacles remain. The design of the application process and the main parameters of the selection process are centrally determined and are the same for all types of EU-funded projects. This over-centralization will likely continue to create administrative and bureaucratic burdens for applicants. Implementing bodies should have more flexibility in designing the calls for proposals, application forms, and selection processes.

The implementation of the new S3 2029 should be expedited to kickstart a more effective governance system. The new S3 2029 was adopted in December 2023. The proposed changes (including the main governance challenges identified in the midterm evaluation, particularly those referring to the role of the NIC and the overall policy governance structure) are yet to be implemented. Because the activity of the NIC has been limited in recent years, it remains to be seen how the revised structure will perform once formally instated by the new S3.

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Annexes

Annex 1 Initial list of outcomes in the research proposal

Table I-1 Outcomes of interest for the evaluation

CATEGORY	OUTCOME	DEFINITION	MEASUREMENT LEVEL /SOURCE	TIME/ FREQUENCY
RESEARCHERS' PERFORMANCE	Project completion	Whether the project submitted has been completed	Survey	Regular intervals
	Publications	Number and quality-adjusted publications	Publicly available data	Rolling basis
	Networks of collaboration	Size and quality of the collaboration networks	Publicly available data and Survey	Rolling basis
	Patents	Number of patents applied for and granted	Publicly available data and Survey	Rolling basis
	Employment: Including young Researchers PhD students, Research staff	Number of research staff	Admin records, publicly available data, and surveys	Rolling basis
	Mentoring and success measures for mentees	Placement and publication of mentees	Survey	Rolling basis
	Researchers' outcomes	Career progress, conferences, and workshops participation	Publicly Available Data and Surveys	Rolling basis
	Marketable products and processes and innovation	Product and processes innovation and technology transfer	Survey	Regular intervals
	Subsequent grants	Further grants in related areas	Survey	Regular intervals

CATEGORY	OUTCOME	DEFINITION	MEASUREMENT LEVEL /SOURCE	TIME/ FREQUENCY
FIRMS' PERFORMANCE	Project completion	Whether the project submitted has been completed	Survey	Regular intervals
	Expenditure in R&D	Amount spent in R&D	Survey and admin	Different intervals
	Sales and Profits	Firms sales	Admin and survey records	Rolling basis
	Employment	Firms R&D and total employment	Admin and survey records	Rolling basis
	Patents	Number of patents applied for and granted	Publicly available data	Rolling basis
	New product/ services/process	Including green/ sustainable innovations	Survey	Rolling basis
	Certifications	Product and process quality certifications, including green and sustainable	Survey	Regular intervals
	Market access national and export	New market access including exports	Survey and administrative data	Different intervals

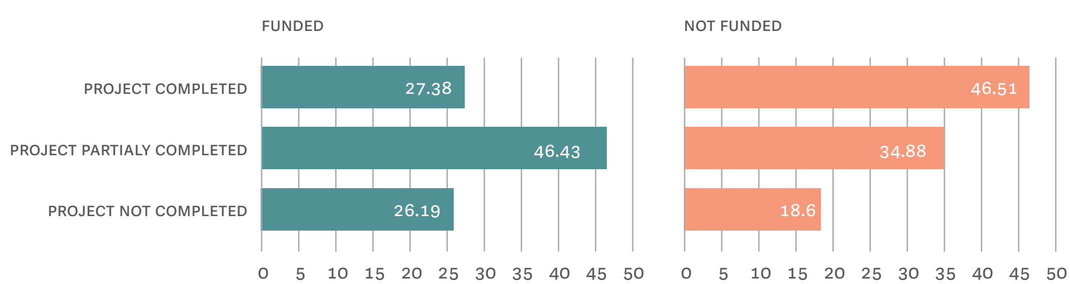
Annex 2 Survey data analysis: funded vs. non-funded applicants

Considering the constraints of a limited sample size, the survey data have been primarily subject to descriptive analysis. Descriptive analysis, the main analytical tool for survey data analysis, is less rigorous but provides a comprehensive understanding of the project execution. Although the analysis based on the survey data may not be as reliable as that derived from administrative sources, it offers context and uncovers information that is not accessible through administrative data alone. This is especially true when delving into the intricacies of project execution and examining the resulting outcomes. Using this supplementary data, we gain a more comprehensive understanding of the broader landscape surrounding these projects.

The low survey response rate should be interpreted the context of sample demographics characterized by a large number of inactive, sleeping, and micro entities which are typically unwilling to participate in surveys. As discussed in section 2.4, about one-fifth of the initial sample are inactive firms or firms that demonstrate no activity which makes their responsiveness to surveys such as ours low. A further group worth considering are firms with zero or one employee and with annual revenues below the lump sum income tax threshold. Such firms are characterized by limited activity and resources. This puts about one-third of the initial sample in the category with low probability of response but also shows the profile of applicants to different public funding instruments. Finally, about half of the sample are respondents with 10 or fewer employees, micro firms that were historically found to demonstrate low participation in surveys as the one in question (see for example evidence from the Business Environment and Enterprise Performance-BEEPS survey rounds). The analysis in this Annex shows results for both researchers and firms.

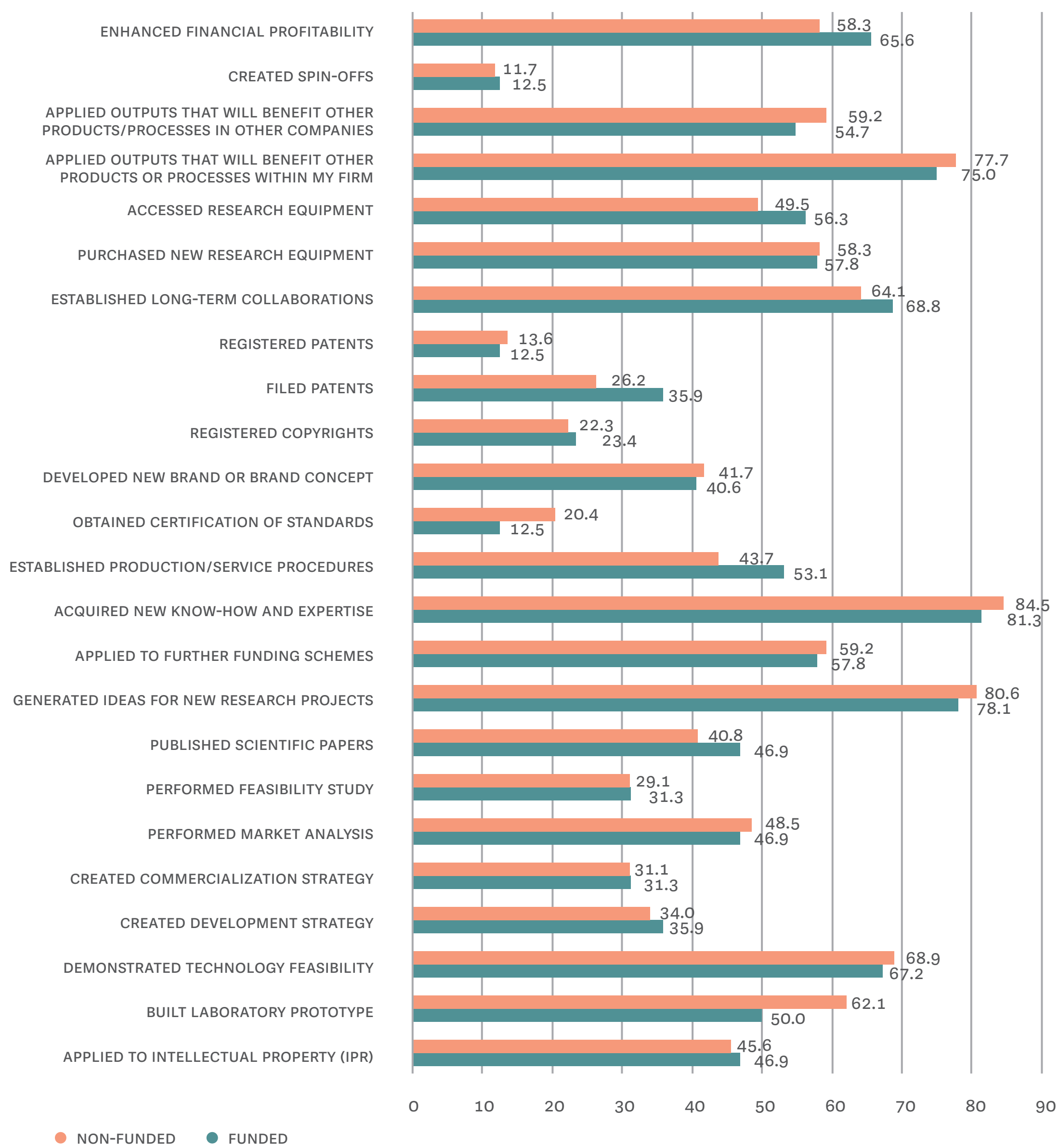
A relatively high proportion of respondents completed their project despite not receiving funding. Among funded projects, 74 percent of respondents fully or partially completed their project compared to 81 percent among non-funded projects. (Figure II-1).

Figure II-1 Non-funded projects have higher completion rate



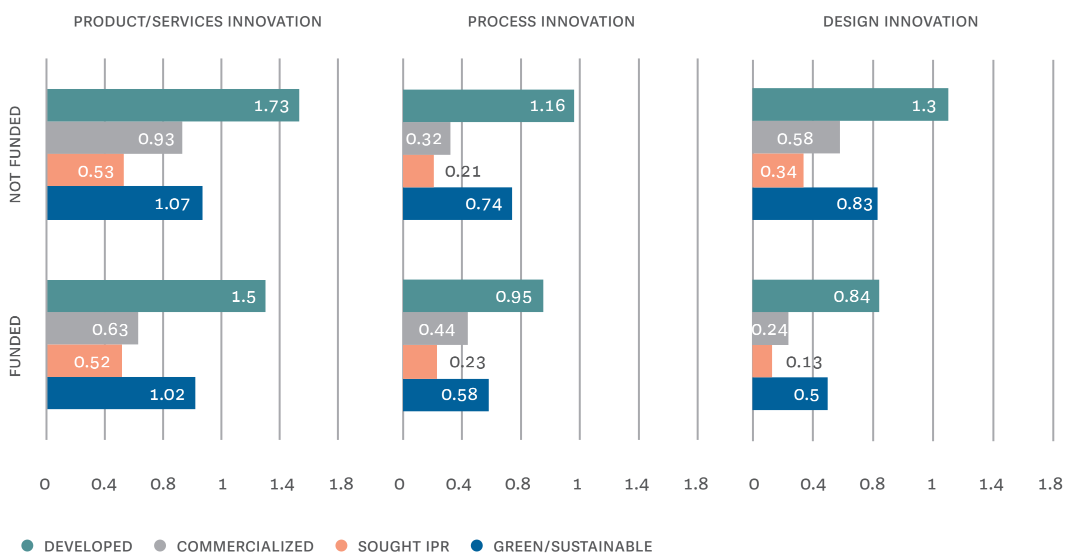
The most commonly reported project outcomes include new know-how, expertise, and ideas for new research projects. The overwhelming majority of entities (over 80 percent of surveyed institutions) reports their project results in new know-how, expertise and ideas for new project (Figure II-2). At the same time, a relatively small percentage of projects (between 10 and 20 percent) result in registering patents or obtaining certification of standards. In most cases, the share of projects reporting certain outcomes is similar across both funded and non-funded projects. The only exception are two outcomes (built laboratory prototype and obtained certification of standard), which are more often reported among the non-funded firms.

Figure II-2 New know-how, expertise, and ideas for new research projects are the most commonly reported project outcomes



The differences in product and service innovation are small between funded and non-funded applicants, and somewhat in favor of non-funded applicants. Projects that are not funded tend to generate a higher number of product, process, and design innovations, on average, compared to their funded counterparts (Figure II-3). For example, non-funded applicants report on average 1.7 new products/services vs. 1.5 for funded applicants. The difference is more pronounced in design innovation, where non-funded entities report an average of 50 percent more innovative output than funded companies. Furthermore, both funded and non-funded projects reveal that environmental sustainability of innovation is high up the agenda. A larger share of innovations developed by funded types of entities is green/sustainable.

Figure II-3 Product, Service, and Design Innovations

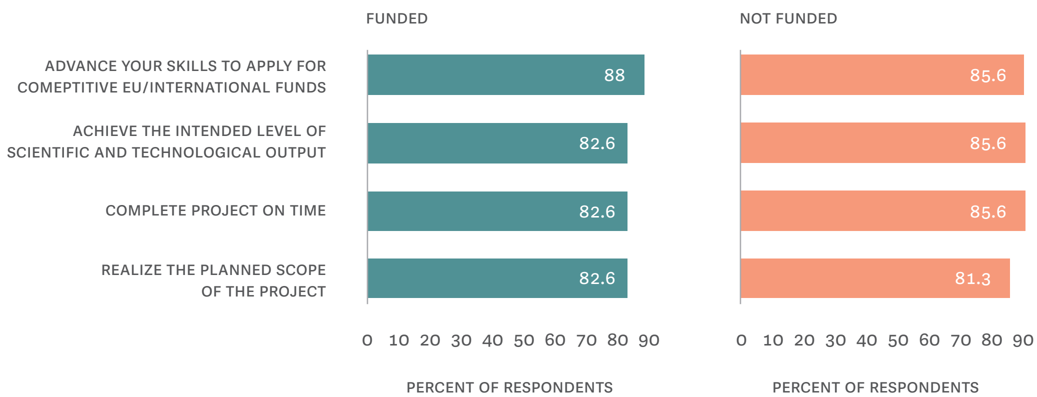


Funded entities focus more on commercialization of innovation, but only a small fraction of them seeks IPR. In terms of commercialization, a greater proportion of funded projects succeeded in introducing product and process innovations to market, with over 40 percent of innovation being commercialized, in contrast to the nearly 30 percent reported by non-funded entities. However, the landscape shifts when it comes to design innovation. Non-funded firms are forerunners in placing their designs in the market, achieving a commercialization rate of almost 45 percent, whereas only 28 percent of funded designs make it to market. Notably, 43 percent of non-funded companies, as opposed to 24 percent of funded companies, report selling any of the project results. Collectively, these results suggest that, when it comes to commercialization, funded entities remain focused on the program core, i.e., innovative output. Interestingly, only a small fraction of entities seeks IPR for their innovations. Roughly one-third of developed product innovations have sought IPR, whereas the proportion is considerably smaller for process and design innovations.

Projects without funding tend to employ a slightly higher average number of new staff members for project execution (5.9 compared to 5.4 newly hired personnel). Simultaneously, variation in the number of new hires is larger among funded entities. The gender structure of new employees is in favor of funded projects, employing more women and R&D personnel than the non-funded projects. Fifty percent of newly employed staff for funded projects are women in contrast to 37 percent employed for non-funded projects. Funded projects hired predominantly in R&D (72 percent of newly hired for funded projects compared to 50 percent for non-funded projects).

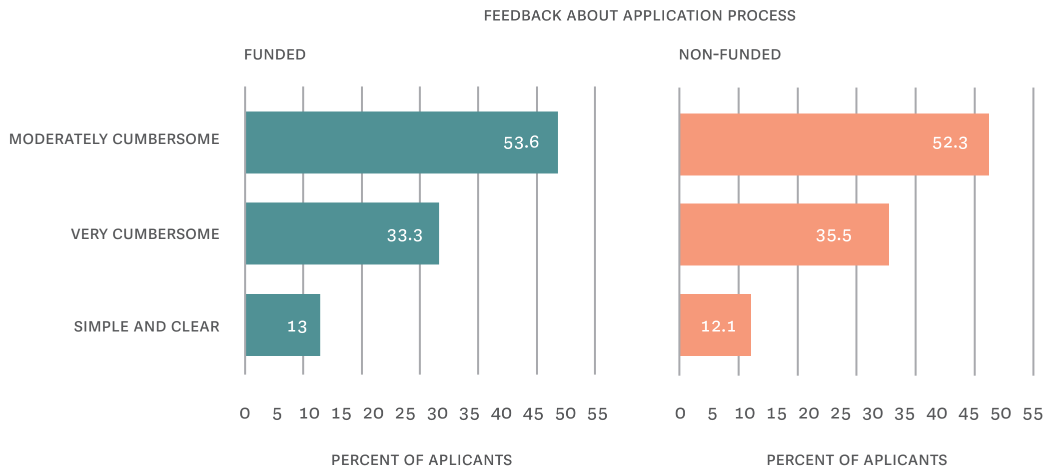
Both funded and non-funded applicants acknowledge the project's benefits. Most respondents (almost 90 percent) agree that the project has enhanced their abilities to pursue competitive EU or international funding. Furthermore, over 80 percent of respondents stated that they achieved the intended level of scientific and technological output as well as the planned scope of the project (Figure II-4).

Figure II-4 The majority of surveyed applicants responded positively regarding the project achievements

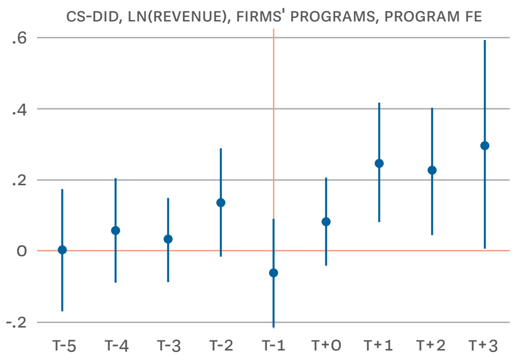


Applicants found the application process to be cumbersome. The vast majority of applicants found the application process moderately to very cumbersome. Dissatisfaction with the bureaucracy of the application process is equally present among over 85 percent of both funded and non-funded applicants (Figure II-5). This feedback corroborates program weaknesses identified in earlier analyses (e.g., World Bank 2020, World Bank 2021), where bureaucratized selection has been recognized as a systematic weakness across all programs. Similarly, the anecdotally collected comments from those unwilling to participate in survey also reveal dissatisfaction with organization of funds allocation procedures as one of determinants of willingness to participate.

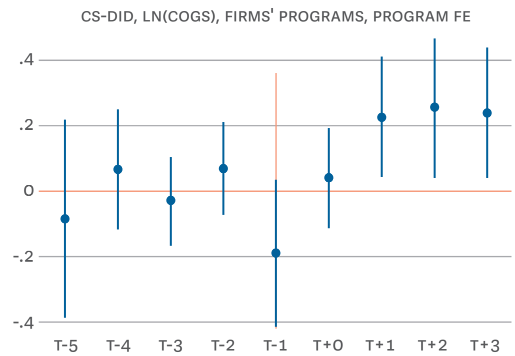
Figure II-5 The application process is perceived to be cumbersome



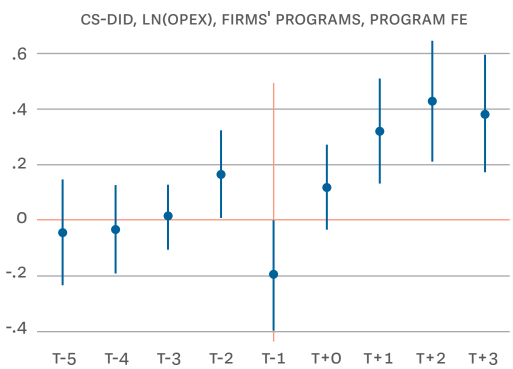
Annex 3 Impact estimation of firm outcomes controlling for fixed effects



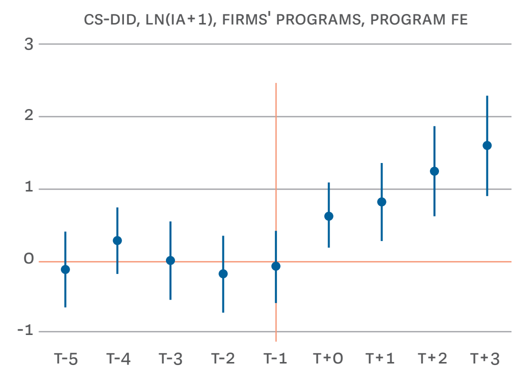
(A) LOG REVENUES



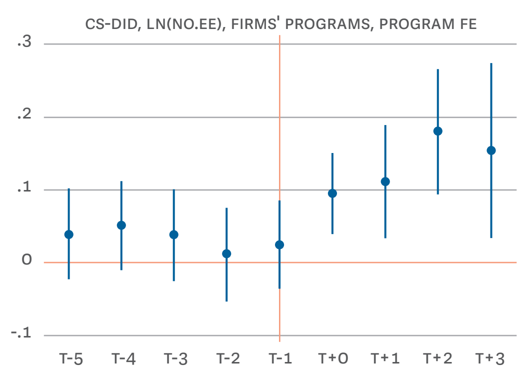
(B) LOG COGS



(C) LOG OPERATING EXPENSES



(D) LOG (INTANGIBLE ASSETS+1)



(E) LOG # EMPLOYEES

Note: Point estimates (circles) and 95 percent confidence intervals (vertical error bar). The pre-program periods are up to T−1. Variables with confidence intervals that do not cross zero are considered statistically significant at 5 percent level of significance.

Source: Staff elaboration.

Annex 4 Achieved S3 indicator values

This Annex presents the complete consolidated data on all outputs and outcomes collected in the revised S3 monitoring framework. Whereas section 7.2 presented the achievements of key S3 indicators according to the revised monitoring framework, tables IV-1 and IV-2 present all values collected from the program managers. Although the data received was at the instrument level, this Annex presents consolidated data, with reference to the instruments contributing to the achievements shown.

Table IV-1 Consolidated data on achieved outputs tracked through the revised S3 M&E Framework, September 2023

INDICATOR (OUTPUT)	TOTAL	TPA 1	TPA 2	TPA 3	TPA 4	TPA 5	POLICY INSTRUMENTS CONTRIBUTING TO INDICATOR ACHIEVEMENT
Number of RDI infrastructural projects	30	10.37	10.67	1.95	2.09	4.90	(1) infrastructure projects (Center for advanced laser techniques (CALT); Children Center for Translational Medicine at the Children's Hospital Srebrnjak; Croatian Scientific and Educational Cloud (HR-ZOO); Open scientific infrastructural platforms for innovative applications in economy and society – O-ZIP) (2) Investment into organizational reform and infrastructure of RDI sector (3) Development and strengthening synergies with HORIZON 2020 horizontal activities: Twinning and ERA chairs
Number of researchers working in improved research infrastructure facilities	1,017.50	472.67	340.79	62.76	37.98	103.31	
Number of National Centers of Research Excellence (CoRE) projects supported	10	5	1,58	0,5	1	1,92	CoRE performing excellent science
Number of researchers who participated in the work of supported CoRE	791	418	109.25	28.17	85.50	150.08	
Number of joint research projects supported	11	n/a	n/a	n/a	n/a	n/a	Croatian-Swiss Research Programme 2017 – 2023 (CSRP)

INDICATOR (OUTPUT)	TOTAL	TPA 1	TPA 2	TPA 3	TPA 4	TPA 5	POLICY INSTRUMENTS CONTRIBUTING TO INDICATOR ACHIEVEMENT
Number of new researchers in supported entities	333	27	0	21	13	10	(1) Croatian-Swiss Research Programme 2017 – 2023 (CSRP) (2) Installation research projects of Croatian Science Foundation (3) Program for enhancing R&D climate change activities (4) Young Researchers' Career Development Program (5) Supporting development of Centers of Competence (6) EUREKA and EUROSTARS
Number of supported Teaming, Twinning, and ERA Chair projects	6	1	1.83	0.33	0.83	2	(1) Development and strengthening synergies with HORIZON 2020 horizontal activities: Teaming (2) Development and strengthening synergies with HORIZON 2020 horizontal activities: Twinning and ERA chairs
RDI infrastructural projects prepared	17	6.54	3.65	2.02	1.34	3.45	Preparation of RDI infrastructural projects
Number of research projects supported	453	n/a	n/a	n/a	n/a	n/a	(1) Program for enhancing R&D climate change activities (2) Research projects of Croatian Science Foundation

INDICATOR (OUTPUT)	TOTAL	TPA 1	TPA 2	TPA 3	TPA 4	TPA 5	POLICY INSTRUMENTS CONTRIBUTING TO INDICATOR ACHIEVEMENT
Number of (laboratory) prototypes resulting from Proof of Concept projects	156	24	32	15	9	8	Proof of Concept (public and private)
Number of commercialization strategies resulting from Proof of Concept projects	51	8	11	5	1	1	
Number of demonstrations of technical feasibility resulting from Proof of Concept projects	155	24	31	11	9	8	
Number of market analyses	59	10	18	5	3	4	
Technical success of projects (concept proven or not)	114	19	24	7	4	6	
Number of FTE researchers engaged in PROs	n/a	n/a	n/a	n/a	n/a	n/a	(1) Science and Innovation Investment Fund (SIIF) (2) Strengthening capacities for research, development and innovation (STRIP)
Number of R&D projects conducted by research organizations	20	4.50	6.50	0.33	0.33	8.33	Science and Innovation Investment Fund (SIIF)
Number of supported doctoral students	346	n/a	n/a	n/a	n/a	n/a	Young Researchers' Career Development Program

INDICATOR (OUTPUT)	TOTAL	TPA 1	TPA 2	TPA 3	TPA 4	TPA 5	POLICY INSTRUMENTS CONTRIBUTING TO INDICATOR ACHIEVEMENT
Legal framework for collection and management of RDI data in research organizations developed	1	n/a	n/a	n/a	n/a	n/a	Strategic Project Science and Technology Foresight
Reports and common vision (foresight) developed	1	n/a	n/a	n/a	n/a	n/a	
Visualized maps of defined research disciplines and technology areas	n/a	n/a	n/a	n/a	n/a	n/a	
Web-based user interface for input, management, and analysis of data developed and operational	1	n/a	n/a	n/a	n/a	n/a	
Number of enterprises cooperating with research organizations	341	55.43	120.92	75.58	36.95	34.12	(1) Strengthening capacities for research, development and innovation (STRIP) (2) Research infrastructure usage and researchers' services for SMEs (IRCRO) (3) Supporting development of Centers of Competence (4) Support to development of new products/services resulting from R&D activities (Phases I and II)
Number of supported collaborative projects of the scientific research and business sector	210	28	76	38	28	22	
Number of FTE researchers engaged in private companies	n/a	n/a	n/a	n/a	n/a	n/a	Strengthening capacities for research, development and innovation (STRIP)

INDICATOR (OUTPUT)	TOTAL	TPA 1	TPA 2	TPA 3	TPA 4	TPA 5	POLICY INSTRUMENTS CONTRIBUTING TO INDICATOR ACHIEVEMENT
Private investment matching public support in innovation or R&D projects (EUR million)	205.28	30.03	40.68	71.10	18.47	17.82	(1) Strengthening capacities for research, development and innovation (STRIP) (2) Research infrastructure usage and researchers' services for SMEs (IRCRO) (3) Supporting development of Centers of Competence (4) Innovation Support programs for SMEs (Commercialization of Innovation in Entrepreneurship, Innovation Vouchers, Innovations in S3 areas, Innovations of newly established SMEs (Phases I and II), Integrator) (5) EUREKA and EUROSTARS (6) Proof of Concept (private) (7) Support for RDI activities of SMEs (RAZUM) (8) Support to development of new products/services resulting from R&D activities (Phases I and II)
Share of companies that are newcomers to support RDI schemes (%)	82.75	16.18	36.24	23.25	15.32	9.01	
Number of enterprises supported to introduce new-to-firm products	856	72	170	116	79	55	
Number of enterprises receiving non-financial support	306	n/a	n/a	n/a	n/a	n/a	(1) Strategic Project for Establishment of Innovation Network for Industry and Thematic Innovation Councils (2) Strategic project to support the Cluster Competitiveness Initiatives

INDICATOR (OUTPUT)	TOTAL	TPA 1	TPA 2	TPA 3	TPA 4	TPA 5	POLICY INSTRUMENTS CONTRIBUTING TO INDICATOR ACHIEVEMENT
Innovation web platform established	1	n/a	n/a	n/a	n/a	n/a	Strategic Project for Establishment of Innovation Network for Industry and Thematic Innovation Councils
Number of established Thematic Innovation Councils	5	1	1	1	1	1	
Number of prepared thematic strategies for RDI	7	1	1	1	1	2	
Report on mapping of RDI capacities in business sector	1	n/a	n/a	n/a	n/a	n/a	
Number of company-company collaborations within RDI projects	294	22	51	158	29	34	(1) Supporting development of Centers of Competence (2) Support to development of new products/services resulting from R&D activities (Phases I and II)
Number of enterprises implementing KET	198	35	70	33	21	39	
Number of R&D projects supported	91	14	30	25	14	8	
Number of enterprises receiving grants	575	37	69	63	34	19	(1) Supporting development of Centers of Competence (2) Innovation Support programs for SMEs (Commercialization of Innovation in Entrepreneurship, Innovation Vouchers, Innovations in S3 areas, Innovations of newly established SMEs (Phases I and II), Integrator) (3) Support to development of new products/services resulting from R&D activities (Phases I and II)
Number of enterprises receiving support	848	74	169	113	82	55	

INDICATOR (OUTPUT)	TOTAL	TPA 1	TPA 2	TPA 3	TPA 4	TPA 5	POLICY INSTRUMENTS CONTRIBUTING TO INDICATOR ACHIEVEMENT
Number of enterprises supported to introduce new-to-market products	795	72	161	113	76	52	(1) Supporting development of Centers of Competence (2) Innovation Support programs for SMEs (Commercialization of Innovation in Entrepreneurship, Innovation Vouchers, Innovations in S3 areas, Innovations of newly established SMEs (Phases I and II), Integrator) (3) EUREKA and EUROSTARS (4) Support for RDI activities of SMEs (RAZUM) (5) Support to development of new products/services resulting from R&D activities (Phases I and II)
Number of commercialization and technology transfer agreements (signed with industry)	11	n/a	n/a	n/a	n/a	n/a	Transfer of technology from ROs to business sector
Number of new enterprises receiving grants	272	0	4	1	0	1	(1) Innovation Support programs for SMEs (Commercialization of Innovation in Entrepreneurship, Innovation Vouchers, Innovations in S3 areas, Innovations of newly established SMEs (Phases I and II), Integrator) (2) Proof of Concept (private) (3) Support for RDI activities of SMEs (RAZUM)
Share of funded projects per specific starting/ending TRL	n/a	n/a	n/a	n/a	n/a	n/a	Support to development of new products/services resulting from R&D activities (Phases I and II)

INDICATOR (OUTPUT)	TOTAL	TPA 1	TPA 2	TPA 3	TPA 4	TPA 5	POLICY INSTRUMENTS CONTRIBUTING TO INDICATOR ACHIEVEMENT
Number of companies / associations (Competitiveness Clusters) taking part in internationalization initiatives (fairs, exhibitions, trade visits)	29	n/a	n/a	n/a	n/a	n/a	Strategic project to support the Cluster Competitiveness Initiatives
Number of identified potential new brands under sub-thematic priority areas	13	n/a	n/a	n/a	n/a	n/a	
Number of implemented competitiveness cluster initiatives	20	n/a	n/a	n/a	n/a	n/a	
Number of fellowships for training and career development of researchers on doctoral and postdoctoral level	169	n/a	n/a	n/a	n/a	n/a	Career development of young researchers (PhD education)
Development of new forecasting model/ system and model for establishing Human Resources Recording System	0	n/a	n/a	n/a	n/a	n/a	Improving the system of lifelong professional guidance and career development in the Republic of Croatia
Number of new or improved services that support development and implementation	0	n/a	n/a	n/a	n/a	n/a	
Number of occupational standards in line with CROQF developed, based on which new educational programs will be aligned with labor market needs	100	n/a	n/a	n/a	n/a	n/a	Implementing the CROQF and development of tools for connecting education and labor market

INDICATOR (OUTPUT)	TOTAL	TPA 1	TPA 2	TPA 3	TPA 4	TPA 5	POLICY INSTRUMENTS CONTRIBUTING TO INDICATOR ACHIEVEMENT
Number of education programs / qualification standards in line with CROQF developed	222	n/a	n/a	n/a	n/a	n/a	Implementing the CROQF on the higher education level
Number of qualification standards in the CROQF Register based on which new study programs will be aligned with labor market needs	14	n/a	n/a	n/a	n/a	n/a	
Number of Sectoral curricula for vocational education and training based on learning outcomes in targeted sectors developed	1	n/a	n/a	n/a	n/a	n/a	Modernization of vocational education and training programs and raising their quality to increase students' employability and opportunities for further education
Number of students awarded with scholarships	16,881	n/a	n/a	n/a	n/a	n/a	STEM student scholarships

Note: CROQF = Croatian Qualifications Framework; STEM = science, technology, engineering, and mathematics; TPA 1 = Health and Quality of Life; TPA 2 = Energy and Sustainable Environment; TPA 3 = Transport and Mobility; TPA 4 = Security; TPA 5 = Food and Bioeconomy. In some cases, there is a discrepancy between the sum of reported TPA values and the total value. More precisely, the total achieved values in the tables are in some cases higher than the sum of values for the five TPAs. The difference refers to progress not attributed to any of the S3 TPAs. n/a is shown for indicators for which TPA disaggregation is not applicable, or the data is not available.

Source: Authors based on revised S3 monitoring framework and data provided by S3 institutions.

Table IV-2 Consolidated data on achieved outcomes tracked through the revised S3 M&E Framework, September 2023

INDICATOR (OUTCOME)	TOTAL	TPA 1	TPA 2	TPA 3	TPA 4	TPA 5	POLICY INSTRUMENTS CONTRIBUTING TO INDICATOR ACHIEVEMENT
Number of collaborative contracted projects (by beneficiaries in HEIs and PRO) with foreign HEI and PRO institutions	2	n/a	n/a	n/a	n/a	n/a	(1) infrastructure projects (Center for advanced laser techniques (CALT); Children Center for Translational Medicine at the Children's Hospital Srebrnjak; Croatian Scientific and Educational Cloud (HR-ZOO); Open scientific infrastructural platforms for innovative applications in economy and society – O-ZIP) (2) Investment into organizational reform and infrastructure of RDI sector (3) Development and strengthening synergies with HORIZON 2020 horizontal activities: Teaming, Twinning, and ERA chairs (4) CoREs performing excellent science (5) Croatian-Swiss Research Program 2017–2023 (CSRP), Installation Research Projects, and Research Projects (6) Science and Innovation Investment Fund (SIIF) and Strengthening capacities for research, development and innovation (STRIP) (7) Proof of Concept (public)
Number of Scientific publications published in journals indexed in the Web of Science core collection	4,717	1,651.23	1,285.49	551.43	517.67	709.17	

INDICATOR (OUTCOME)	TOTAL	TPA 1	TPA 2	TPA 3	TPA 4	TPA 5	POLICY INSTRUMENTS CONTRIBUTING TO INDICATOR ACHIEVEMENT
Total contracted amount for RDI funding from centralized EU funds (attracted by beneficiaries) (EUR thousand)	15.13	n/a	n/a	n/a	n/a	n/a	(1) infrastructure projects (Center for Advanced Laser Techniques (CALT); Children Center for Translational Medicine at the Children's Hospital Srebrnjak; Croatian Scientific and Educational Cloud (HR-ZOO); Open scientific infrastructural platforms for innovative applications in economy and society – O-Z) (2) Investment into organizational reform and infrastructure of RDI sector (3) Development and strengthening synergies with HORIZON 2020 horizontal activities: Teaming, Twinning, and ERA chairs (4) CoREs performing excellent science (5) Croatian-Swiss Research Program 2017 – 2023 (CSRP), Installation Research Projects, and Research Projects of Croatian Science Foundation (6) Science and Innovation Investment Fund (SIIF) and Strengthening capacities for research, development and innovation (STRIP) (7) Proof of Concept (public) (8) Program for enhancing R&D climate change activities (9) Young Researchers' Career Development Program

INDICATOR (OUTCOME)	TOTAL	TPA 1	TPA 2	TPA 3	TPA 4	TPA 5	POLICY INSTRUMENTS CONTRIBUTING TO INDICATOR ACHIEVEMENT
Total contracted amount for RDI funding from national funds (attracted by beneficiaries) (EUR million)	1.38	n/a	n/a	n/a	n/a	n/a	(1) infrastructure projects (Center for Advanced Laser Techniques (CALT); Children Center for Translational Medicine at the Children's Hospital Srebrnjak; Croatian Scientific and Educational Cloud (HR-ZOO); Open scientific infrastructural platforms for innovative applications in economy and society – O-ZIP) (2) Investment into organizational reform and infrastructure of RDI sector (3) Croatian-Swiss Research Program 2017 – 2023 (CSRP) (4) Science and Innovation Investment Fund (SIIF) and Strengthening capacities for research, development and innovation (STRIP) (5) Proof of Concept (public) (6) Program for enhancing R&D climate change activities
Number of publications in top-ranking international, peer-reviewed first or second-quartile journals with applicant being main or corresponding author in certain scientific area according to the relevant scientific databases	8,079	n/a	n/a	n/a	n/a	n/a	(1) Croatian-Swiss Research Program 2017–2023 (CSRP), Installation Research Projects, and Research Projects of Croatian Science Foundation (2) Program for enhancing R&D climate change activities (3) Young Researchers' Career Development Program
Number of applied research projects implemented/in implementation after the end of funded project	15	n/a	n/a	n/a	n/a	n/a	Proof of Concept (public)

INDICATOR (OUTCOME)	TOTAL	TPA 1	TPA 2	TPA 3	TPA 4	TPA 5	POLICY INSTRUMENTS CONTRIBUTING TO INDICATOR ACHIEVEMENT
Number of collaborative contracted projects between companies and HEIs/PROs after the end of supported projects	31	0	4	3	2	2	(1) Proof of Concept (public) (2) Science and Innovation Investment Fund (SIIF) and Strengthening capacities for research, development and innovation (STRIP) (3) Research infrastructure usage and researchers' services for SMEs (IRCRO) (4) Supporting development of Centers of Competence (5) Support to development of new products/services resulting from R&D activities (Phases I and II) (6) Strategic project to support the Cluster Competitiveness Initiatives
Number of IP protection applications—filed	66	10	8	14	7	4	(1) Proof of Concept (public and private) (2) Science and Innovation Investment Fund (SIIF) and Strengthening capacities for research, development and innovation (STRIP) (3) Research infrastructure usage and researchers' services for SMEs (IRCRO) (4) Supporting development of Centers of Competence (5) Transfer of technology from ROs to business sector (6) Support to development of new products/services resulting from R&D activities (Phases I and II) (7) Strategic project to support the Cluster Competitiveness Initiatives
Number of IP protection applications—registered	52	7	7	10	4	5	

INDICATOR (OUTCOME)	TOTAL	TPA 1	TPA 2	TPA 3	TPA 4	TPA 5	POLICY INSTRUMENTS CONTRIBUTING TO INDICATOR ACHIEVEMENT
Number of new innovative products / services / processes / technologies	252	11	40	16	6	2	(1) Proof of Concept (public and private) (2) Strengthening capacities for research, development and innovation (STRIP) (3) Research infrastructure usage and researchers' services for SMEs (IRCRO) (4) Supporting development of Centers of Competence (5) Transfer of technology from ROs to business sector (6) Innovation Support programs for SMEs (Commercialization of Innovation in Entrepreneurship, Innovation Vouchers, Innovations in S3 areas, Innovations of newly established SMEs (Phases I and II), Integrator) (7) EUREKA and EUROSTARS (8) Support for RDI activities of SMEs (RAZUM) (9) Support to development of new products/services resulting from R&D activities (Phases I and II)

INDICATOR (OUTCOME)	TOTAL	TPA 1	TPA 2	TPA 3	TPA 4	TPA 5	POLICY INSTRUMENTS CONTRIBUTING TO INDICATOR ACHIEVEMENT
Number of start-ups/spin-offs/spin-outs originating from supported projects	1	0	0	1	0	0	(1) Proof of Concept (public and private) (2) Science and Innovation Investment Fund (SIIF) (3) Strengthening capacities for research, development and innovation (STRIP) (4) Supporting development of Centers of Competence (5) Transfer of technology from ROs to business sector (6) Support for RDI activities of SMEs (RAZUM) (7) Support to development of new products/services resulting from R&D activities (Phases I and II)
Total contracted amount for R&D funding from private sector attracted by PROs/HEIs beneficiaries (EUR thousand)	264.85	n/a	n/a	n/a	n/a	n/a	(1) Proof of Concept (public) (2) Science and Innovation Investment Fund (SIIF) (3) Strengthening capacities for research, development and innovation (STRIP) (4) Supporting development of Centers of Competence
Priority setting system for scientific R&D policy in Croatia created	n/a	n/a	n/a	n/a	n/a	n/a	Strategic Project Science and Technology Foresight
Rate of public infrastructure usage by companies	n/a	n/a	n/a	n/a	n/a	n/a	
Rate of public infrastructure usage by owner	n/a	n/a	n/a	n/a	n/a	n/a	
Rate of public infrastructure usage shared between Public Research Organizations	n/a	n/a	n/a	n/a	n/a	n/a	

INDICATOR (OUTCOME)	TOTAL	TPA 1	TPA 2	TPA 3	TPA 4	TPA 5	POLICY INSTRUMENTS CONTRIBUTING TO INDICATOR ACHIEVEMENT
Number of commercialization and technology transfer agreements	14	3	7	0	0	4	(1) Strengthening capacities for research, development and innovation (STRIP) (2) Supporting development of Centers of Competence (3) Support to development of new products/services resulting from R&D activities (Phases I and II)
Number of job positions in R&D created in enterprises by RDI projects after the end of funded project	158	9	9	46	21	26	(1) Strengthening capacities for research, development and innovation (STRIP) (2) Research infrastructure usage and researchers' services for SMEs (IRCRO) (3) EUREKA and EUROSTARS (4) Proof of Concept (private) (5) Support for RDI activities of SMEs (RAZUM) (6) Support to development of new products/services resulting from R&D activities (Phases I and II)
Number of joint publications (between RO beneficiary and industry partner)	n/a	n/a	n/a	n/a	n/a	n/a	Strengthening capacities for research, development and innovation (STRIP)
Number of strategic (project proposals) defined within thematic innovation platforms	300	63	110	54	45	28	Strategic Project for Establishment of Innovation Network for Industry and Thematic Innovation Councils
Number of job positions in R&D created in ROs by RDI projects after the end of funded project	n/a	n/a	n/a	n/a	n/a	n/a	Supporting development of Centers of Competence

INDICATOR (OUTCOME)	TOTAL	TPA 1	TPA 2	TPA 3	TPA 4	TPA 5	POLICY INSTRUMENTS CONTRIBUTING TO INDICATOR ACHIEVEMENT
Number of licensing agreements	2	0	0	0	2	0	(1) Supporting development of Centers of Competence (2) Transfer of technology from ROs to business sector (3) Support to development of new products/services resulting from R&D activities (Phases I and II)
Number of partnerships with other TTOs	n/a	n/a	n/a	n/a	n/a	n/a	Transfer of technology from ROs to business sector
Sales of new-to-firm innovation (as percentage of turnover)	14.41	n/a	n/a	n/a	n/a	n/a	(1) Supporting development of Centers of Competence (2) Innovation Support programs for SMEs (Commercialization of Innovation in Entrepreneurship, Innovation Vouchers, Innovations in S3 areas, Innovations of newly established SMEs (Phases I and II), Integrator) (3) EUREKA and EUROSTARS (4) Support for RDI activities of SMEs (RAZUM) (5) Support to development of new products/services resulting from R&D activities (Phases I and II) (6) Strategic project to support the Cluster Competitiveness Initiatives
Sales of new-to-market innovation (as percentage of turnover)	14.35	n/a	n/a	n/a	n/a	n/a	

INDICATOR (OUTCOME)	TOTAL	TPA 1	TPA 2	TPA 3	TPA 4	TPA 5	POLICY INSTRUMENTS CONTRIBUTING TO INDICATOR ACHIEVEMENT
Increase in companies' turnover compared to year of contracting (%)	1,044.28	n/a	n/a	n/a	n/a	n/a	(1) Innovation Support programs for SMEs (Commercialization of Innovation in Entrepreneurship, Innovation Vouchers, Innovations in S3 areas, Innovations of newly established SMEs (Phases I and II), Integrator) (2) EUREKA and EUROSTARS (3) Support for RDI activities of SMEs (RAZUM) (4) Support to development of new products/services resulting from R&D activities (Phases I and II) (5) Strategic project to support the Cluster Competitiveness Initiatives
Increase in share of turnover from exports compared to contracting year (percentage points)	6.1	n/a	n/a	n/a	n/a	n/a	
Private investment in R&D projects after the end of public funded project (EUR million)	10.86	0.74	1.78	3.07	0.80	0.23	(1) Innovation Support programs for SMEs (Commercialization of Innovation in Entrepreneurship, Innovation Vouchers, Innovations in S3 areas, Innovations of newly established SMEs (Phases I and II), Integrator) (2) EUREKA and EUROSTARS (3) Support for RDI activities of SMEs (RAZUM) (4) Proof of Concept (private) (5) Support to development of new products/services resulting from R&D activities (Phases I and II)
Number of collaborative contracted projects (by beneficiaries in companies) with foreign HEI and PRO institutions	4	n/a	n/a	n/a	n/a	n/a	EUREKA and EUROSTARS

INDICATOR (OUTCOME)	TOTAL	TPA 1	TPA 2	TPA 3	TPA 4	TPA 5	POLICY INSTRUMENTS CONTRIBUTING TO INDICATOR ACHIEVEMENT
Number of persons who in the reference year acquired a PhD degree in STEM areas	60	n/a	n/a	n/a	n/a	n/a	Career development of young researchers (PhD education)
Number of young researchers who gained doctoral (PhD) degree	90	n/a	n/a	n/a	n/a	n/a	Career development of young researchers (PhD education)
Percentage of vocational schools in which newly developed VET curricula based on learning outcomes in targeted sectors are implemented	n/a	n/a	n/a	n/a	n/a	n/a	Modernization of vocational education and training programs and raising their quality to increase students' employability and opportunities for further education
Completion rate of students who received scholarships (%)	76.78	0	0	0	0	0	STEM student scholarships

Note: IP = intellectual property; STEM = science, technology, engineering, and mathematics; TPA 1 = Health and Quality of Life; TPA 2 = Energy and Sustainable Environment; TPA 3 = Transport and Mobility; TPA 4 = Security; TPA 5 = Food and Bioeconomy; VET = vocational education and training. In some cases, there is a discrepancy between the sum of reported TPA values and the total value. More precisely, the total achieved values in the tables are in some cases higher than the sum of values for the five TPAs. The difference refers to progress not attributed to any of the S3 TPAs. n/a is shown for indicators for which TPA disaggregation is not applicable, or the data is not available.

Source: Authors based on revised S3 monitoring framework and data provided by S3 institutions.

NOTES

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