Croatia Public Expenditure Review in Science, Technology and Innovation

ANALYSIS OF THE QUALITY AND COHERENCE OF THE POLICY MIX

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Note

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CONTENTS

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This report on the *Analysis of the Quality and Coherence of the Policy Mix* was prepared by a World Bank team led by Todor Milchevski (Private Sector Specialist, Task Team Leader). *Section 1: Productivity and Innovation* was written by Elwyn Davies (Economist), Todor Milchevski, and Jasmina Mrkonja (Economist) with contributions from Joao Bevilaqua T. Basto (Research Analyst). *Section 2: Research Sector* was written by Todor Milchevski and Ljiljana Tarade (Research and Innovation Specialist) with contributions from Kristian Vlahovicek (Research and Innovation Expert), Hrvoje Mestric (Research and Innovation Expert) and Martina Tolic (Research Analyst). *Section 3: Benchmarking and Innovation Performance was written* by Todor Milchevski and Jasmina Mrkonja with contributions from Martina Tolic, Hrvoje Mestric, and Joao Bevilaqua T. Basto. Section *4: Institutional Landscape of the National STI System* was written by Todor Milchevski with contributions from Hrvoje Mestric and Martina Vojkovic (Research Analyst). *Section 5: Budget Financing* was written by Todor Milchevski, Jasmina Mrkonja and Hrvoje Mestric, with contributions from Martina Tolic. *Section 6: Project Financing* was written by Todor Milchevski, Jasmina Mrkonja, Lukasz M. Marc (Economist) and Bartlomiej Skowron (Research Analyst), with contributions from Hrvoje Mestric and Martina Tolic. *Section 7: Recommendations* was written by Todor Milchevski and Jasmina Mrkonja. *Appendix I: Survey on firm-level productivity* was written by Lukasz M. Marc with contributions from Todor Milchevski and Bartlomiej Skowron. The report benefited from the editing of Aarre Laakso (Editor). Suncica Plestina (Communications Expert) provided communications support. Ruzica Jugovic (Program Assistant) provided administrative support.

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ACRONYMS AND ABBREVIATIONS

AIF	Alternative Investment Funds
APPRRR	Agency for Payments in Agriculture, Fisheries and Rural Development
ASHE	Agency for Science and Higher Education
BSO	Business Support Organization
CA	Competent Authority
CEE	Central and Eastern Europe
CESEE	Central, Eastern and Southeastern Europe
CFCA	Central Financing and Contracting Agency
CIRAZ	Center for Industrial Development
CNB	Croatian National Bank
CNR	Common National Rules
CORDIS	Community Research and Development Information Service
COSME	EU program for the Competitiveness of Enterprises and SMEs
CRANE	Croatian Business Angel Network
CSF	Croatian Science Foundation
DEFCO	Agency for Vocational Education and Training and Adult Education
DTF	Distance to frontier
EBAN	European Business Angel Network
ECA	Europe and Central Asia
ECB	European Central Bank
ECF	Economic Cooperation Funds
EIB	European Investment Bank
EIF	European Investment Fund
EJP	European Joint Programme
EPEEF	Environmental Protection and Energy Efficiency Fund
EPO	European Patent Office
ERC	European Research Council
ERDF	European Regional Development Fund
ESF	European Social Fund
ESIF	European Structural and Investment Funds
EU	European Union

EU-10	Member states that joined the EU in 2004: Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia.
EU-13	Member states that joined the EU in 2004, 2007 and 2013. Includes the EU-10, plus Bulgaria, Romania and Croatia.
EU-28	All EU member states
FFP	Firm's financial performance
FINA	Financial Agency
FP7	Framework Programme 7
FTE	Full-time equivalent
GBAORD	Government Budget Appropriations or Outlays on R&D
GDP	Gross Domestic Product
GERD	Gross Expenditures on R&D
GVC	Global value chain
H2020	Horizon 2020
HAMAG-BICRO	Croatian Agency for SMEs, Innovations and Investments
HANFA	Croatian Financial Service Supervisory Agency
HBOR	Croatian Bank for Reconstruction and Development
HEI	Higher education institution
HGF	High growth firm
HGK	Croatian Chamber of Economy
HT	High technology
IA	Innovation Actions
IB1	Intermediate Body 1
IB2	Intermediate Body 2
ICT	Information and communication technologies
IOI	Innovation output indicator
IPR	Intellectual Property Rights
KIS	Knowledge-intensive services
LKIS	Less-knowledge-intensive services
LT	Low technology
MA	Managing Authority
MC	Monitoring Committee
MEEC	Ministry of Economy, Entrepreneurship and Crafts
MRDEUF	Ministry of Regional Development and EU Funds
MSCA	Marie Sklodowska Curie Actions
MSE	Ministry of Science and Education
NACE	Statistical classification of economic activities
NGO	Non-government organization

OECD	Organisation for Economic Co-operation and Development
ORCID	Open Researcher and Contributor ID
OP	Operational Programme
OPCC	Operational Programme Competitiveness and Cohesion
PBA	Performance-based agreements
PER	Public Expenditure Review
PI	Principal investigator
PMR	Product market regulation
PoC	Proof of concept
PPS	Purchasing power standards
PRO	Public research organizations
PRI	Public research institutes
R&D	Research and development
RDI	Research, development and innovation
RIA	Research and Innovation Actions
RIO	Research and Innovation Observatory report
S3	Smart Specialization Strategy
SAFE	Survey on access to finance of enterprises
SME	Small and medium enterprise
STEM	Science, technology, engineering and mathematics
STI	Science, technology and innovation
STP II	Second Science and Technology Project
TFP	Total Factor Productivity
TO1	Thematic objective 1
TO3	Thematic objective 3
TRL	Technology readiness level
VC	Venture capital
WB	World Bank
WEF	World Economic Forum

EXECUTIVE SUMMARY

The Public Expenditure Review aims to provide recommendations for increasing the effectiveness of public spending on Science, Technology and Innovation (STI) in Croatia. This work comes at the request of Croatia's Ministry of Science and Education (MSE), and the World Bank is implementing it in close collaboration with the MSE, the Ministry of Economy, Entrepreneurship and Crafts (MEEC), and other stakeholders. The outputs of the project will serve as a basis for planning and designing the upcoming European Structural and Investment Funds (ESIF) programming. The first deliverable consists of three parts: (i) *Needs Assessment*, (ii) *Policy Mix*, and (iii) *Policy Recommendations*.

Needs Assessment

Productivity, a key determinant of growth, is low in Croatia, with no tendency toward converging with more developed economies. Croatia's lackluster productivity performance is a symptom of low business dynamism and market distortions constraining the growth of productive firms. Croatia struggles with misallocation of resources. Most international benchmarks for ease of doing business place Croatia well behind its peers, state-owned enterprise reforms are still incomplete, and product and service market regulations are restrictive while state aid, bankruptcy and insolvency regimes do not favor allocation toward more productive companies. Low investments in research and development (R&D) by firms hinders competition in the marketplace and the impact of new firms in aggregate productivity. However, EU data show that Croatian firms have been catching up in non-R&D innovation.

Croatian firms, especially smaller and younger ones, exhibit a positive relationship between R&D-based innovation and productivity growth. Yet, R&D expenditures have been stagnating in recent years. All firms see productivity gains from investing in R&D, but they are up to two times higher in smaller firms and up to ten times higher in younger firms. At the same time, R&D innovation expenditures in Croatia are low compared to peers, due to a low extensive R&D margin (i.e., few firms spend on R&D), as well as a low intensive margin (i.e., firms that spend on R&D have a low share of R&D in total expenditures). At the same time, market financing for innovation is severely lacking, especially at the early development stage. Traditional financing models, which are dominant in Croatia, are not suitable for early financing, while venture capital activity is severely limited, in part due to regulatory restrictions.

Reform in the public research sector is incomplete, with legacy issues still prevailing. Fragmentation and weak governance in the research sector (a legacy of the period prior to Croatia's independence) do not allow for the implementation of transformative actions in the system. The current governance and institutional framework stifles R&D activities of higher-education institutions and disincentivizes collaboration both (i) within the research sector and (ii) between the research sector and the private sector. As a result, Croatia stands out compared to other countries in terms of overproduction of low-quality publications, with the highest average of uncited papers in Europe. Internationalization and collaboration raise the quality of research outputs and help national research actors integrate into global research networks. Funding for these activities is part of the solution and should be coupled with a broader structural reform of the research sector because piecemeal interventions are not likely to produce transformative effects on research excellence.

Policy Mix

Leveraging increased budget funding for R&D to raise gross expenditures on R&D will require effective, performance-based funding for public research organizations (PROs) and interventions that crowd in private R&D spending. Total budget spending on R&D in Croatia (including from the EU and national sources) has increased since 2013, but it is still at half the level of the EU in per capita terms. The increase in budget spending on R&D, driven primarily by an increase in EU funding, provides an opportunity for Croatia to increase gross expenditures on RID in the next few years. However, an ineffective policy mix will limit the multiplicative effect that government spending could have on gross R&D expenditures. The analysis of budget allocations to institutional financing shows that:

- The bulk of institutional financing for STI is delivered through public funding of higher education institutions and public research institutes by MSE, and covers salaries of academic staff and researchers, as well as other salaries and overheads.
- Recently introduced performance-based agreements are an attempt to stimulate research excellence through a more meritocratic and transparent distribution of funds. However, these arrangements are still optional and constitute a small portion of the financing of PROs.
- The national budget allocation for research, development and innovation project financing has halved from 2013 until 2019 (to EUR 40 million) likely due to substitution with EU funding. This substitution is not entirely equivalent because ESIF funding has a more complex governance framework and imposes a greater administrative burden on both institutions and potential beneficiaries.

There are several opportunities to adjust the portfolio of innovation programs to Croatia's needs. The productivity analysis suggests that R&D investments in young firms would result in the largest productivity gains. However, larger, more mature firms benefit most from Croatia's project financing. Furthermore, Croatia is still making substantial investments in non-R&D innovation. The portfolio of innovation programs displays the following characteristics:

- Project-based financing constitutes a large portion of the STI funding policy mix (EUR 1.1 billion), mostly thanks to a substantial allocation from ESIF.
- The portfolio of support programs for the business sector is heavily skewed toward interventions to support existing firms, while diversification and new ventures are supported to a lesser degree. Funding went predominantly to mature companies, especially those established before 2010.
- Medium-sized firms were most likely to obtain ESIF funding and micro enterprises were least likely.
- Some of the largest programs are too broad to effectively achieve their stated objectives. In some cases, their size has resulted in overly complex program design. Croatia needs a more targeted approach to tailoring program design to the needs and capacities of the target beneficiaries and the desired outcomes.
- Many programs cover a seemingly wide range of R&D and technology readiness level phases. In fact, 15 programs cover five or more phases. However, elements of program design (such as selection criteria, results framework, or eligible partners) might create a bias toward very early or very late stages of R&D.
- Many programs, including some of the largest ones, have experienced implementation delays. This is mainly due to complex program design and slow application evaluations. In some cases, evaluations have taken several years. Language restrictions have made finding experts in frontier fields very difficult.

Recommendations

Croatia could take a number of steps to support innovation. Among other possibilities, the report recommends:

STI Policy Governance

- **Improving interinstitutional coordination** using the existing interministerial National Innovation Council to provide a platform for regular, structured discussions and coordination on long-term and short-term plans for STI support and financing.
- **Dividing responsibility for the STI agenda by lifecycle stages** to make the most of the knowledge accumulated in the MSE to support earlier stages of R&D and in the MEEC to support activities that are closer to the market.
- **Creating an agency dedicated to implementing STI policy** with a clear mission to support coordination, design, monitoring and evaluation would provide a vehicle for MSE and MEEC to effectively implement STI policy.

Research Excellence and Collaboration

- **Simplifying the governance of public research institutions** by integrating PROs and reinforcing accountability principles. This would allow for the kinds of transformative actions that are impossible under the current highly fragmented structure, such as rewarding research excellence and providing incentives for collaboration and internationalization.
- **Fostering public-private linkages** by supporting technology transfer activities and allocating more funds towards applied research and experimental development. This should help the public research sector get closer to the market, commercialize its research and transform new knowledge into intellectual property.

Business Innovation

- **Supporting R&D investment in younger firms** in knowledge-intensive sectors to target productivity growth because young and micro firms see the highest productivity gains from R&D spending.
- **Improving targeting in business R&D programs** by tailoring program elements to the specific needs of intended beneficiaries and program objectives.

Croatia also needs to improve its business environment. Croatia's lackluster productivity performance is not only due to a dearth of innovation. It is also a symptom of low business dynamism and market distortions constraining the growth of productive firms through misallocation of resources. More productive firms are not growing, indicating that there are market distortions stemming from weaknesses in the business environment, market regulations and access to finance. Croatia particularly struggles with market distortions stemming from barriers to firm entry and exit, access to finance and state aid, which contribute to the misallocation of resources toward less productive economic actors. Fostering R&D-based innovation will not be sufficient to raise productivity unless there is also an enabling environment that will allow more productive firms to grow and gain market share, foster research excellence, and provide incentives for technology transfer.

The remainder of the report contains detailed conclusions and recommendations and the means by which we collected and analyzed data to reach them. Croatia has an enormous opportunity to grow. This requires increasing productivity by improving its innovation ecosystem and its business environment. While there is much work to do, this report points to actions that can be taken to achieve results.

INTRODUCTION

The Public Expenditure Review (PER) in STI is a method developed by the World Bank[1] for comprehensive analysis of national STI systems. It examines public spending for STI and recommends ways to improve its cost effectiveness and targeting through reallocating resources and redesigning and rationalizing policies and instruments. Its main purpose is to improve the impact of public support for STI on productivity and growth by focusing on (i) actionable measures – design of programs, policies, and institutions – and (ii) managing for results – design of monitoring and evaluation mechanisms.

The Croatia PER in STI aims to provide an analytical background for increasing the effectiveness of public spending on STI in Croatia. This work comes at the request of MSE, and the World Bank has implemented it in close collaboration with the MSE, the MEEC, and other stakeholders. The outputs of the project will serve as a basis for planning and designing the upcoming ESIF programming with a view toward improving the STI system in Croatia. Over the medium term, the project is expected to contribute to increasing the absorption of funds for science, technology, and innovation. In the long term, this should increase innovation performance in Croatia, as measured by innovation outputs such as intellectual property rights (IPR) and publications.

The Croatia PER in STI has three components:

1. **Quality and coherence of the policy mix** – provides a comprehensive overview of the flow of funds in the system, the budget structure and policy mix, and how well they respond to the country's needs. This component consists of mapping the portfolio of all the STI support programs and analyzing the collected information.
2. **Functional and governance analysis** – an in-depth assessment of the design, implementation, and governance of instruments, institutions, and positions within the policy mix. The component consists of extensive field work and data collection through semi-structured interviews with program managers and analysis of the collected information.
3. **Monitoring and evaluation (M&E)** – includes developing a theory of change and customized M&E framework for the programs reviewed and analyzing outputs and outcomes for selected programs. The analysis includes studying the relationship between inputs and outputs and monitoring the progress of the outcomes of interest.

A summary of activities under each component is presented in Figure 0.1 at the end of this section.

This report presents the findings of the analysis performed under the first component – *Quality and coherence of the policy mix*. It consists of three parts: *Needs Assessment, Policy Mix, and Recommendations.* The *Needs Assessment* comprehensively evaluates the STI system, analyzing the environment and exogenous factors relevant for policy design and implementation and identifying strengths and weaknesses in innovation. The *Policy Mix* presents information on the supply of all public support for STI, identifying main areas and mechanisms of intervention and how well they correspond to the needs of the STI system. The *Recommendations* identify the areas of intervention to improve STI policy governance, enhance research capabilities and foster innovation.

1 Correa (2014).

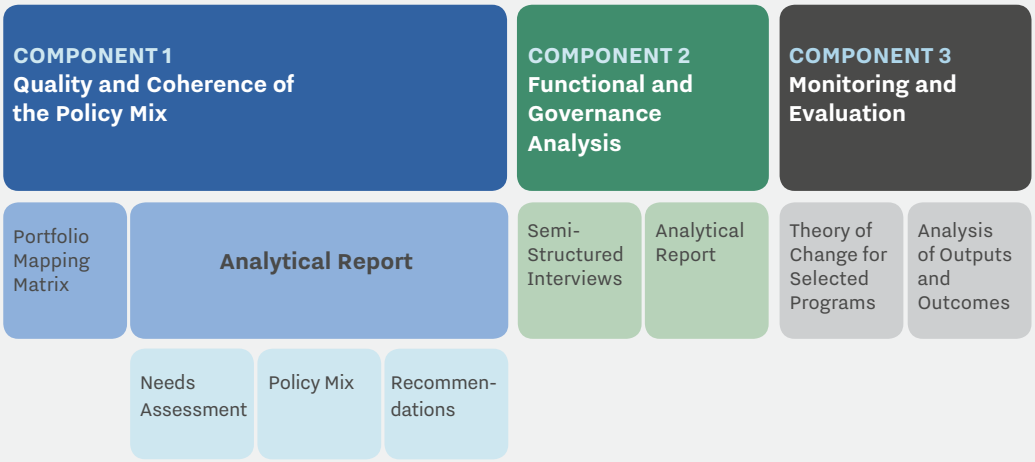
The *Needs Assessment* has three sections: (i) productivity and innovation, (ii) research sector, and (iii) benchmarking and innovation performance. The first section, productivity and innovation, analyzes productivity as a catalyst for economic growth, identifies the main drivers of productivity, explores the role of research, development, and innovation (RDI) in boosting productivity and growth, and reviews the market conditions under which innovation actors operate (such as business environment, competition policy, dynamism in the enterprise sector, and access to finance). Relevant findings from a survey on firm-level productivity are presented in Appendix I. The second section, research sector, presents the systemic conditions that impact research excellence (including the structure of the research sector, human resources and skills levels, and governance of public research institutions), as well as the quality and quantity of scientific publications by Croatian researchers (scientometric analysis). The third part of the *Needs Assessment*, benchmarking and innovation performance, examines innovation in Croatia compared to its peers through internationally comparable metrics (such as the European Innovation Scoreboard), as well as by reviewing Croatia's participation in internationally competitive RDI funding schemes.

Where possible, the analysis benchmarks Croatia's performance to a mix of regional and aspirational peers. Regional peers include countries that joined the EU in 2004 or later, are of comparable size, and are near Croatia (Bulgaria, Czech Republic, Slovenia, and Slovakia), as well as one non-EU country that is near Croatia and has a research sector of a similar size (Serbia). When possible, the analysis also benchmarks Croatia against EU-10, EU-13 or Central and Eastern European (CEE) averages. Aspirational benchmarks include Austria, the United States, and the EU-28.

The second part of the report, the *Policy Mix*, reviews the current policy mix and its fit with the needs of the STI system. It starts by providing a background on the institutional landscape for STI policy making and governance (including the governance of ESIF programs). The policy mix is analyzed by reviewing funding for STI (i) from the national budget (that is, institutional funding) and (ii) through dedicated support programs (that is, project financing). Section 5 examines budget spending for STI, including its composition and allocation mechanism. Section 6 uses the portfolio mapping of STI support programs, which allows analysis of their objectives, target beneficiaries, delivery mechanisms, R&D stages, budgets, and similar factors to assess potential gaps or overlaps in innovation policy. The analysis of the portfolio mapping is complemented by a qualitative analysis of individual support programs. The qualitative analysis considers alignment with strategic objectives, internal consistency among program elements, and implementation issues such as transparency and clarity. This section of the analysis also examines the beneficiaries of STI programs to explore any gaps between policy goals and actual results.

The two initial parts of the report – the *Needs Assessment* and the *Policy Mix* – are brought together through a *Recommendations* part. This part advises STI policymakers on how to revamp and fine-tune STI policy, reallocate resources toward areas of strength, and overcome weaknesses in the STI system. The recommendations draw on the findings of the Needs Assessment and the Policy Mix and are organized into three broad categories: (i) improving STI policy governance, (ii) enhancing research capabilities, and (iii) fostering innovation. This part also sets the stage for the second component of the analysis within the PER, the *Functional and Governance Analysis*, which will identify bottlenecks in program design, implementation, and governance.

FIGURE 0.1 *Summary of activities under the Croatia PER in STI*



Source: Staff elaboration

“NOTHING IN LIFE IS TO BE FEARED, IT IS ONLY TO BE UNDERSTOOD.”

- Marie Sklodowska-Curie

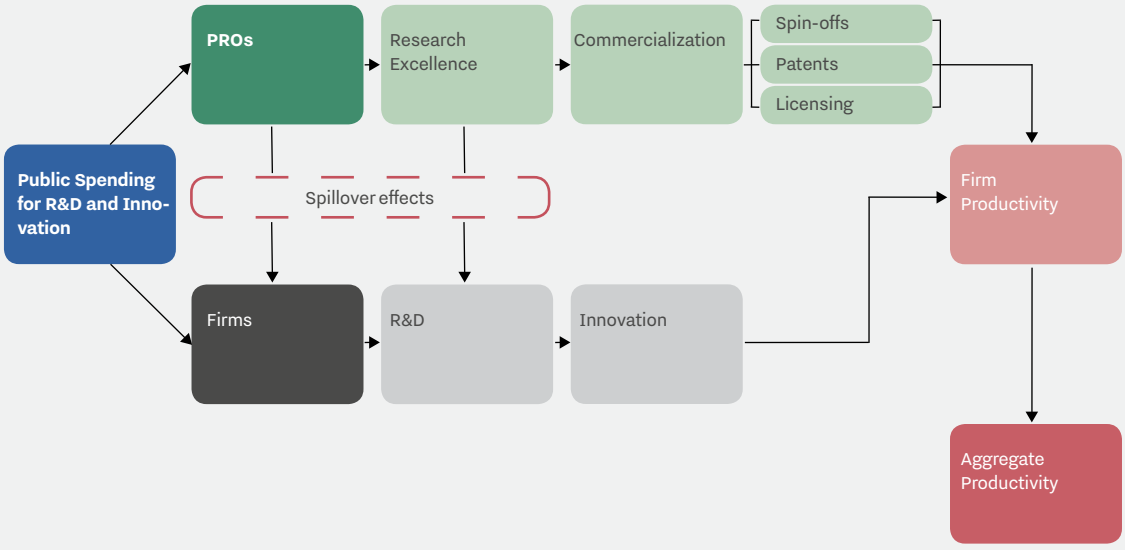
PART ONE
NEEDS ASSESSMENT

METHODOLOGY

The *Needs Assessment* examines the demand for innovation by identifying the needs of the economy and characteristics of the National Innovation System (NIS). The *Needs Assessment* reviews the challenges and opportunities in the STI system from two perspectives – private sector and public research sector – following the analytical framework presented in Figure 0.2. The needs and capabilities of the private sector are assessed through an analysis of productivity and innovation, while the public research sector is analyzed through a review of the current research setting and an assessment of Croatia's science capabilities.

The analysis of productivity and innovation determines the demand for STI policy by identifying opportunities, challenges and priorities for firm-level innovation. The analysis looks into aggregate productivity, uses Melitz-Polanec productivity decomposition and Shapley decomposition of R&D growth, data on investment in R&D, and Community Innovation Survey (CIS) data to shed light on sources of productivity, its sectoral distribution, and the link between R&D investment and productivity in firms of different size and age. The analysis is complemented by an assessment of the prevailing framework conditions (allocation of resources, business environment, market competition and access to finance) that affect productivity in Croatian firms and their ability to invest in research and innovation.

FIGURE 0.2 *The analytical framework for determining the demand for innovation*



Source: Staff elaboration based on Correa (2014).

The review of the research sector analyzes its framework conditions and capability to produce excellent science and create spillovers toward the private sector. The analysis of the framework conditions entails a review of the institutional landscape of the research sector, its financing models, the human resource base, and governance of higher education institutions. The capabilities of the research sector to produce excellent science are assessed through an analysis of quantitative and qualitative indicators of the scientific output of R&D-performing institutions in Croatia, using Scopus data on citations, MSE's Register of Scientists and Register of Research Organizations, EC's CORDIS database, Eurostat and Scimago. The ability to create spillovers towards the private sector is analyzed through a review of Eurostat data on types of research expenditures and patenting activity.

Benchmarking Croatia's NIS puts its strengths and weaknesses in an international context by assessing Croatia's overall innovation performance, creation of innovation outputs and knowledge assets, R&D intensity, entrepreneurship and performance in international competitive funding schemes. In this context, the Needs Assessment reviews Croatia's performance as measured by the European Innovation Scoreboard, and benchmarks it to regional and aspirational peers. The creation of innovation outputs is analyzed using Eurostat data on patent and design applications, as well as EC's Innovation Output Indicator. The level of R&D intensity is determined by assessing the achievement of the Europe 2020 target on Gross expenditures on R&D (GERD). The Global Entrepreneurship Monitor is used to examine the level of opportunity-driven entrepreneurship. This analysis of international benchmarks and indicators is complemented by an analysis of Croatia's performance in transnational competitive EU programs, such as Horizon 2020, Interreg, and similar. The analysis uses data from EC's CORDIS database, the EC's Financial Transparency System, as well as the Interreg, Eureka and Eurostars portal to assess Croatia's ability to absorb transnational competitive funding compared to regional and aspirational peers.

1 PRODUCTIVITY AND INNOVATION

1 PRODUCTIVITY AND INNOVATION

Science, technology and innovation are key factors in productivity. They help nations converge toward higher incomes and promote equitable growth. This section presents an in-depth empirical exploration of the sources of low productivity growth in Croatia, the types of R&D contributing to it, and the effects of innovation on the productivity of a variety of actors. This will help policymakers enact policies to unleash productivity and economic growth.

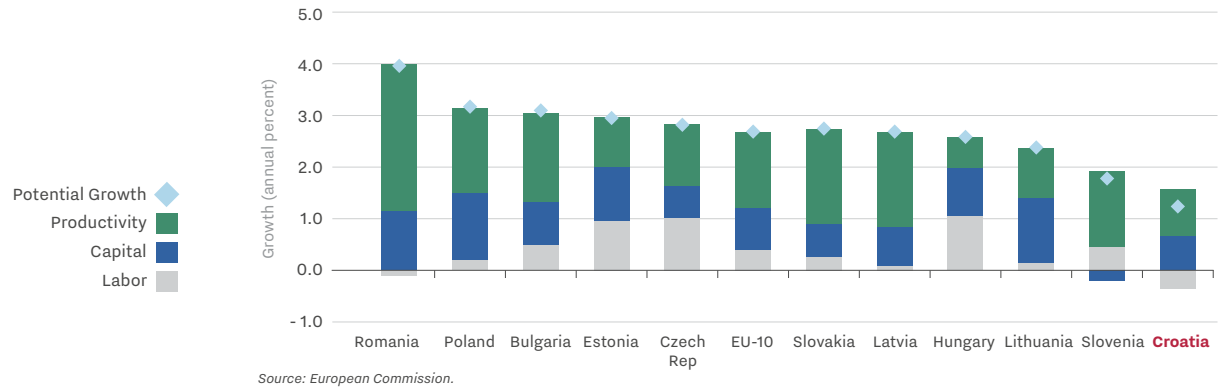
1.1 Productivity as a Driver of Growth

- Despite increases in investment, productivity in Croatia is failing to converge to U.S. levels. Productivity remains low – especially outside tourism – and is growing slowly compared to similar countries.
- Croatia needs a broad-based strategy to diversify its economy and exports beyond tourism. Raising productivity is essential to achieving this and to generating better and more sustainable jobs.
- Productive firms are not growing, suggesting there are barriers preventing the flow of capital and labor to these firms. The barriers include obstacles to market entry and exit, which constrain business dynamism.

Productivity is a key driver of growth, but its contribution in Croatia is low. Productivity is the efficiency by which inputs – such as labor and capital – are transformed into production. Productivity growth is a key determinant of long-term economic growth, explaining up to half of income differences across countries (see, for example, Hall & Jones 1999). In Croatia, productivity increases over the last three years have contributed to economic growth. Figure 1.1 decomposes economic growth into contributions from capital, labor, and productivity. Between 2015 and 2018, productivity contributed to 0.9 percentage points of annual economic growth in Croatia (which was 1.3 percent overall). However, productivity contributes about twice as much to growth in Central and Eastern European countries like Slovenia (1.5 percentage points), Slovakia (1.9 percentage points) and Latvia (1.9 percentage points).

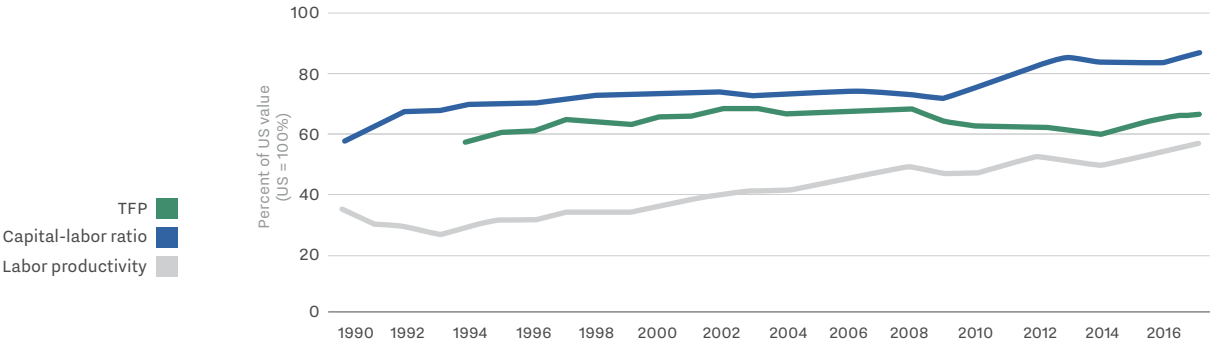
Productivity in Croatia is failing to catch up with the global frontier despite significant capital investments. Figure 1.2 shows labor productivity, the ratio between capital and labor, and total factor productivity (TFP) relative to the United States. In the run-up to Croatia's EU accession in 2013, capital investment, mostly targeted at mining and tourism, increased. This resulted in a sharp increase in the country's capital-labor ratio. Labor productivity – which measures output per worker – also increased. However, TFP – which

FIGURE 1.1 *Potential economic growth in Croatia between 2015 and 2018 was low*



Source: European Commission.

FIGURE 1.2 *Growth in labor productivity has been driven by capital increases, while TFP decreased relative to the United States between 2003 and 2014*



Source: Penn World Tables.

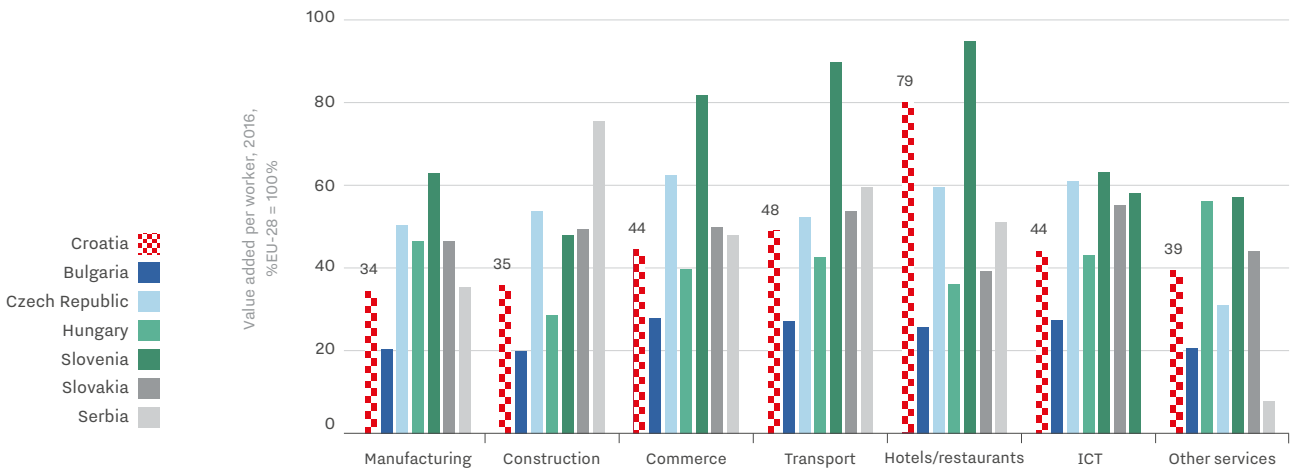
measures how efficiently a country uses both capital and labor – stagnated and is now converging slowly with the United States. This indicates that the increased investment in Croatia has not led to gains in the efficiency with which capital and labor are used in production.

To foster growth outside of tourism and expand exports, Croatia needs a broad strategy to increase productivity and diversify production. Figure 1.3 compares value added per worker in Croatia with other European countries and the EU-28 average. Outside of tourism, Croatian firms lag those in many regional comparator countries: a Croatian manufacturing firm is three times less productive than the average EU firm. Croatia also performs badly when comparing exports: among CEE countries inside the EU, Croatia has the smallest goods export sector (Figure 1.4). Increasing the productivity of Croatian firms can rejuvenate Croatia's economy and expand the base of potentially exportable goods and services,[2] including non-tourism services exports. A more diversified and productive economy will, in turn, lead to the diversification of exports, reducing reliance on tourism. It will also enable the country to explore the opportunities opened by the emergence of the digital economy[3] and related technologies, such as fintech.

2 As shown in the analysis in Appendix I, exporters are more productive than non-exporters.

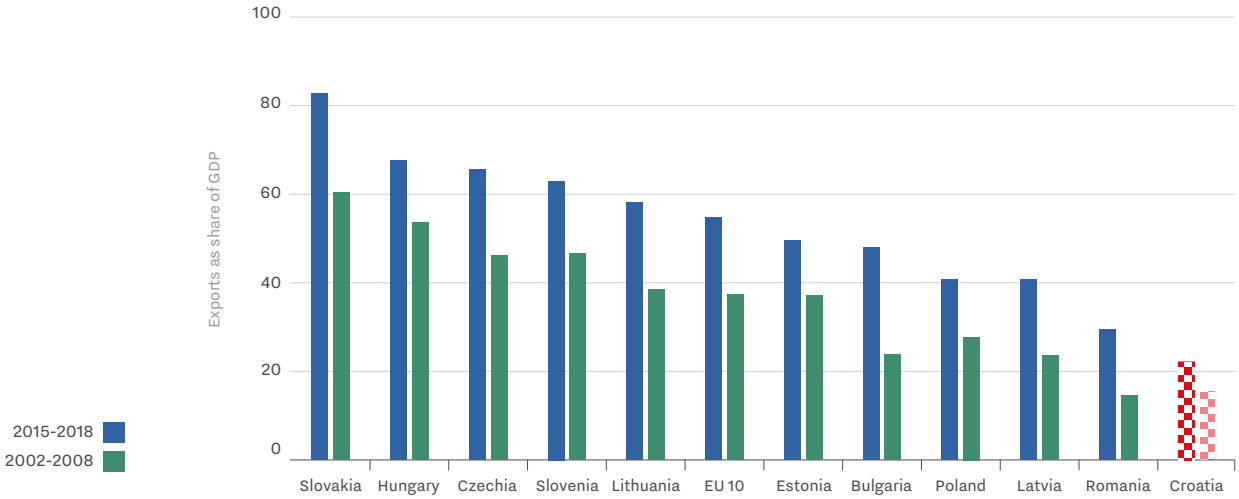
3 Digital readiness is an important element of innovation performance, especially if countries are to take advantage of the digital economy. Without going into extensive detail, Croatia is roughly at the level of EU-13 when it comes to digital readiness, and at the level of the EU-28 in human capital, use of internet services, and integration of digital technologies, while connectivity and digital public services lag behind (DESI, 2019). For more detail, see Correa, Milchevski, et al. (2019).

FIGURE 1.3 *In most sectors, apart from hotels and restaurants, Croatian firms are 2–3 times less productive than the average EU firm*



Source: Eurostat Structural Business Survey.

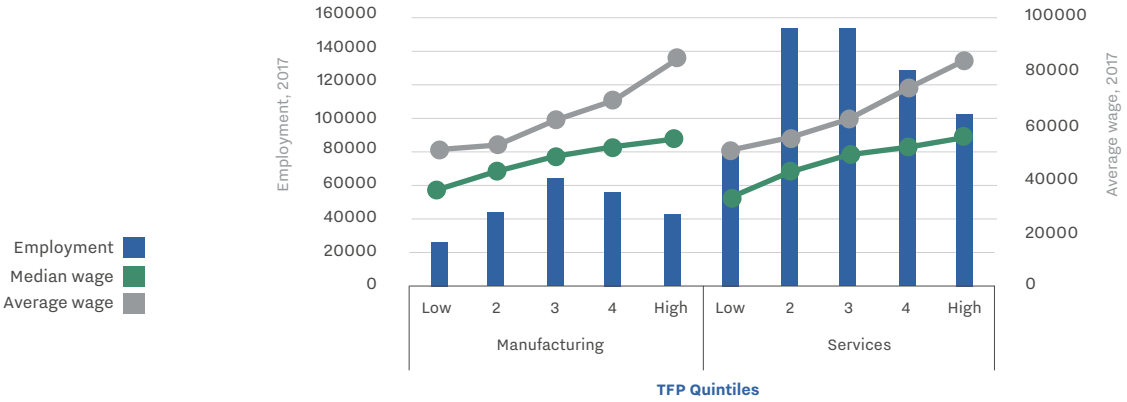
FIGURE 1.4 *Croatia has the smallest goods exports sector among CEE countries*



Source: Eurostat.

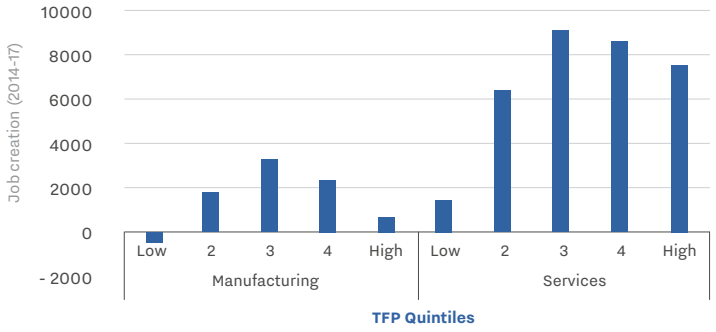
More productive firms create better jobs. Increasing productivity is also important from a jobs perspective: a more productive and diversified economy can help Croatia address its demographic challenges of an aging population and net negative migration. Figure 1.5 shows employment and average wages by firm productivity quintile. While most employment is in firms with median levels of productivity, more productive firms pay on average higher wages than less productive firms. Figure 1.6 shows job creation by productivity quintile. There is a positive relationship between productivity and job creation, even though it is lower for the highest productivity quintiles.

FIGURE 1.5 *More productive firms pay higher wages, but most employment is in firms with median levels of productivity*



Source: Staff elaborations based on FINA data.

FIGURE 1.6 *Most job creation is in firms with median levels of productivity*



Source: Staff elaborations based on FINA data.

Productivity can grow as a result of three processes. Decompositions of productivity growth attribute growth to these three interacting processes:

- *Innovation and improvement of firm capabilities:* First, firms can improve their productivity by innovating, adopting better technologies and implementing better managerial practices ("within-firm" productivity growth).
- *Improving factor allocation:* Second, productivity can improve if the factors of production – labor and capital – move from less efficient to more efficient firms ("between-firm" productivity growth). Lack of growth of more productive firms can be a sign that there are barriers to the efficient reallocation of resources.
- *Productive entry and exit:* Finally, productivity can improve through the entry of new firms that are more productive than the average firm and the exit of less productive firms (dynamic productivity growth).

Table 1.1 summarizes these three components and their links with policy. Most policies are not associated exclusively with a single component. For example, reforming business regulations can facilitate both the entry of new firms (dynamic productivity growth) and the growth of firms that were previously restricted (between-firm productivity growth).

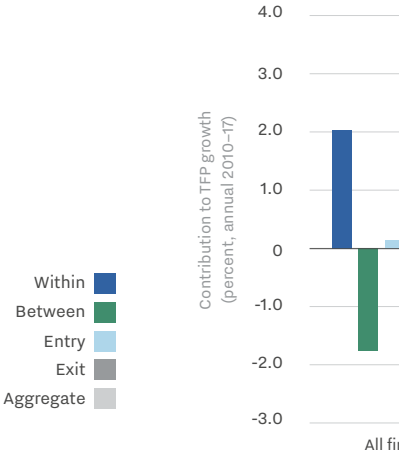
TABLE 1.1 *Sources of productivity growth and links with policy*

WITHIN-FIRM	BETWEEN-FIRM	DYNAMIC
Firms increasing their capabilities	**Allocating resources to more productive firms**	**Entry of productive firms and exit of unproductive firms**
Capabilities include: human capital skills, management and organizational practices, using and adopting technology, and innovation by the firm.	Misallocation of resources indicate barriers that prevent the movement of capital, labor and other factors of production to the most productive firms in the economy.	Entry of highly productive, fast-growing firms (*gazelles*) and exit of less productive firms that are not growing (*laggards*).
Links with policy: improving education and technical skills; encouraging entrepreneurship, technology adoption and innovation; and reducing regulatory constraints on firm growth	**Links with policy:** product market regulations, distortions in access to financing or SME financing, labor market frictions, and removing protections of certain industries	**Links with policy:** barriers to entry of new firms (for example, costly licensing), competition policy, and encouraging entrepreneurship

Source: Adapted from Davies, Iootty & Zouhar 2019.

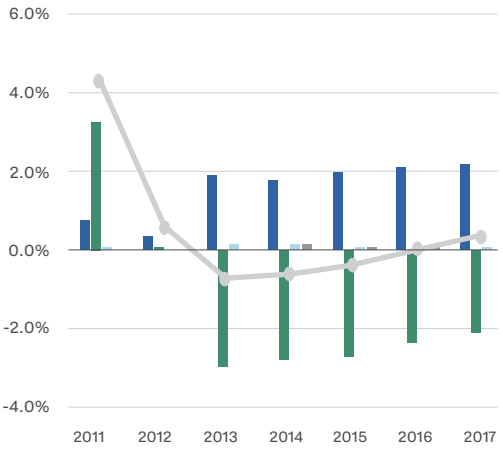
In Croatia, productivity growth has been driven by existing firms becoming more productive (positive "within-firm" growth), while more productive firms have not expanded their market share (negative "between-firm" growth). Figure 1.7 shows the decomposition of productivity growth for the period between 2010 and 2017. Overall, the growth in TFP was modest, on average 0.5 percent per year, which is lower than the historical TFP growth rate of the United States (1.6–1.8 percent per year). The "within-firm" component was positive between 2010 and 2017, indicating that existing firms became more productive. However, the negative "between-firm" component suggests a shift of resources from more to less productive firms. This shift cancels out the gains from the "within-firm" component for most years (Figure 1.8).

FIGURE 1.7
Productivity growth has been driven by the "within" component, suggesting increased firm capabilities



Source: Staff calculations based on World Bank 2019, using the Melitz-Polanec decomposition.

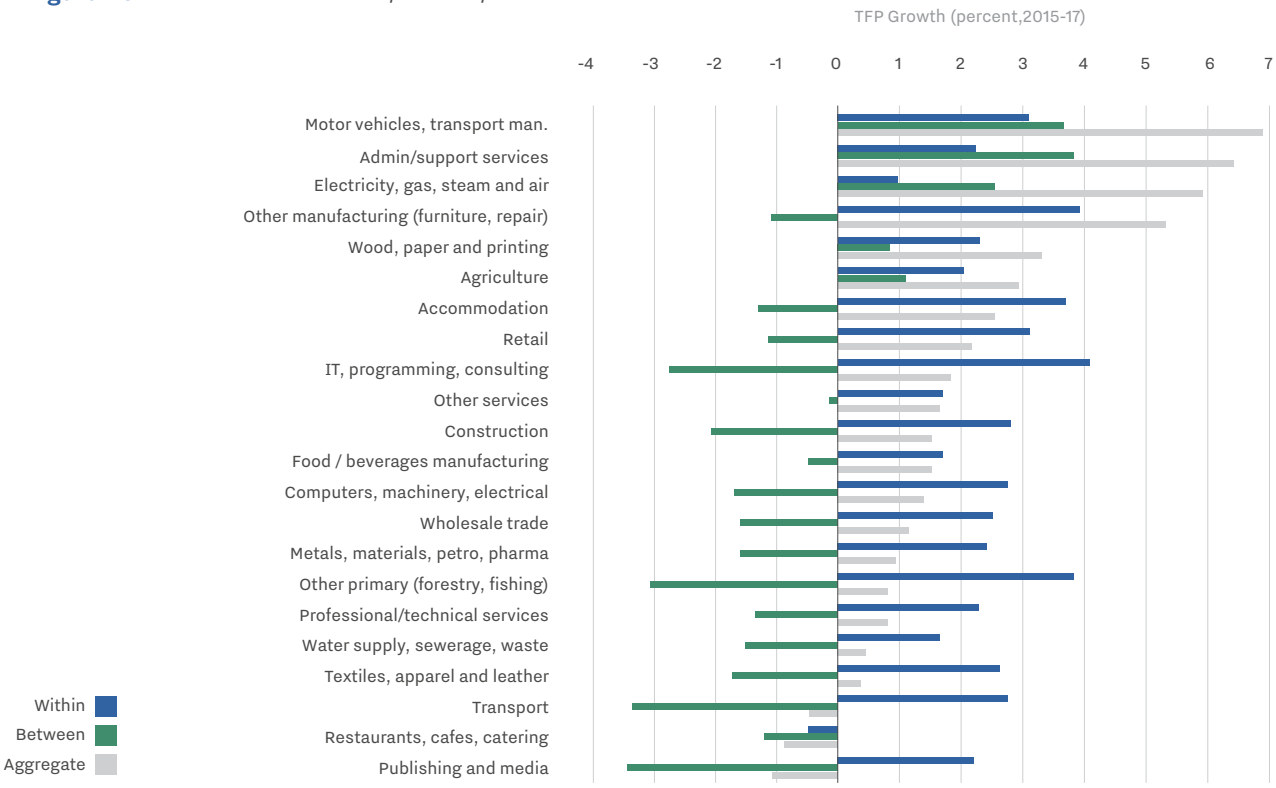
FIGURE 1.8
The negative "between-firm" component cancels out the "within-firm" component in most years



Source: Staff calculations based on FINA data.

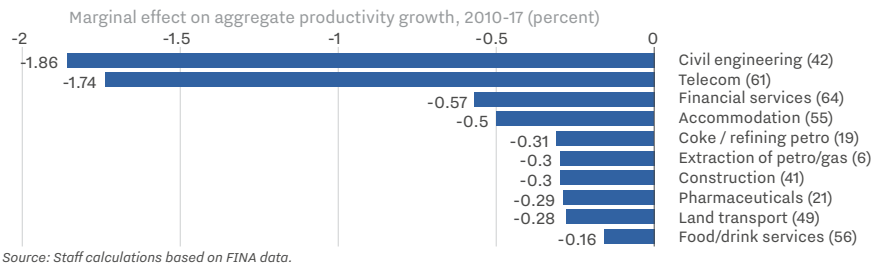
Similar TFP results hold for most sectors in Croatia, suggesting that the lack of business dynamism is pervasive. Figure 1.9 shows a decomposition of productivity growth by industry. It confirms that productivity growth in most sectors was driven by a positive "within-firm" component but often counterbalanced by a negative "between-firm" component. Industries with negative "between-firm" components include accommodation, commerce (retail and wholesale trade), IT, professional and technical services, transport, and publishing and media. Figure 1.10 shows the marginal effect on aggregate productivity growth. The largest negative contribution to aggregate productivity growth between 2010 and 2017 was from civil engineering. It was mostly driven by a negative "between-firm" component, suggesting allocative inefficiencies. Other sectors with negative contributions include telecom, financial services and accommodation.

Figure 1.9 *The "within" component is positive in most industries*



Source: Staff calculations based on FINA data.

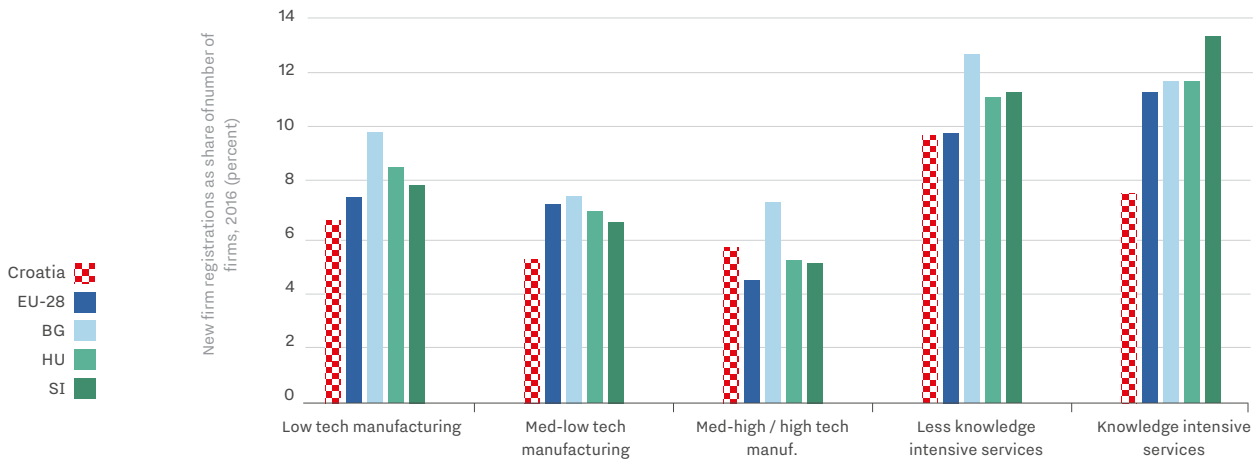
FIGURE 1.10 *Civil engineering, telecom and financial services held back productivity growth the most*



Source: Staff calculations based on FINA data.
Note: The numbers in parentheses refer to the NACE industry classifications.

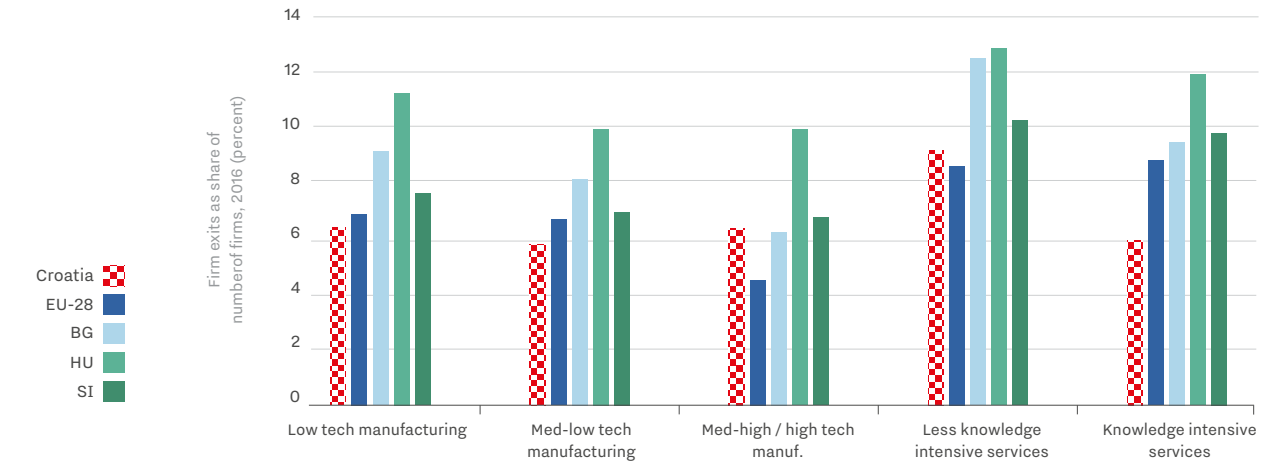
Low firm entry and exit rates compared to other EU countries confirm the lack of business dynamism. New firms can be important sources of productivity growth because they can bring new technologies to the market and increase competition. Similarly, exit of less productive firms can free up resources to be used in more productive firms. However, in Croatia, as shown in the productivity decompositions, entry and exit have contributed little to productivity growth. Compared to comparator countries in the EU, business dynamism is low, especially in more knowledge-intensive service activities. Figure 1.11 and Figure 1.12 compare entry and exit rates in Croatia with those in the EU, Bulgaria, Hungary and Slovenia. While the entry rate in Croatia is low across all industry groups, it is especially low for knowledge-intensive services (7.7 percent, compared to 11.3 percent in the EU). The exit rate for knowledge-intensive services is low as well (5.9 percent, compared 8.7 percent in the EU).

FIGURE 1.11 *New firm registrations have been low, especially in knowledge-intensive services*



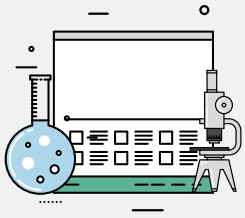
Source: Staff calculations based on Structural Business Survey (SBS) data from Eurostat. For Serbia, data from the Serbian Statistical Office.

FIGURE 1.12 *Low exit rates are another sign of lacking business dynamism*



Source: Staff calculations based on Eurostat SBS data.

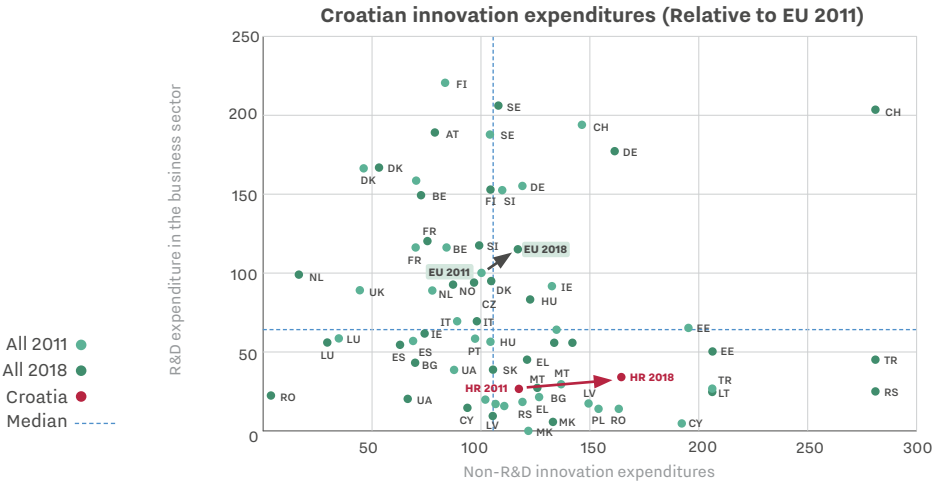
1.2 Research and Development Based Innovation is Lagging



- Innovation in Croatia has focused mostly on "lighter" forms of innovation rather than innovation through research and development (R&D) activities. R&D innovation expenditures have stagnated (or even declined) in the last decade.
- Low R&D spending has been driven both by a low number of firms spending on R&D (a low extensive margin) and by low spending by these firms (a low intensive margin).
- The lack of growth in R&D expenditure has not been driven by a reduction in the number of firms spending on R&D (which actually increased) but by a reduction in the average amount that firms spent on R&D.

Non-R&D innovation expenditures rather than R&D-driven innovation have been behind positive "within-firm" productivity growth in Croatia. The positive "within-firm" component in Croatia's productivity growth suggests that firms have been upgrading their production processes. Innovation expenditures have increased. However, the increases have been mostly on "lighter" forms of innovation (such as purchases of advanced machinery, licenses, patents, and minor modifications in products or processes) rather than on R&D.[4] Figure 1.13 shows how countries' expenditures on innovation have changed since 2011. It depicts expenditures on R&D and non-R&D innovation in 2018 compared to the EU average in 2011. Non-R&D innovation expenditures in Croatia in 2018 were 83 percent larger than the EU average in 2011. Meanwhile, Croatia's expenditures on R&D remained basically unchanged. By contrast, EU countries, on average, increased both R&D and non-R&D innovation expenditures. Croatia is behind the EU on R&D spending, and it is falling further behind.

FIGURE 1.13 *Innovation expenditures outside of R&D increased*

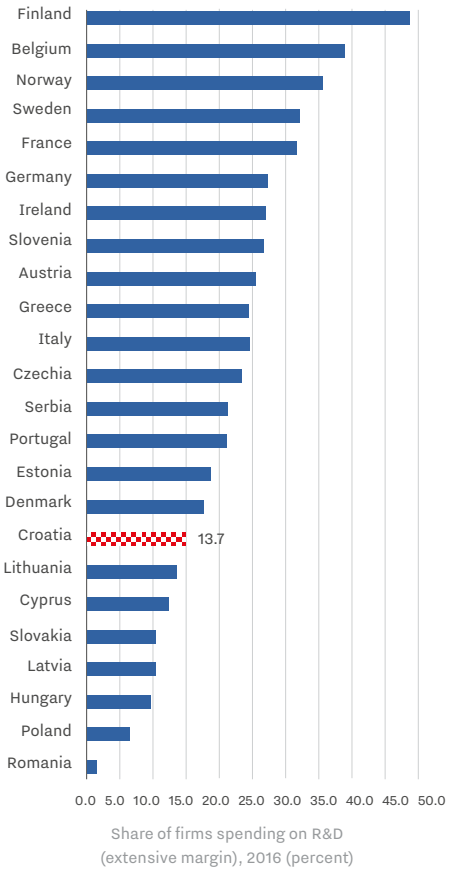


Source: European Innovation Scoreboard 2018.
Note: Values along the vertical axis represent R&D expenditures in the business sector (as a percentage of country GDP) in 2018 relative to the EU average in 2011. For example, in 2018, Croatia spent only 29.2 percent of the average 2011 EU business expenditures on R&D. Values along the horizontal axis represent non-R&D innovation expenditures (as a percentage of turnover) in 2018 relative to the EU average in 2011. For example, in 2018, Croatia spent 183.4 percent of average 2011 EU non-R&D innovation expenditures.

4 See Appendix I for a more detailed analysis of types of innovation introduced by Croatian firms.

FIGURE 1.14

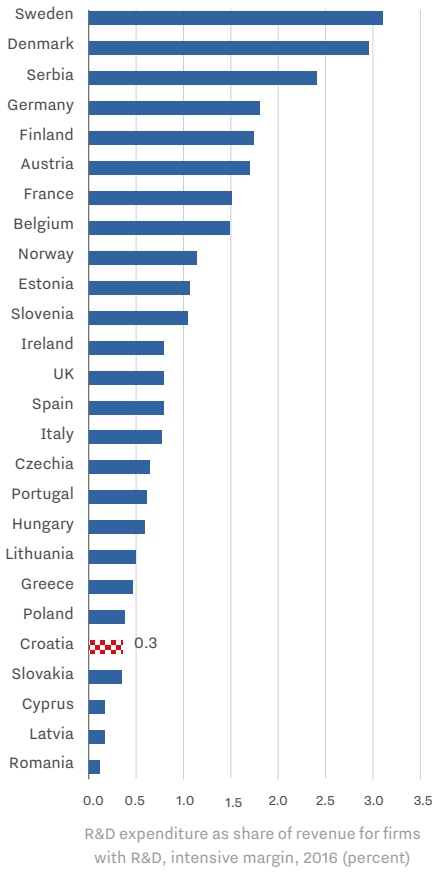
The share of Croatian firms spending on R&D is below that of most European countries...



Source: Staff calculations based on Community Innovation Survey data.

FIGURE 1.15

... and the share of revenue firms spend on R&D is among the lowest in Europe



Source: Staff calculations based on Community Innovation Survey data.

Few Croatian firms spend on R&D, and they do not spend much. Firm-level data from the Community Innovation Survey suggests that Croatia's low R&D spending is driven by both a scarcity of firms spending on R&D (a low extensive margin) and those firms' low spending (a low intensive margin). Figure 1.14 shows the share of Croatian firms spending on R&D (the extensive margin), while Figure 1.15 shows the share of revenue spent on R&D by firms with R&D spending (the intensive margin). About 14 percent of Croatian firms with over five employees spend on R&D, compared to 21 percent in the Czech Republic and 24 percent in Slovenia. The share of Croatian firms spending on R&D is below that in most EU countries. The share of revenue they spend is even lower. Croatian firms with R&D spending spend on average 0.3 percent of their revenue on R&D, among the lowest levels of R&D spending in Europe.

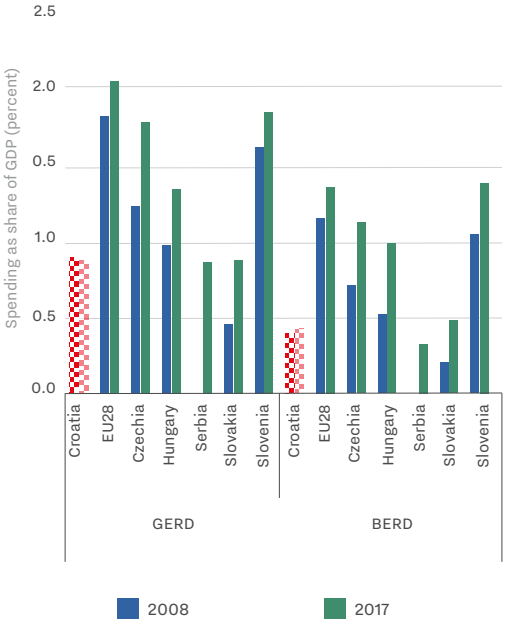
R&D expenditure has stagnated or even declined in recent years. Gross expenditure on R&D (GERD) and business expenditure on R&D (BERD) have grown modestly. Figure 1.16 shows BERD between 2008 and 2016. In 2016, Croatia spent 0.86 percent of its GDP on R&D, which is 2.3 times lower than the average in the EU-28 and Slovenia. This is almost the same level of GERD as before the global financial crisis – the corresponding figure was 0.88 percent in 2008. Other data sources, such as the Community Innovation Survey, suggest that R&D even declined between 2008 and 2016.

This lack of growth was not driven by fewer firms investing in R&D, but by a decrease in average spending. Figure 1.17 decomposes growth in R&D by whether it was driven by an increase in the number of firms investing (the extensive margin) or by a change in the average amount invested by a firm (the intensive margin).[5] The decomposition suggests that the decrease in R&D spending was driven solely by a decrease in the average amount spent by firms, rather than fewer firms spending. This contrasts with other countries, where R&D spending increased mostly due to an increase in the average amount spent.

Large firms are more likely than small firms to spend on R&D, but they do not spend more. Large firms are an important source of R&D expenditure, contributing to 65 percent of overall R&D expenditure in 2016. Figure 1.18 shows the share of firms spending on R&D by size category, while Figure 1.19 shows the share of revenue spent on R&D. Among large firms (those with over 250 employees), 38 percent spend on R&D, compared to 19 percent of medium-sized firms (those with 50–249 employees) and 11 percent of small firms (10–49 employees). These shares are lower than what is seen in most of the peer countries, but higher than in Slovakia. However, firms with R&D spending spend relatively low amounts, and this holds true for all size categories: the share of revenue spent on R&D ranges between 0.3 and 0.5 percent.

FIGURE 1.16

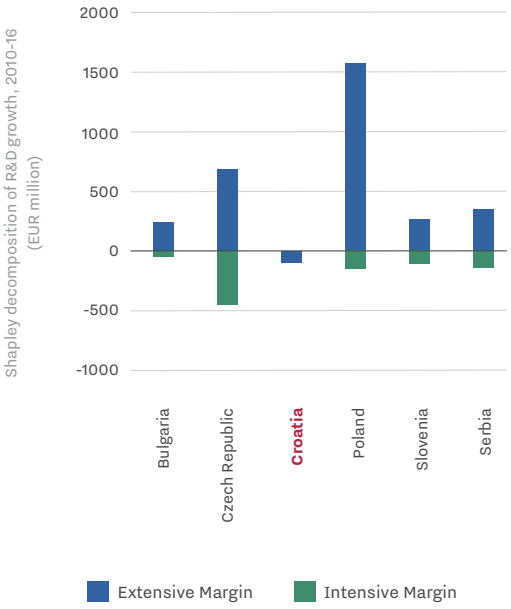
Gross expenditure on R&D (GERD) and business expenditure on R&D (BERD) have stagnated compared to other EU countries



Source: Eurostat. The numbers refer to the value for 2017.

FIGURE 1.17

The stagnation has been driven by a lack of growth of both the extensive and intensive margin

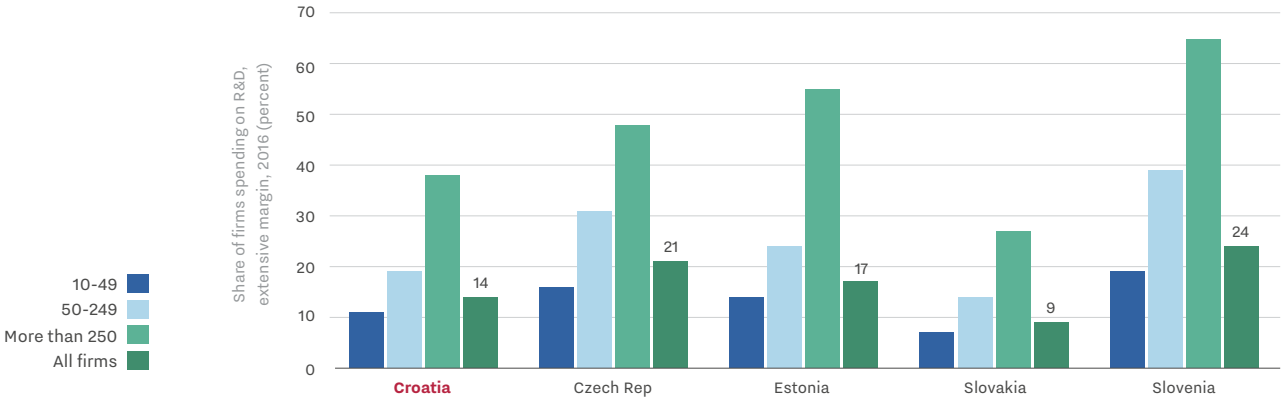


Source: Staff calculations based on Community Innovation Survey data.

5 The decomposition used is an adapted version of the Shapley decomposition, which decomposes the observed change ΔY into the difference attributable to a change in the number of innovating firms Δn and a change in the average amount spent Δ $\bar{y}$:

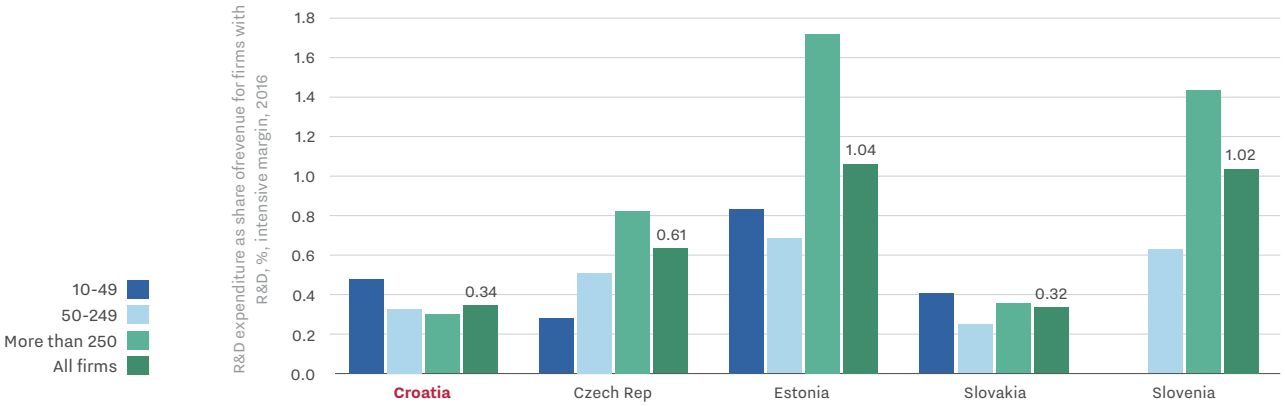
$$\Delta Y = \Delta n \times \frac{\bar{y}_2 + \bar{y}_1}{2} + \bar{y} \times \frac{n_2 + n_1}{2}$$

FIGURE 1.18 *Large firms are more likely to spend on R&D than small firms…*



Source: Staff calculations based on Community Innovation Survey data.

FIGURE 1.19 *…but large firms with R&D spending are not spending a higher share of their revenue*



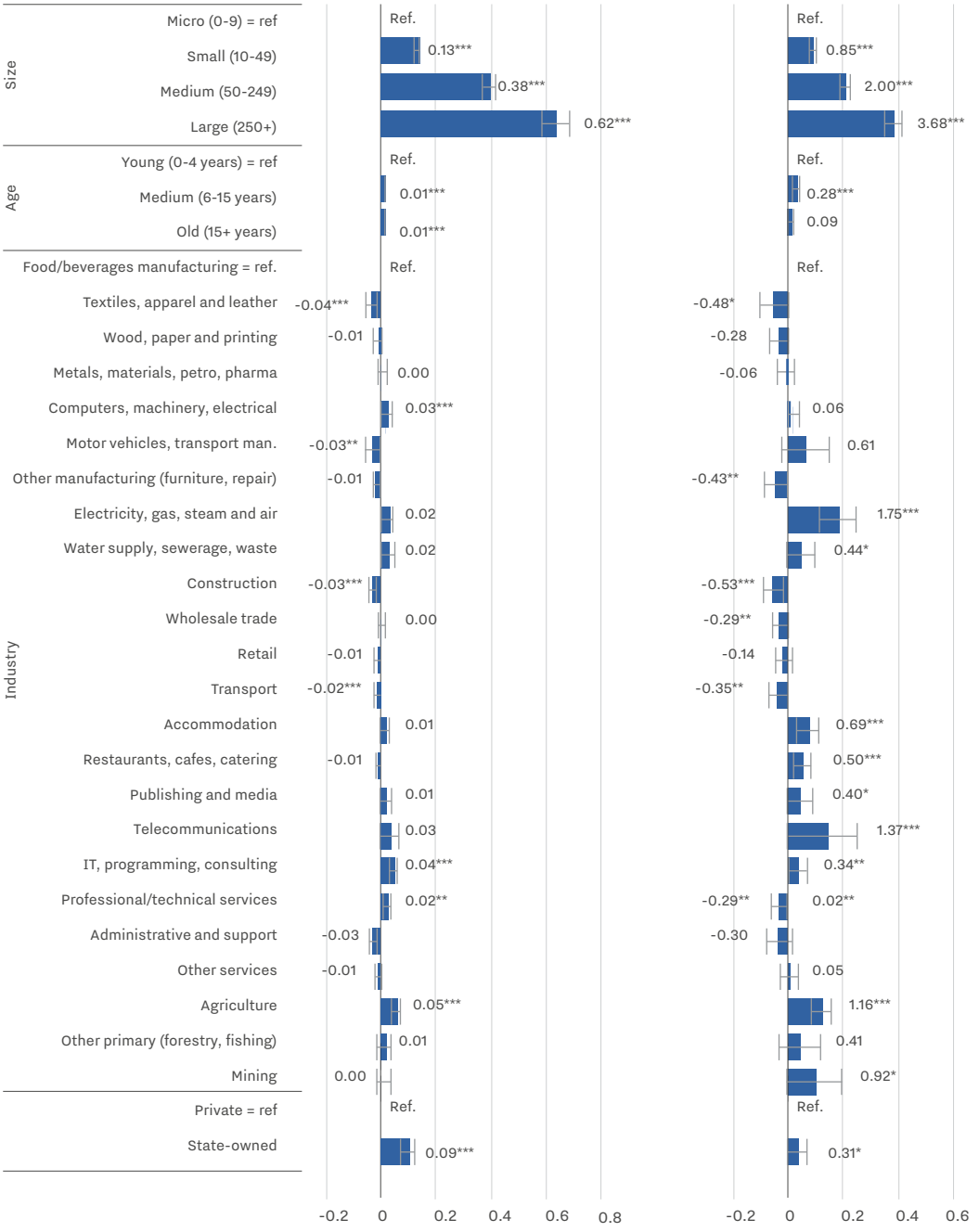
Source: Staff calculations based on Community Innovation Survey data.

Regressions confirm the importance of firm size as a determinant of R&D spending. Innovation spending data from financial reports maintained by FINA, which capture investment in R&D and other intangible assets (such as patents, software and biological assets[6]), show that firm size, age and sector are important characteristics determining spending on R&D and other intangible assets. Figure 1.20 presents results from a regression of firm characteristics on whether a firm spends on R&D (the extensive margin) and the amount spent (the intensive margin). Large firms are more likely to invest, and they spend more.[7] Older firms and state-owned firms are also more likely to spend on R&D and to spend more than younger firms and privately-owned companies. Industries that are more likely to spend include computer manufacturing, telecom and programming, professional and technical services, and agriculture.

6 The analysis presented here is based on financial accounts indicator AOP282 ("Gross investment in other tangible assets and intangible assets (biological assets, investments in research and development, software, databases and other intangible assets)"), which is available from 2016 onwards. Unlike the Community Innovation Survey, the financial accounts data does not allow separating R&D investments from investments in biological assets or other intangible assets.

7 Even though Figure 1.19 suggests that if we control for size (for example, by dividing by revenues), large firms do not proportionally spend more on R&D than smaller sized firms.

FIGURE 1.20 *Determinants of R&D expenditure: large firms are more likely to spend on R&D and other intangible assets, and they spend more*



*Note: the reported coefficients are from a linear regression of an indicator variable indicating positive expenditure (left) and the natural logarithm of the amount invested (right). The error bars indicate the 95% confidence intervals. *** p < 0.01, ** p < 0.05, * p < 0.10. Source: Staff elaborations based on FINA data.*

1.3 Innovation and Productivity Growth

- Among Croatian firms, there is a positive relationship between expenditure on R&D and other intangible assets and productivity growth: firms that spend on R&D have higher TFP.
- This relationship is the strongest for micro-sized and young firms, which see the largest increases in productivity when they spend on R&D and other intangible assets.

Innovation is an important contributor to productivity growth. Inventing new technologies and adopting existing technologies allow firms to improve their production processes and increase efficiency and productivity. On a global level, roughly half of productivity growth can be attributed to firms adopting new technologies, products and processes (Cirera & Maloney, 2018).

From a methodological viewpoint, precisely attributing productivity growth to R&D investments is challenging. There are several reasons. First, not all R&D investments lead to immediate productivity gains. Some investments fail, while others take longer to materialize. Second, productivity growth is achieved through many other means, often interacting with R&D investments. A positive relationship between R&D investment and productivity growth does not necessarily imply that the productivity growth was solely driven by the R&D investment. Firms that invest in R&D might also have other characteristics that contribute to productivity growth, such as qualified and highly skilled personnel, good management practices or state-of-the-art technology. There is a growing literature suggesting that such complementary factors are important for innovation, both as enablers and as catalysts. Data is not available for some of these factors. Any found relationship between R&D and productivity growth is likely overstated and should not be given a strict causal interpretation.

Firms that invest in R&D and other intangible assets have higher productivity growth. Regressions using firm-level data suggest positive effects on both the extensive margin and the intensive margin. A regression of TFP growth on whether a firm invests in R&D (column 3 in Table 1.2) shows that firms that invested saw a 2.0 percent higher growth in TFP compared to firms that did not. Similarly, for firms with investments in R&D and other intangible assets, a 1 percent increase in investment in R&D is associated with a productivity growth of 0.6 percent (column 4 in Table 1.2).[8]

Micro-sized firms and young firms see the greatest increases in productivity when investing in R&D and intangible assets. Figure 1.21 shows how much TFP increased for firms investing in R&D and intangible assets among different size firms. Figure 1.22 shows how much TFP increased for firms investing in R&D and intangible assets among firms of different ages. The productivity increases on the extensive margin were largest for micro firms (2.6 percent for those investing in R&D, compared to those who did not). Young firms with R&D investments saw the greatest increases in TFP (6.7 percent, compared to young firms who did not), while for older firms the productivity increases were minimal.

8 Column 1 of Table 1.2 suggests that there might be some selection bias – firms that spend on R&D and other intangible assets are more productive than those that do not. However, Column 2 suggests that this does not hold on the intensive margin – firms with higher spending are not necessarily more productive than firms with lower spending.

TABLE 1.2 *Partial correlations between R&D spending and TFP gains (2017)*

	TFP		TFP Growth	
	(1) Extensive margin	(2) Intensive margin	(3) Extensive margin	(4) Intensive margin
Firm invests in R&D and other intangible assets (0/1, in 2016)	0.0182** (0.00846)		0.0201*** (0.00593)	
Log amount of investment in R&D and other intangible assets (in 2016)		-0.0196*** (0.00442)		0.00554** (0.00276)
Controls	Yes	Yes	Yes	Yes
Observations	63530	6994	54144	6792
R-squared	0.197	0.259	0.010	0.023
Adjusted R-squared	0.196	0.256	0.010	0.019

*Standard errors in parentheses. * p<0.10, ** p<0.05, *** p<0.01.*
Controls include firm age, firm size, sector and ownership.
Source: Staff calculations.

FIGURE 1.21
Micro-sized firms benefit most from investment in R&D and other intangible assets

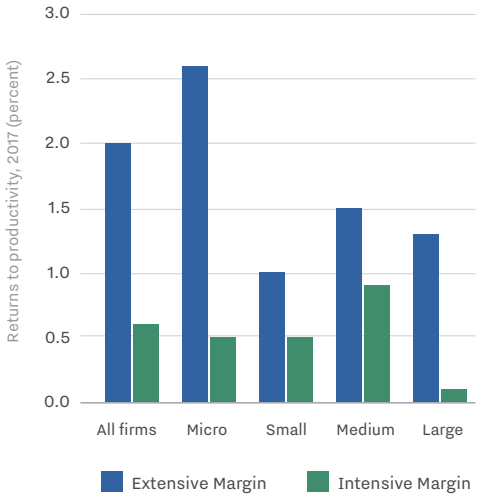
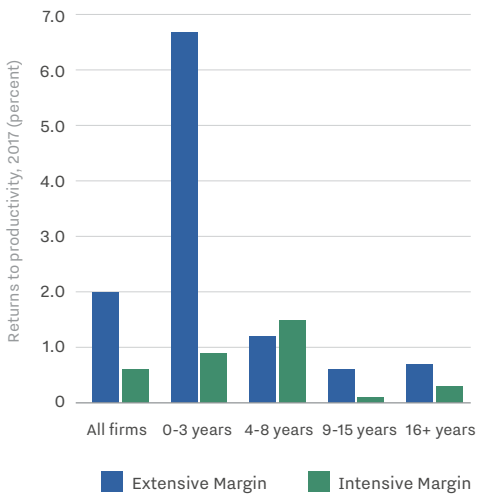


FIGURE 1.22
Young firms see the highest returns on spending on R&D

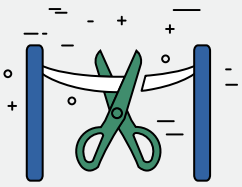


Source: Staff calculations based on FINA data.
Note: The reported figures are partial correlations estimated from a regression of TFP growth on investment in R&D and other intangible assets, controlling for firm age, size, industry and ownership.

At the intensive margin, returns on R&D spending are highest for medium-sized firms and slightly older firms. Among firms that spend on R&D and other intangible assets, productivity returns are the highest for medium-size firms; firms of 50–249 employees saw an increase of 0.9 percent in TFP for each 1 percent increase in investment in R&D and other intangible assets. By firm age, the highest productivity returns on investment in R&D and other intangible assets were among firms aged between 4 and 8 years.

This analysis suggests that firm innovation and investment in R&D can increase productivity. However, as the analysis in the previous sections has shown, innovation spending, especially in R&D, has been lagging in Croatia. A targeted policy approach aimed at improving the innovation capabilities of firms could boost firm productivity and set Croatia back on a trajectory converging toward the global productivity frontier. Moreover, boosting productivity would help diversify the economy and exports and create better jobs.

1.4 Market Conditions – Allocation of Resources, Business Environment and Competition



- Croatia lags peers in most benchmarks measuring business environment and market competition.
- Key elements of the market framework – such as firm entry and exit, access to finance, and state presence – remain problematic.
- The effects of the shift in state aid from specific sectors toward regional development and SMEs remain to be seen. There is a risk that resources will end up in less productive firms, distorting the market and delaying reallocation.

Misallocation of resources – the main driver behind Croatia's weak productivity in recent years – can be attributed to an unfavorable business environment and lack of market competition. In an efficient market economy, market resources shift from less to more productive firms. New and innovative firms are often more productive than existing ones, and less productive firms are forced to exit the market. In Croatia, evidence suggests that, since 2010, resource reallocation, especially between incumbent firms, has dampened productivity growth. At the same time, the lack of R&D-driven innovation limits the impact that firms' efforts to upgrade have on aggregate productivity.

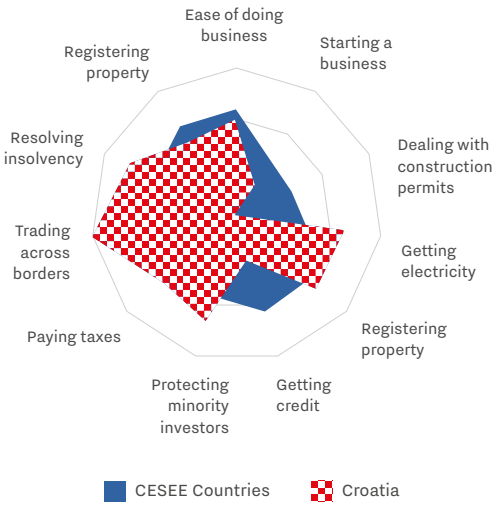
Croatia lags peers in many business environment rankings.[9] Croatia's overall ranking in *Doing Business 2020* is 51st, improving seven places from last year. Nevertheless, Croatia continues to lag Central, Eastern and Southeastern European (CESEE) countries on major Doing Business indicators, including starting a business, dealing with construction permits, access to credit and resolving insolvency (Figure 1.23). Firm entry in Croatia has improved in the past year, but still ranks poorly, in 114rd place, with seven procedures that typically take 19.5 days and cost 6.2 percent of income per capita. This is more burdensome than in the Europe and Central Asia (ECA) region on average and almost double the average of OECD countries. A recent World Bank study suggests that business registration reform in Serbia increased the number of new firms by up to 34 percent and that the effect of the reform was larger in regions with high distrust in courts than in regions with low distrust in courts (Bruhn, et al. 2018). The World Economic Forum (WEF) ranks Croatia 63rd of 141 countries, among the lowest of EU Member States (Figure 1.24).[10] Croatia ranks 101st on business dynamism, its lowest rank on any indicator.

9 According to the analysis of the Survey on firm-level productivity in Croatia, the most commonly reported obstacles for firm growth include high taxes, excess government procedures, lack of credit, and the qualifications, availability and costs of the workforce (see Appendix I for further details).

10 World Economic Forum - Global Competitiveness Report 2019. European countries include: AL, AU, BA, BE, BG, CH, CY, CZ, DK, EE, FI, FR, GE, GR, HR, IR, IS, IT, LT, LU, LV, ME, MK, MT, NE, NO, PL, PR, RO, RS, SE, SI, SK, SP, TR, and UK.

FIGURE 1.23

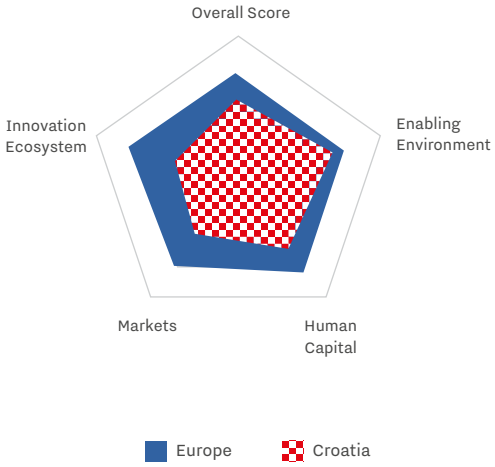
Croatia lags CESEE countries on several key Doing Business indicators



Source: Doing Business 2020.
Note: The outer perimeter reflects the top ranking, while values closer to the center reflect lower rankings

FIGURE 1.24

The WEF Global Competitiveness Index shows that Croatia is behind the EU in all aspects



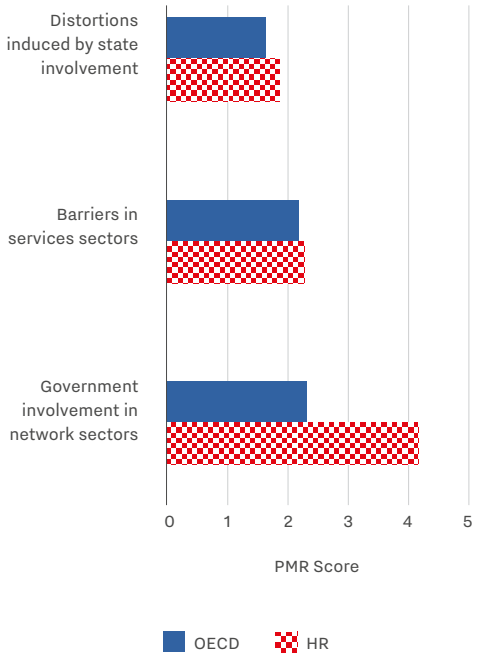
Source: WEF Global Competitiveness Report 2019.
Note: The outer perimeter reflects the top ranking, while values closer to the center reflect lower rankings

Despite recent progress, Croatia has space to further improve its insolvency law. Figure 1.23 shows that Croatia has an inefficient insolvency framework. An inefficient insolvency framework impedes businesses from exiting and re-entering markets. Firms' inability to exit and re-enter markets, in turn, contributes to the significant misallocation of capital in Croatia. Well-structured and simple bankruptcy and insolvency regimes are important to enable market re-entry of entrepreneurs who have failed in a business activity. According to *Doing Business 2020*, Croatia ranks 63rd of 190 economies on the ease of resolving insolvency. The ranking has deteriorated compared to its 2018 rank (60th) and is diverging from its 2017 and 2016 ranks (54th and 57th respectively). Resolving a sample insolvency case at the Zagreb Commercial Court takes 3.1 years and costs 14.5 percent of the claim value. Croatia scores 12 of 16 points in the Quality of Judicial Processes Index. Croatia recently amended its insolvency law in response to the financial crisis. Although there is room for improvement, there seems to be a consensus that it would be better not to change the law again in the short term, to avoid reform fatigue.

Croatia is approaching the OECD average when it comes to product market regulation, but certain areas remain problematic. Comparing Croatia's results on the OECD's Product Market Regulation (PMR) rankings in 2013 and 2018 is difficult due to a change in methodology. However, the fact remains that Croatia's PMR score (1.45) has converged significantly with the OECD (1.4) and CEE (1.39) averages. State involvement remains an issue. Croatia's score on distortions induced by state involvement is 13 percent higher than in the OECD (Figure 1.25) and 18 percent higher than in CEE. This is expected to a certain extent given the state's strong presence in Croatia's economy. There have been attempts to make progress on deregulating services, but overall, there is a lot of room for improvement. Croatia's score on barriers in services sectors is 4 percent higher that of the OECD. Certain restrictions on the professions of engineering, architecture, the law, accounting, and so on

FIGURE 1.25

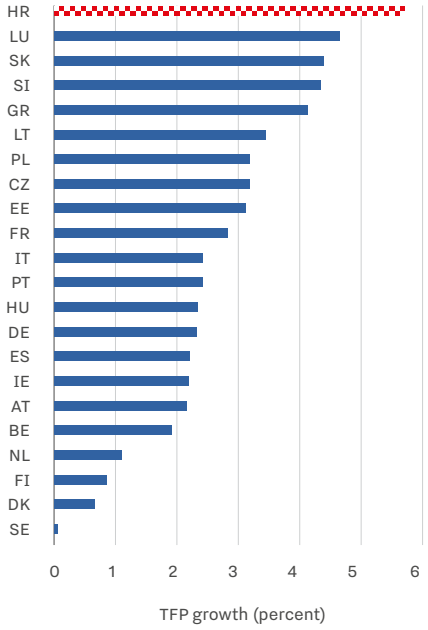
Croatia continues to have strong state presence and regulated services sector



Source: OECD PMR 2018.

FIGURE 1.26

Estimated impact of reducing service regulatory barriers on TFP growth, based on PMR data 2013



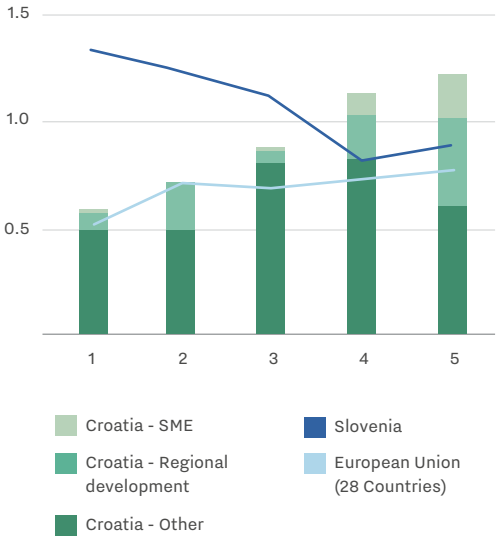
Source: OECD PMR, WB EU Regular Economic Report, van der Marel, Kren and Iootty 2016.

have been removed. However, Croatia has over 300 regulated professions, so much more progress can be achieved. A World Bank study based on the 2013 PMR data suggests that reducing regulatory restrictions on services would have a sizable impact. In particular, reducing overall restrictions on the service sector in Croatia would result in over 5.7 percent productivity gains, more than in any of Croatia's EU peers (Figure 1.26).

With the availability of ESIF, state aid has increased significantly in Croatia and shifted from sectoral focus to regional development and SME support, without evidence of its effectiveness. Croatia adopted the 2005 State Aid Act and related bylaws in preparation for EU accession. State aid has increased in recent years, becoming more concentrated in regional development and SME support policies. Between 2013 and 2017, total state aid in Croatia (excluding railways) rose from EUR 259.9 million to EUR 597.7 million. State aid in 2017 corresponds to 1.23 percent of GDP, compared to 0.76 percent on average in the EU-28 – the eighth highest among EU members. Over the same period, state aid for rescue and restructuring declined from 0.19 to 0.07 percent of GDP, reflecting shipbuilding and steel reforms. Support for regional development, SMEs and culture rose steadily (Figure 1.27). By 2017, 33 percent of Croatia's state aid (0.41 percent of GDP) was allocated for regional development, 17 percent (0.21 percent of GDP) for SME support including risk capital, and 10 percent (0.13 percent of GDP) for culture. To a good extent, the increase in so-called "risk" capital (as defined by the State Aid Scoreboard of the EC) is due to the extensive use of the *de minimis* rule in innovation support programs. Data confirms that Croatia has included more firms in the support network with an average lower ticket (Figure 1.28). Average spending per firm decreased 55.3 percent between 2009 and 2017, whereas the number of firms

FIGURE 1.27

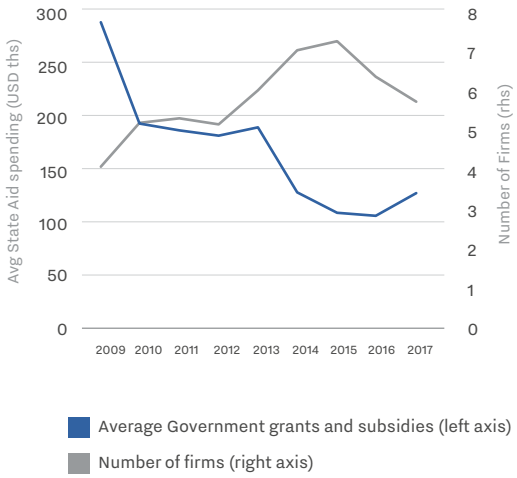
Total state aid spending (excluding railways) has shifted toward regional development and SME support



Source: Staff elaboration based on European Commission State Aid database.

FIGURE 1.28

There has been an increase in the number of firms supported and a decline in the average amount of state aid granted per firm



Source: Staff elaboration based on FINA data.

supported increased by 44.5 percent in the same period. However, the trend has reversed in recent years.

The contribution of Croatia's state aid to aggregate productivity growth is unclear. The main risk is that resources allocated to regional development or SME support might postpone more efficient reallocation of resources by artificially extending the survival of less productive firms. This possibility is not negligible. Such policies very often aim to help less productive firms survive rather than to enable innovative young firms to grow. Also, state aid regulations are conceived to mitigate the distortionary effects of member state policies on the European market but not the distortions and sources of misallocation that may occur in domestic markets. Moreover, most state aid programs fall under the general block exemption regulation, which, by eliminating ex-ante approval by the EC, may weaken the capacity of EC state aid rules to minimize distortions on competition.[11] Not surprisingly, a recent study has shown that reduced financial pressure – in part, but not only, related to lower interest rates – has increased the number of 'zombie' firms[12] in Europe (Banerjee and Hofman 2018).

11 According to the 2018 EC State Aid Scoreboard, member states spent almost half of their total spending on general block exemption measures, an increase of 13 percent since 2013.

12 Firms that are unable to cover debt servicing costs from current profits over an extended period.

1.5 Access to Finance for Innovation

- Innovation requires a wide variety of financing mechanisms to support business activities from idea to commercialization.
- Croatia's financial sector is dominated by banks whose business models preclude them from taking risks inherent to innovation. The financial sector favors established firms with credit histories and sufficient collateral.
- In Croatia, the main gap in access to finance for innovation occurs at the early development stage because there is no scope for traditional financing models and virtually no early-stage venture capital activity.
- The lack of a market for early-stage financing can be attributed to unfavorable regulatory conditions, weaknesses in the innovation pipeline, and investment readiness of start-ups.
- To bridge the gap in early-stage financing, policymakers should provide a targeted financing mix tailored to each stage of the innovation process and invest in the investment readiness of start-ups. As a long-term objective, developing a private early-stage financing market will require building up the innovation pipeline and reducing the regulatory burden on the establishment of venture capital funds.

Inadequate access to finance is one of the unfavorable market conditions that hamper resource reallocation and productivity growth. Unfavorable framework conditions in Croatia's financial sector hamper its ability to act as the main vehicle for resource reallocation in the economy. This section explores the main obstacles to obtaining finance for innovation in Croatia and how they contribute to the misallocation of resources toward less productive economic actors.

A vibrant business innovation ecosystem requires access to a variety of financing options that can support firms during all parts of their life cycles and all stages of the innovation cycle, from idea to commercialization. The relationship between innovation and financing has been extensively studied. Firms have different financing needs depending where they are in their life cycles and the sectors in which they act (Figure 1.29). Small firms and knowledge-based start-ups cannot access traditional credit markets due to uncertain revenue streams and lack of collateral, making them dependent on angel investors, venture capital, and similar forms of equity finance. Large firms may use their own funds, debt finance, and capital markets to finance R&D and innovation, but they should balance these long-term investment decisions with the short-term interests of company management and investors. The types of financing available for innovation should be carefully tailored to reach an optimal mix of grant financing and financial instruments. Firms tend to prefer grants, and overuse of grants in the policy mix poses a risk of crowding out other types of investment. Grants should be used to build up the innovation pipeline at the idea and seed stage, while equity, quasi-equity, mezzanine finance and lending should support subsequent stages.

The availability of early-stage financing is critical for the survival and growth of innovative start-ups. Early-stage financing not only provides operational funds but can also build capacity and accelerate market readiness. Start-ups typically go through extended periods of low or no revenue coupled with intensive investments in product development and slow build-up of a customer base.

FIGURE 1.29 *Firms require a variety of financing options depending on where they are in their life cycles*

	 IDEA	 START-UP	 SCALE-UP	 INCUMBENT
Characteristics	Negative cash flows due to intensive investment and build-up of customer base.		Fast growth requiring flexible financing and soft support.	Positive cash flow Access to collateral Access to capital markets
Financing options	**Seed funding** Own funds Co-founder Personal networks	**Early-stage financing** Business angels Venture capital (VC) Crowdsourcing	**Late-stage financing** Non-bank financial corporations Private equity Banks	**Capital markets** Banks Institutional investors The public
Financial products	**Grants** **Equity**	**Equity** **Grants** **Venture debt**	**Equity** **Hybrid financing** **Debt (loans and loan guarantees)**	**Equity** **Debt (loans and loan guarantees)**
Policy considerations	Support research excellence and technology transfer activities Foster entrepreneurship and risk-taking Facilitate business entry	Foster pipeline of innovation and investment readiness Public support in VC (direct investment, co-investment or fund-of-funds) Business angel networks	Tax incentives	Develop capital market depth

Source: Staff elaboration based on Cirera (forthcoming).
Note: This is a stylized representation of financing needs at different stages of the life cycle. In practice, demand for different finance types varies from firm to firm, and different instruments and policy considerations may overlap between different stages.

The purpose of early-stage financing should be to bridge this extended period of negative cash flows (the "valley of death")[13] and eventually bring the start-up to a point where they may access capital and debt markets. VC investments not only provide financing but are also associated with upgrades in governance and professionalization of human resource and marketing functions (Hellmann and Puri 2002). This can help the start-up grow further and set it on the path to financial sustainability.

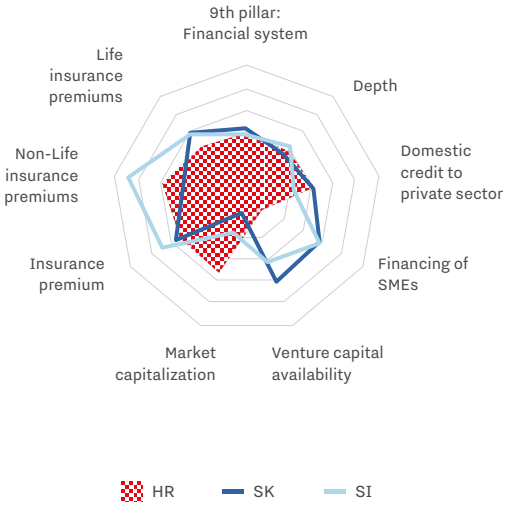
13 The term "valley of death" refers to the period in the life cycle of a start-up characterized by a lack of steady revenue, increasing the probability of failure.

A variety of market failures constrain innovation financing. They stem from information asymmetries between investors and innovators and the substantial risk of failure inherent in innovation. Innovators have an incentive not to disclose information due to concerns about appropriation (that is, competitors benefiting from their innovations). At the same time, private financing is often unwilling to accept the long-term commitment and substantial risk of failure necessary to bring an idea to market. Traditional bank financing requires high-quality collateral and a stable revenue stream, which newly established companies cannot secure. Similarly, equity markets require much more information disclosure and proven marketability of the innovation output.

Croatia's bank-centric financial system caters mostly to incumbent firms, making access to finance for innovation difficult. The WEF ranks Croatia poorly in terms of the depth of its financial system (Figure 1.30), particularly in SME financing (104th) and VC availability (106th). Deposit institutions and institutional investors dominate the financial system (Figure 1.31). These institutions are constrained by design in the risks they may undertake. Pension funds invest two-thirds of their assets in government securities due to regulatory requirements and restrained engagement in private capital investments. Neither insurance companies nor money market and investment funds have significant shares of assets invested in the corporate sector. Assets of private equity funds make up less than 0.3 percent of GDP, and angel investments are almost non-existent. Access to finance is the most pressing concern for 11 percent of Croatian SMEs, more than in the EU overall (7 percent) and more than in most peer countries.[14]

FIGURE 1.30

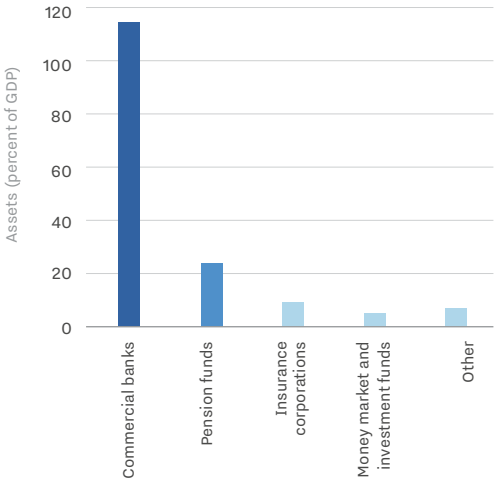
Croatia ranks poorly in terms of SME financing and VC availability



Source: WEF Global Competitiveness Report 2019.
Note: Values closer to the outer perimeter reflect a higher ranking, while values closer to the center reflect a lower ranking.

FIGURE 1.31

The financial sector in Croatia is dominated by banks offering mostly risk-averse collateral-based financing

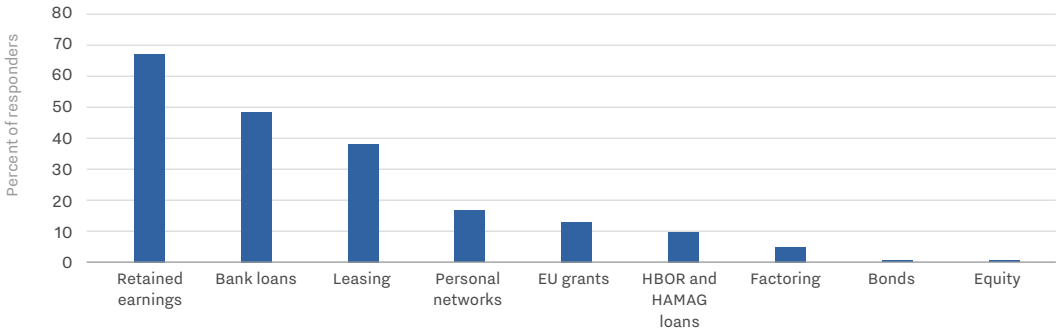


Source: Croatian National Bank (CNB) and staff calculations.

14 ECB, Survey on Access to Finance of Enterprises (SAFE), 2018.

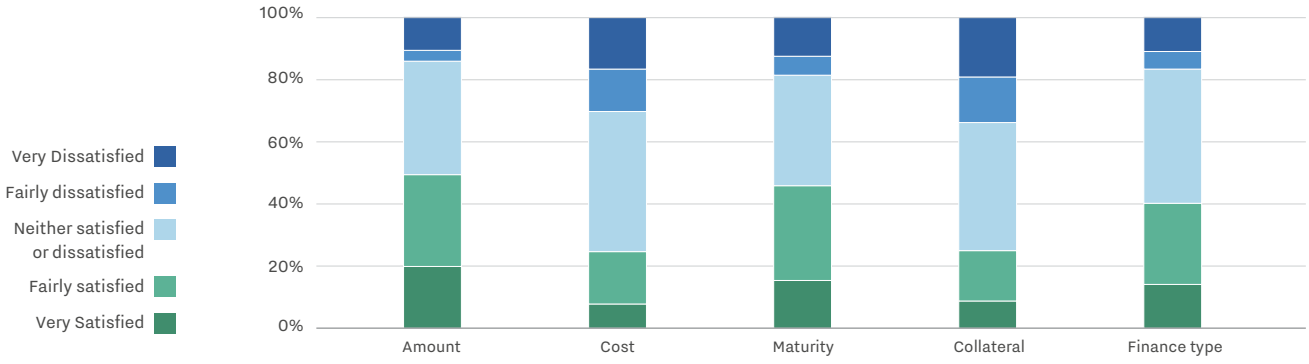
Bank loans and leasing are the most common sources of external financing for Croatian SMEs, but they are not suited for innovation projects. In a survey conducted by the World Bank in Croatia in 2019,[15] over two-thirds of firms had used retained earnings for their business activities in the past year. Almost half of them had a bank loan, and there were no equity investments (Figure 1.32). The high cost of capital and collateral burdens are reflected in the fact that almost a third of respondents were fairly dissatisfied or very dissatisfied with these aspects of external finance (Figure 1.33).

FIGURE 1.32 Croatian SMEs mostly rely on internal sources of finance and bank loans



Source: World Bank, Survey on firm-level productivity, 2019.

FIGURE 1.33 *Cost and collateral requirements are the main causes of concern for Croatian SMEs*



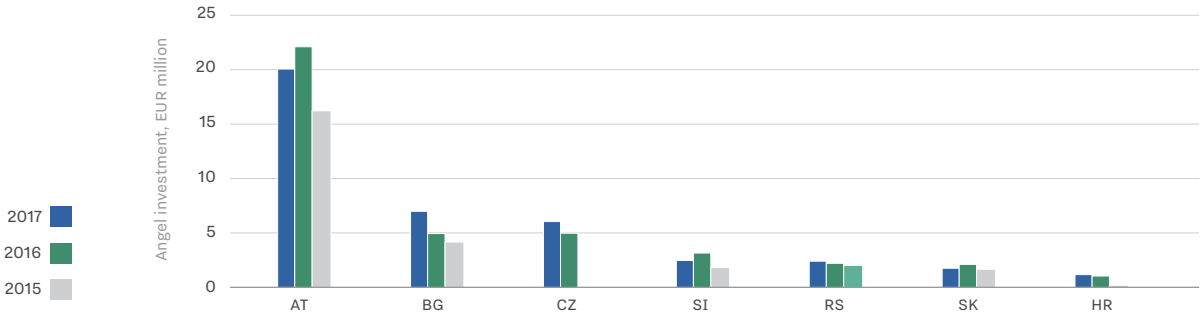
Source: World Bank, Survey on firm-level productivity, 2019.

The market for early-stage financing in Croatia is underdeveloped. There is very low business angel or VC activity. Croatia's sole business angel network (CRANE) includes 27 business angels who invest EUR 25 to 250 thousand in individual or syndicated investments. In 2017, there were four visible[16] business angel investments in Croatia amounting to EUR 1.1 million (Figure 1.34). This puts Croatia at the bottom of business angel investments compared to peers (EBAN 2017). Business angels cited

15 World Bank, Survey on firm-level productivity, 2019. See also Appendix I for further details on sources of financing of Croatian firms.

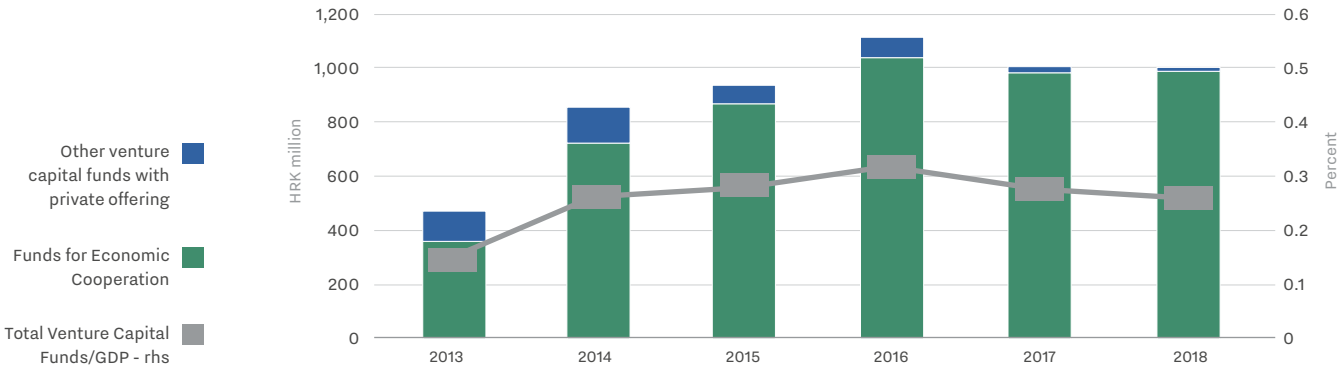
16 Visible angel investments are those that were reported through a business angel network. According to EBAN, the visible market is estimated at 10 percent of the total market.

FIGURE 1.34 *Visible business angel investments in Croatia are very low*



Source: EBAN, 2018.

FIGURE 1.35 *The assets of VC funds in Croatia are declining*



Source: Croatian Financial Service Supervisory Agency (HANFA) and staff calculations.

elevated risks and overly high valuations as the main reasons for not investing in the past five years. Similarly, the capacity of risk capital funds to provide a significant boost to early-stage financing is low, given that their total assets are below 0.3 percent of GDP and declining (Figure 1.35). Most of the assets of risk capital funds in Croatia are concentrated in five Economic Cooperation Funds (ECFs) managed by four asset management companies. These are open-ended investment funds with private offerings whose establishment was regulated by a special act with the aim to improve access to finance for SMEs with joint private and public (HBOR) funds. However, these funds are de facto private equity funds, investing in more mature medium-sized enterprises with stable cash flows. According to a survey conducted by the Croatian Bankers' Association (HUB) in 2015, ECFs made 22 investments, in the amount of HRK 892.4 million, of which 72 percent pertained to expansion and restructuring (HUB, 2015). The average investment in start-ups was HRK 31.3 million (around EUR 4 million), indicating a bias toward later-stage financing.

One reason for the lack of early-stage finance is the unfavorable regulatory environment. Recently enacted legislation on alternative investment funds transposed EU regulation[17] but retained burdensome provisions that hamper the establishment of investment vehicles for early-stage financing. Unlike

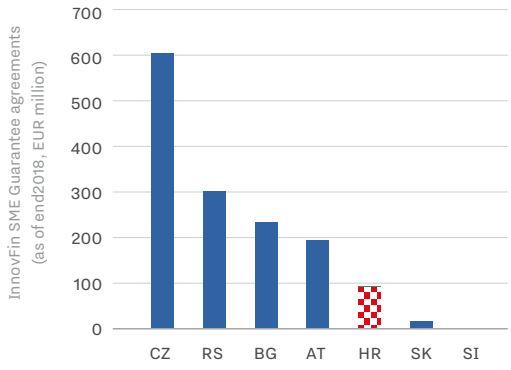
17 Directive 2011/61/EU of the European Parliament and of the Council of 8 June 2011 on Alternative Investment Fund Managers.

the EU directive, which imposes requirements only on funds exceeding a size threshold, the Croatian Act on Alternative Investment Funds (AIFs)[18] recognizes small- and medium-sized funds – which it exempts, to varying degrees, from requirements imposed on large funds. The law also excessively restricts the legal form of AIFs, which has adverse tax implications and discourages establishing AIFs with foreign capital. Corporate governance requirements are unnecessarily burdensome and not in line with international best practices, discouraging the establishment of AIFs in Croatia.

Besides supply-side deficiencies, the lack of early-stage financing in Croatia is symptomatic of issues with the investment readiness of start-ups. Entrepreneurs are often unwilling to surrender their ownership stakes or even partial control of their firms. Even when they do seek external finance, they might have internal deficiencies (such as issues with the team, marketing, strategy or intellectual property) or lack of pitching skills that prevent them from attracting investors (Mason and Kwok 2010). A 2018 investment readiness program in Croatia and four Western Balkan countries aimed to help start-ups improve financial plans, product pitches, market strategy, and willingness to take equity financing. Start-ups from the treatment group received higher investment readiness scores at a subsequent presentation event and were more likely to be selected to pitch to investors (Cusolito, Dautovic and McKenzie 2018).

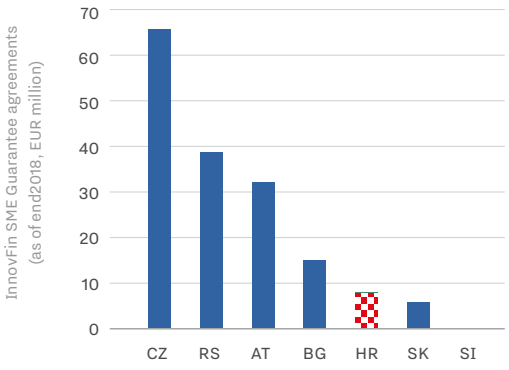
The weakness of the innovation pipeline is also reflected in low participation in EU-funded financial instruments. The European Investment Bank (EIB) and European Investment Fund (EIF) offer a variety of financing for RDI that includes debt support (in the form of guarantees) and equity (either directly or through financial intermediaries). Croatia's participation in InnovFin, the EIB and EIF scheme financing research and innovation, is limited to its SME guarantee, as in most peer countries. Four commercial banks were awarded portfolio guarantees in the amount of EUR 87.5 million (Figure 1.36), with only seven final recipients within the scheme (Figure 1.37). Section 3.2 addresses participation in other transnational EU programs financing innovation (mainly through grants).

FIGURE 1.36
Croatian participation in InnovFin SME Guarantee agreements is low



Source: EIF, 2019.

FIGURE 1.37
The number of beneficiaries of the InnovFin SME Guarantee is also low



Source: EIF, 2019.

18 Official Gazette 21/2018.

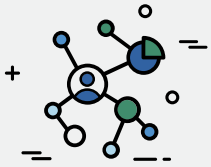
The Government of Croatia is attempting to close the gap in early-stage financing by launching a fund-of-funds in cooperation with EIF. The ESIF VC Fund received a EUR 35 million investment from European Regional Development Fund (ERDF) in 2018, to be invested in SMEs with high growth potential. The Fund features an Acceleration Compartment (which supports SMEs in researching, assessing, and developing their concepts) and a Venture Capital Compartment (which provides financing to successful graduates from the Acceleration Compartment, as well as direct investments in other early-stage innovative companies).

2 RESEARCH SECTOR

2 RESEARCH SECTOR

The productivity analysis in Section 1 identified misallocation of resources and insufficient R&D-driven innovation as the main factors behind Croatia's weak growth performance. Similarly, public research plays an important role in building a country's innovative capacity. By focusing on research excellence, public research institutions can accumulate knowledge and, through technology transfer and industry-science collaboration, transfer it to the private sector. This section explores the needs of Croatia's research sector by reviewing the enabling conditions in which it operates and assessing its science capabilities.

2.1 Current Research Setting



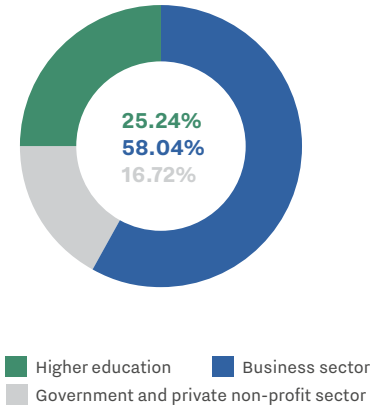
- The institutional complexity of the research sector, which consists of 123 public legal bodies, is unsustainable.
- Fragmentation and poor governance of institutions are at the root of inefficient coordination, weak science-business cooperation and moderate innovation results.
- Private firms have limited to no opportunities to tap into funding available to research organizations.
- Introduction of accountability principles – through quality reviews, evaluation, and performance orientation – is critical for improving research.

Supporting R&D and innovation has proven a good policy for countries' development and creating efficient framework conditions for the research sector is a key success factor. In addition to overall R&D funding, this includes care for infrastructure, human capital, and the institutional governance that shapes the processes and interactions of the main actors. The challenge that Croatia faces is how to advance its framework conditions so that the best performers can achieve their maximum and create spillover effects. This is essential for advancing Croatia's research system, which ranks among the last in the EU on the European Innovation Scoreboard.

Croatia's research sector, consisting of higher education institutions (HEIs), public research institutes (PRIs) and other research entities, continues to operate in an old setup unfavorable to innovation. The public research sector provides the basic infrastructure for conducting R&D, employing over 80 percent of all researchers and attracting a similar percentage of all students. HEIs are universities (*sveučilišta*), polytechnics (*veleučilišta*), and schools of professional higher education or colleges (*visoke škole*), including all their constituents (faculties, art academies, departments and institutes). There are 25 PRIs that operate independently. The fragmented structure of large higher education institutions (the universities of Osijek,[19] Rijeka, Split and Zagreb) and PRIs originates from the 1970s

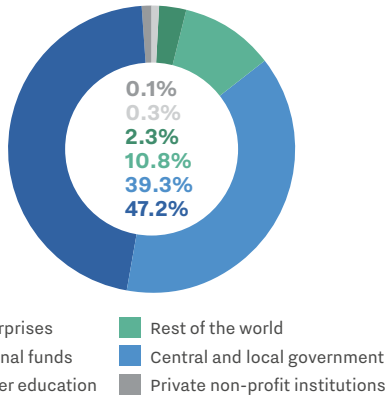
19 The universities of Osijek, Rijeka and Split are sometimes referred to as "semi-integrated" because they also include departments or constituents that are not legal entities.

FIGURE 2.1
The business sector dominates among R&D performing entities



Source: Croatian Bureau of Statistics, 2019.

FIGURE 2.2
R&D is mostly financed through internal funds and government funding



Source: Croatian Bureau of Statistics, 2019.

and has been firmly established. It is at the root of outdated features of public research and funding management, such as inefficient resource management (serving in total 123 public legal entities)[20] and weak incentives for science-business cooperation (which are unfavorable to innovation capacity building). The share of HEI constituents among entities performing R&D is 25 percent (Figure 2.1).

Government and the private non-profit sector depend on central government funds for over 70 percent of R&D financing, while enterprises predominantly rely on their own funds. Two sources fund close to 90 percent of all R&D in Croatia (Figure 2.2) – internal funds (with a share of over 47 percent) and central and local government funds (over 39 percent). Enterprises mostly finance R&D with internal funds (up to 83.1 percent), whereas government, private non-profit, and HEIs rely on central and local governments as the main source of financing (up to 70.5 percent and 78.1 percent respectively).[21] Almost half of all R&D spending is with the business sector (48.4 percent in 2017), which is the engine of competitiveness. The spending of higher education on R&D is significantly lower (29.3 percent), and the government and private non-profit sector spends 22.3 percent on R&D.

2.1.1 Higher Education Institutions

The institutional complexity of the Croatian higher education system impedes modernization. Higher education in Croatia is performed within two vertical pillars – academic and professional education – where academic education is offered only by universities. The complexity stems from the fact that faculties, academies and university centers are part of public universities, but they act as independent legal entities with considerable autonomy in their work. This is especially case in the four oldest and largest universities, Zagreb, Split, Osijek and Rijeka. As a result, there are 122 higher

20 There are 123 public legal entities under the jurisdiction of the MSE: in addition to 25 public research institutes, there are 8 public universities consisting of 72 faculties in total, 14 polytechnics and colleges, and four other public research institutions (the Croatian Academy of Sciences and Arts, the Institute of Lexicography, the National University Library, and the Croatian Meteorological Service).

21 Croatian Bureau of Statistics 2019.

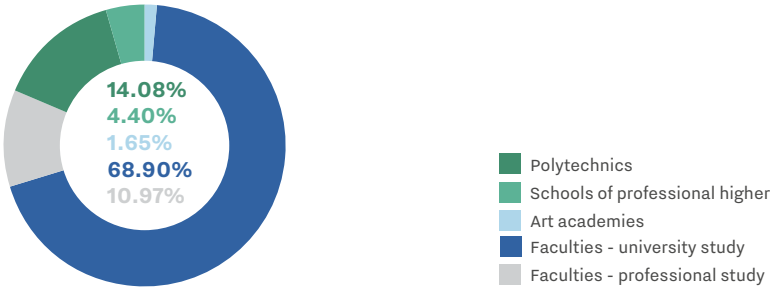
education institutions in Croatia (Table 2.1). This high level of legal and managerial fragmentation is not common in modern universities and has been inherited from the past system (when Croatia had four universities and about 100 legal institutions). Modernization efforts made by several governments aimed at bringing the system more in line with contemporary university setups have been met by strong resistance from the institutions.

TABLE 2.1 *The institutional landscape is fragmented: There are a large number of faculties, academies, and university centers with considerable autonomy*

Number of firms	Public institutions	Private institutions
University	8	2
Faculties, academies and university centers	72	-
Polytechnics	11	6
Colleges	3	20
TOTAL	**94**	**28**

Source: Registry of Research Organizations.

FIGURE 2.3 *Most students in higher education are enrolled in the academic stream*

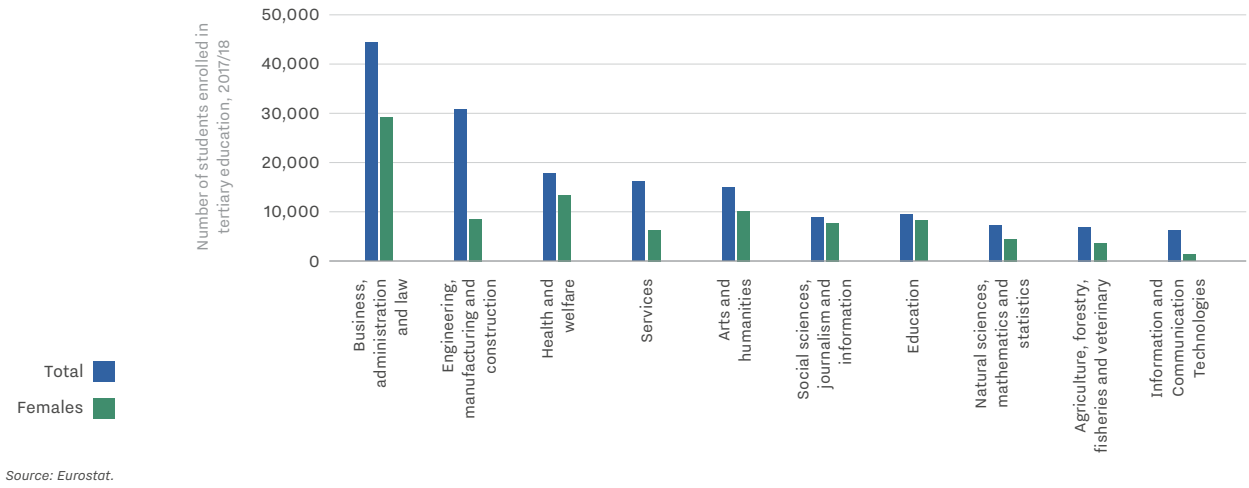


Source: Croatian Bureau of Statistics, 2018.
Note: The figure shows the percent of students enrolled in institutions of higher education in academic year 2018-19.

The majority of students, almost 70 percent, choose the academic stream and enroll in university study programs, qualifying students to develop and apply scientific and professional knowledge. Of the students enrolled in institutions of higher education, 79.9 percent are enrolled in faculties (68 percent in university studies and 11 percent in professional studies), 14 percent in polytechnics, 4.4 percent in schools of professional higher education, and 1.6 percent in art academies (Figure 2.3).

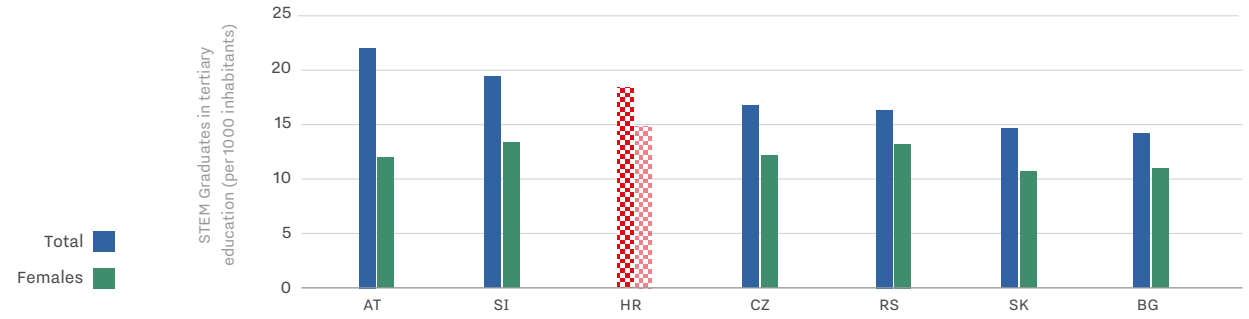
The number of science, technology, engineering and mathematics (STEM) graduates has been increasing since 2013, reaching 18.5 percent in 2017, although a lot of students are still enrolling in social sciences (Figure 2.4). The number of graduates in science, mathematics, computing, engineering, manufacturing and construction is steadily increasing and is comparable with peer countries, albeit falling below the EU average (19.3 percent in 2016, Figure 2.5). They are also increasingly women, opposite to traditional perceptions of gender roles, and leading in this indicator among peer countries. A worrisome trend, however, is a constantly high number of students enrolling in social

FIGURE 2.4 *The number of students enrolling in social sciences remains high*



Source: Eurostat.

FIGURE 2.5 *The number of STEM graduates has increased and is comparable with peers*



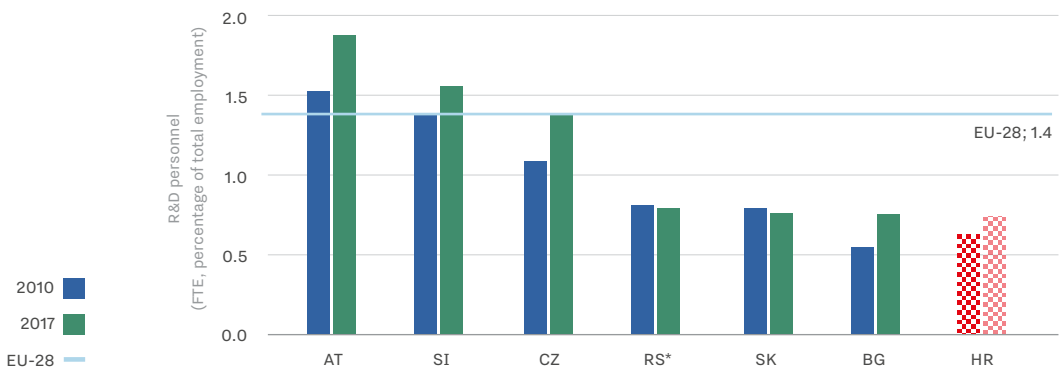
Source: Eurostat.

sciences. 43 percent of students enrolled in social sciences in academic year 2017/2018, followed by engineering (26.0 percent), biomedicine and health (11.2 percent), humanities (7.1 percent), biotechnical sciences (5.1 percent), natural sciences (4.1 percent), arts (1.9 percent) and interdisciplinary fields of science (1.5 percent).

The growing number of STEM graduates is encouraging for the country's R&D capacity, but Croatia needs to build its R&D personnel base and attract researchers. In addition to low investment in R&D, Croatia's negative demographic trends and population outflow are adversely affecting its R&D human resource base. The number of researchers in Croatia decreased between 2000 and 2010 (World Bank 2013). Croatia is lagging in the supply of human resources working on R&D, at 0.7 percent in 2017, compared to the EU 28 average of 1.4 percent in 2017 and peer countries (Figure 2.6). To prevent further outmigration and build its base of researchers, the country needs to improve the conditions for researchers – from wages, infrastructure, and career prospects to overall environment.

The national career advancement system provides no incentive for HEI staff to pursue research that would promote innovation, to work with business, or to foster technology transfer. Research positions are permanent, and there is little to no possibility to reward or penalize staff for their research

FIGURE 2.6 *Croatia lags peers in terms of R&D personnel*



Source: Eurostat.

performance. If HEIs are to shift from their predominant traditional orientation toward teaching, the leadership of the universities needs to make several changes. The adjustments would include supporting an orientation toward innovation, promoting knowledge exchange between science and business, and improving career development conditions.

2.1.2 Governance of HEIs

The institutional fragmentation of public universities affects governance in higher education and prevents the universities from reaching their full research potential. This is especially evident with the University of Zagreb, the largest, oldest and most significant university. The University of Zagreb accounts for 44 percent of students in Croatia (OECD 2019) and employs about 40 percent of academic staff.[22] It has 34 constituents – 30 faculties, three academies and one university department – each with their own autonomy and governance. Such a fragmented structure makes it difficult to establish cooperation between scientists and prevents interdisciplinary and multidisciplinary education and research. It also makes the sector's governance extremely complex, both within the institutions and in the relations between the government and the HEI sector, because it includes dealing with 123 legal entities. It often results in uneven distribution of resources and wastefulness or insufficient coverage. This level of institutional fragmentation is unfavorable to strategic resource planning and is an obstacle to developing a clear and common vision, purpose and identity for an institution (OECD 2014).

Decision-making in HEIs is delegated and reliant on collective bodies, which hinders modernization and comprehensive reform. The governing bodies of the universities are the Rector, the Senate and the University Council. In addition, the universities may establish other advisory and governing bodies. The governing bodies consist of professors and employee and student representatives. Their decisions are made by majority votes. University constituents, faculties and academies have their own deans, professional councils, and other governing and advisory bodies, with great autonomy in decision-making. This complex governance structure entails a high degree of delegation, which may be an obstacle to greater cooperation between constituents and to more comprehensive reform efforts (OECD 2014).

22 Croatian Bureau of Statistics, 2018.

The current model of public funds is not adequate for planning and implementing longer-term programs and investments, which is unfavorable to promoting R&D and innovation. The sources of HEI funding include the state budget, founder's funds, local authorities' funds and funds from the HEI's own sources, such as project-based funding and donor funding. HEIs depend on the state budget, which provides almost 80 percent of their funding, through the allocations by the MSE. There is no strong link between funds awarded and the quality and quantity of research. Little to no progress has been made to push for HEIs to achieve certain levels of research or education (Račić et al. 2017), or for the government to match the achievements with appropriate funds.

The very small percentage of R&D funding at HEIs coming from enterprises indicates low business-research collaboration resulting in limited commercialization of research results. While central and local governments fund 80 percent of higher education research,[23] enterprises (public and private) fund about 1 percent.[24] The universities' leaderships vary in their commitment toward technology transfer from science to business as visible in weak institutional and financial support to these goals and inadequate support systems. The result is limited commercialization of research results and low patenting. Finally, the collaboration among the HEIs themselves in R&D is not at the satisfactory level as evident in that less than 1 percent of research activities in HEIs were financed by other HEIs, while the remaining resources came from foreign investors (9 percent) and non-profit institutions (0.1 percent).

Many independent recommendations (OECD, EC) urge a deeper reform that would include functional integration, establishing performance-based funding implementation, and quality evaluation. This would include not only an external evaluation conducted by the Agency for Science and Higher Education (ASHE) but also introducing recurrent internal evaluations and self-assessments. Over the last decade, initial reforms in financing the universities have been launched by introducing three-year pilot funding agreements in 2012–2015, involving a small portion of funds. However, implementing the agreements did not trigger major changes in the funding model or behavior of institutions. Although funding agreements have continued, they do not include meaningful amounts or scope, and it is unlikely that full-fledged performance-based financing could be negotiated in a system so highly fragmented. Further, lack of cooperation with the business sector and underperformance in attracting highly competitive, central EU funds for research translate into HEIs having limited funding of their own, insufficient for larger investments in scientific infrastructure and development. Introducing stricter and more transparent criteria for allocating public funds to HEIs for career advancement in science, which could increase general research competence and encourage scientific productivity and excellence, is pending.

2.1.3 Public Research Institutes

The primary role of PRIs consists in conducting scientific and research activities and implementing scientific programs of strategic interest to Croatia's development. The institutes are also expected to participate in creating study programs, particularly doctoral study programs, as a manner of transferring highly specialized knowledge and establishing scientific and expert cooperation with the public and private sectors in Croatia and abroad. Together with the universities, the PRIs act as the main operators of the scientific infrastructure for the overall science and higher education system.

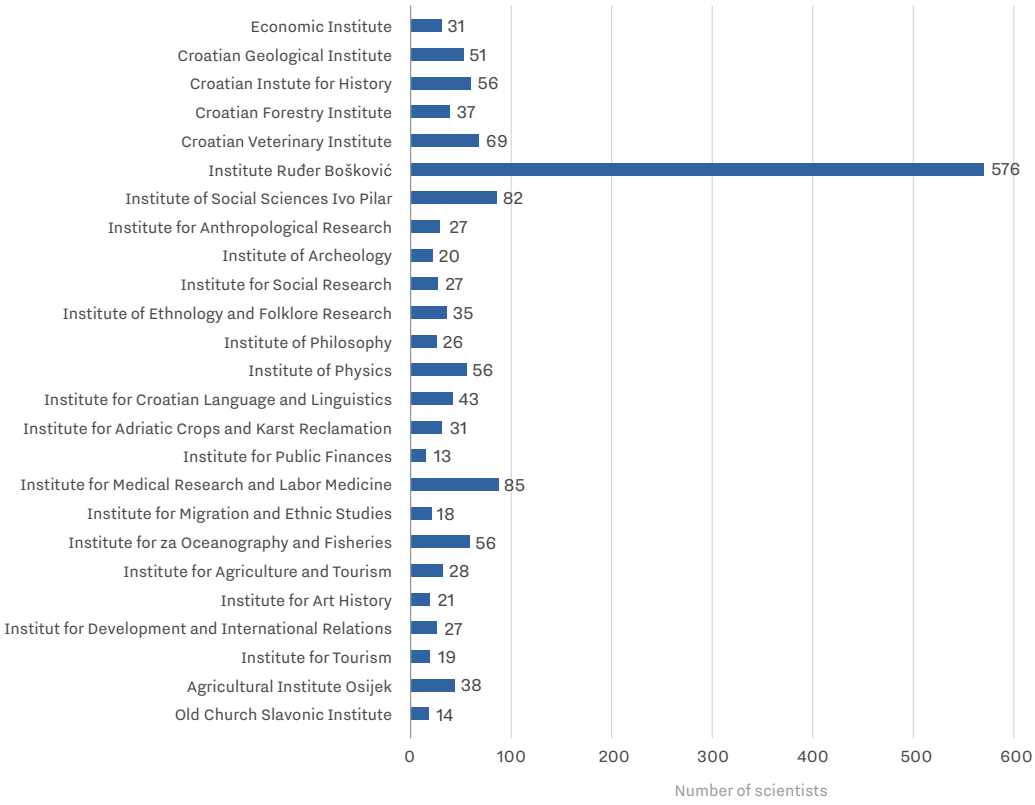
23 Croatian Bureau of Statistics, 2017.

24 The Community Innovation Survey 2014 found that Croatia is on par with the EU-28 with respect to the cooperation of large firms with universities (31 percent and 33 percent respectively), and that it is lagging on the cooperation of small firms (4 percent and 10 percent respectively) and small and medium size enterprises (12 and 17 percent respectively).

There are 25 PRIs in Croatia that operate independently of higher education institutions, with a sporadic collaboration with HEIs or among themselves. Fourteen of them are in the areas of the social sciences and humanities. A dozen are in the sciences and biotechnology. There are no institutes in the engineering technical sciences. The current structure and institutes have a long tradition. Some were initially founded by the University of Zagreb and the Croatian Academy of Arts and Sciences (and later became independent), whereas some were established as independent institutions. After the 1990s, most institutes remained public, but with very weak links with former industrial partners, which also underwent the transition to a market economy – facing lost markets, declining demand or lack of adoption of new technologies. These 25 institutes employ about 2,000 people, of which 950 are scientists in scientific positions. Although many have similar research areas and opportunities to work together, there is limited evidence of regular cooperation between institutes and HEIs.

The largest and most significant PRI is Ruđer Bošković Institute (RBI). RBI stands out for its size, scientific productivity, international recognition in research, and quality of personnel and equipment. RBI is the central scientific institution in Croatia in natural and biomedical sciences and marine and environmental research. The Institute is Croatia's largest multidisciplinary research center, organized into 11 institutes and three centers. The Institute has over 890 employees, of which over 500 are scientists – more than 5 percent of all researchers in Croatia. The RBI owns over 50 percent of the capital research equipment in Croatia.

FIGURE 2.7 *Ruđer Bošković Institute is the largest public research institute in Croatia*



Source: Staff elaboration based on Croatian Registry of Scientists.

Croatia has initiated necessary changes to the finance model of PRIs to shift the budget allocation so it is more merit-based rather than predominantly financing overhead costs (salaries). In 2018, the MSE allocated HRK 386 million for financing PRIs, of which HRK 346 million was for salaries. This is close to 90 percent and leaves a small margin for any strategic planning or programs. Another HRK 165 million came from the projects financed by the Croatian Science Foundation (CSF), the main European research program *Horizon 2020*, and cooperation with industry. In 2019, a new funding model is being applied to PRIs whereby institutes can obtain additional funding based on achieving results and the institutes' specific goals. The new funding model increased the results-based funding for science from HRK 37.7 million in 2018 to HRK 50.7 million in 2019, an increase of 34 percent.[25] This model envisages splitting the cost of PRIs' activity between core funding (overhead expenses) of about 78 percent, results-based funding of about 15 percent and financing of specific institutional goals of about 7 percent. It will be important to assess the results and learn lessons from implementing this new model to increase performance-based funding of PRIs.

There have been several attempts to address the fragmentation of PRIs to improve the efficiency of the research capacity, but an appropriate model is yet to be proposed. The fragmentation of capacity is inefficient and can hinder the collaboration between institutes, preventing larger-scale project activities (OECD 2014) and gains. An increase in competitive, project-based funding would help raise the quality and relevance of research at PRIs. The current institutional structure is a legacy of past times and calls for modernization, particularly in the fields of social science and the humanities. Consolidating the 25 PRIs to a smaller number seems an appropriate step for a country the size of Croatia, particularly given that some institutes have very few scientists and deal with similar topics. The basis for the merger of the institutes may be the international evaluation requested by the MSE in collaboration with the ASHE, coupled with an assessment of results achieved under the funding agreements. The international evaluation suggests that several PRIs could merge together or merge with universities, which is the case with modern western research systems (Račić, Švarc and Testa 2018).

2.1.4 Other Research Organizations

According to the MSE's Register of Research Organizations, 62 other research entities (besides HEIs and PRIs) operate in Croatia. They include public and private hospitals, R&D companies and private institutes. These organizations employ 2,650 researchers (registered in the MSE's evidence of researchers), which is 19 percent of all researchers in Croatia. Private research organizations take various legal forms, such as enterprises, non-profit institutions, and public institutions that are not PRIs (for example, hospitals, state institutions, and specialized agencies). The Act on Quality Assurance in Science and Higher Education requires any legal entity to meet certain administrative criteria, quality standards and research-related criteria to become accredited as a research organization. This accreditation is performed by the ASHE and requires an entity to have a strategic research program, meet infrastructure requirements and employ at least three research staff holding PhD degrees. The accreditation is an eligibility requirement for many R&D programs financed by the MSE and the CSF, which can be seen as an administrative burden hindering more effective state support to R&D.

Management principles of public funds for research could be reconsidered in light of the significant share of R&D-performing constituents from the business sector that are ineligible for some programs. Although public funding programs for STI are generally open to various types of beneficiaries, some programs require a specific legal status, excluding some entities. According to

25 This amount does not include salaries of researchers or project funding from the CSF. Source: https://mzo.gov.hr/vijesti/programsko-financiranje-znanstvenih-instituta-34-posto-vise-sredstava-za-izvrsne/2097

the Act on Scientific Activity and Higher Education, research organizations must have the legal status of (i) public universities or colleges (that is, HEIs); (ii) PRIs that are state-owned non-profit institutions; or (iii) other research organizations – such as state-owned organizations, private universities, private institutes and corporations with R&D departments accredited according to the Act on Quality Assurance in Science and Higher Education. Other SMEs and corporations (private and state-owned), although they perform R&D and are important parts of the RDI system, are neither registered with the registry of research organizations by the MSE nor accredited. Therefore, these entities do not qualify for certain government programs.

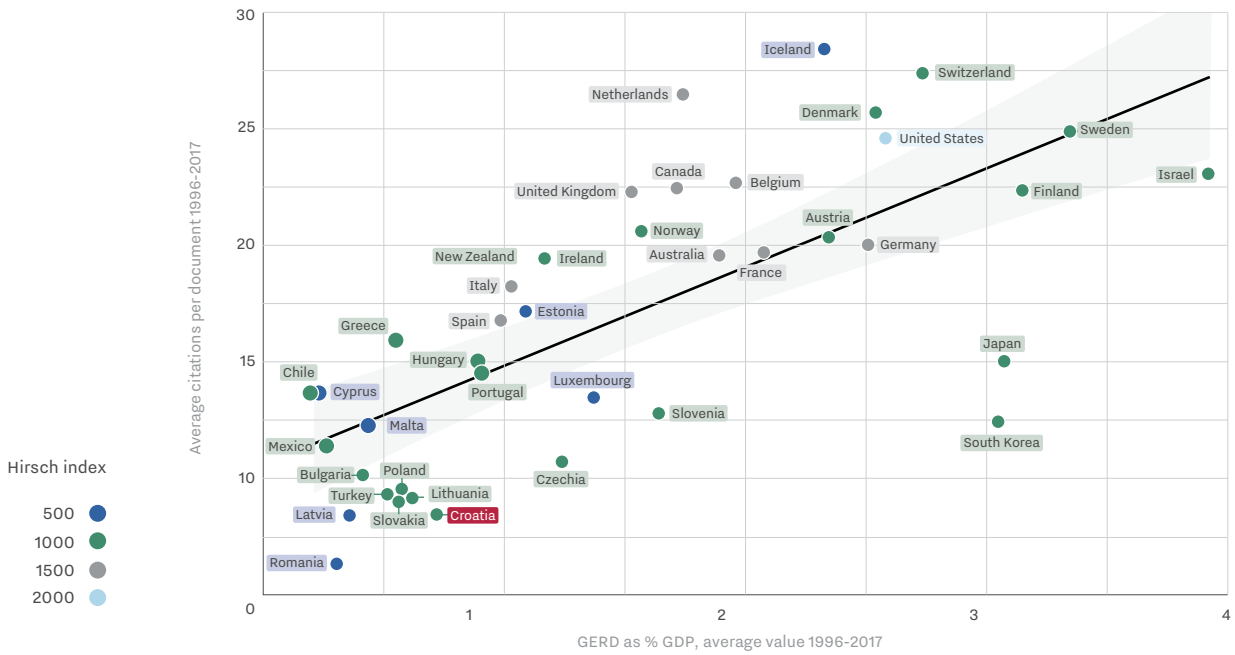
2.2 Croatia's Science Capabilities

- Croatia could do better compared to peers in terms of research excellence. The quantity of Croatian research exceeds its quality –publications often go uncited, suggesting they are not relevant to the international scientific community.
- The few well performing research groups are vastly outnumbered by modest performers.
- Funding is driven by institutional size rather than performance.
- Croatia could take the opportunity to focus its research policy and establish a bold performance and accountability framework for its research system that will be binding for both the government and R&D stakeholders.
- Integrating Croatian science with the European and international research network should be prioritized in the national policy, with a time-bound action plan to attain it. International collaboration, as a key ingredient of knowledge transfer and competitiveness, should be embedded in strategic and policy documents, with incentives provided in research funding programs.

Science globally faces increasing pressures, one of which is to deliver tangible innovation to the highest standards quickly in a highly competitive and critically underfunded setting. Although science has always been about asking questions, nowadays researchers operate in dizzying dynamics and are expected to shift their research attention to meet the needs of society, particularly in connection to innovation and commercialization. To add to this tension, researchers are expected to compete for funding as governments face multiple priorities and are more likely to finance short-term projects and goals, which affects the choice of scientific research topics and methods. Ultimately, scarce funding and competition go hand in hand with an increased focus on the quality of performance. Croatia's science is not an exception to this; if anything, the stakes are higher because the country is behind its peers on critical economic indicators and confronting population outflows.

The quality of scientific publications in Croatia is low, even when compared to countries with similar or lower GERD. While GERD in Croatia is low, its ratio of average citations per publication to GERD is among the lowest in Europe (Figure 2.8). Poland, Slovakia and Lithuania have higher citations per publication with a lower average GERD. Croatia's low ratio of citations to funding indicates that the country's investment in research is ineffective. Increasing GERD is part of the EU 2020 targets, but it needs to be tied with a thorough revamp of national policies. Without reorganizing and improving the institutional system, there is a risk of wasting funds without adding value or improving efficiency.

FIGURE 2.8 *Croatia has an unfavorable ratio of funding to average citations per published document*

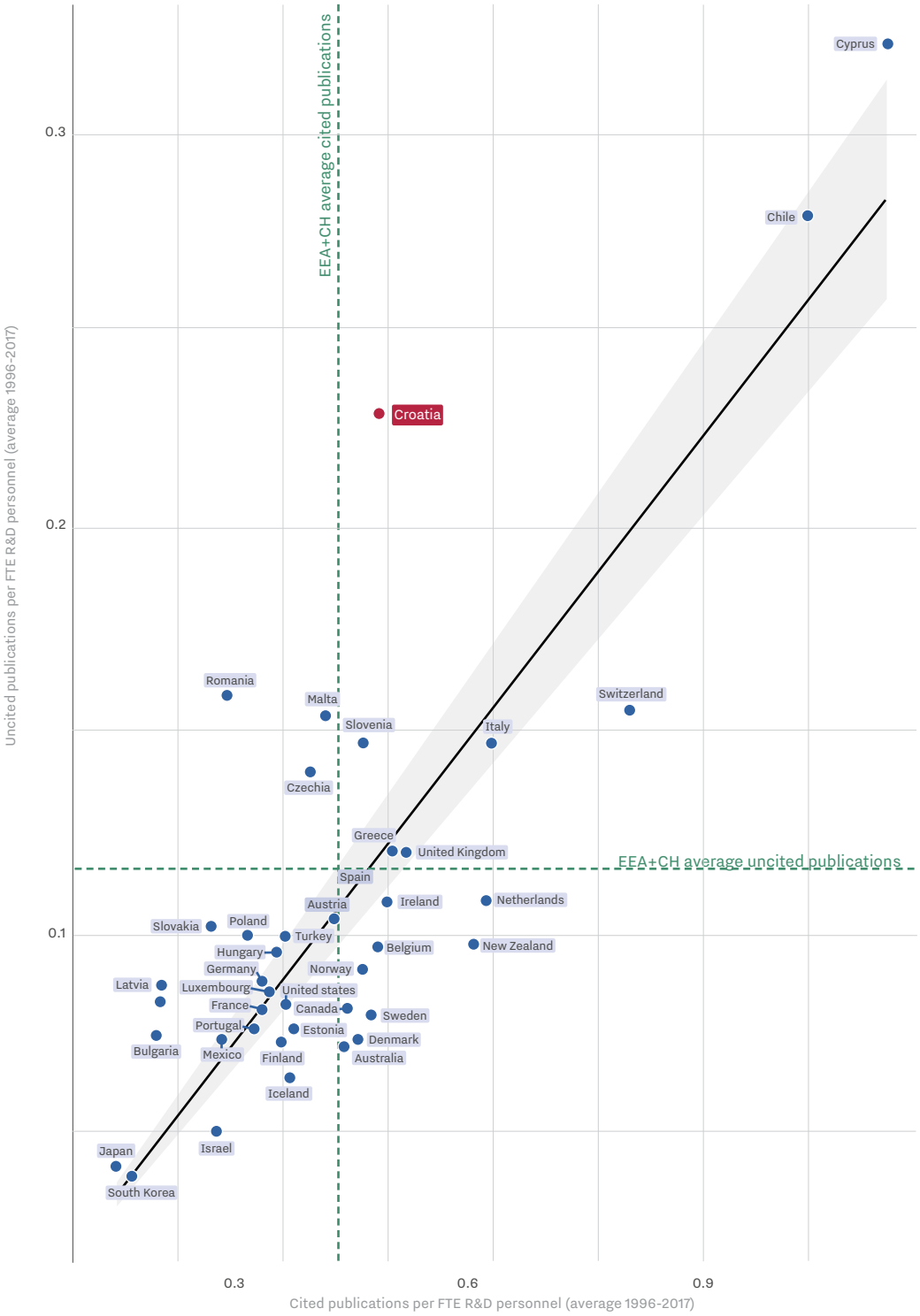


Source: Staff elaboration based on Scimago and Eurostat data.

Croatia struggles to improve its research performance, despite planned measures to foster research excellence. Data on cited and uncited publication count per full-time equivalent (FTE) research staff show that Croatia is somewhat above average by cited papers, but also has the highest average number of uncited papers (Figure 2.9). The National Strategy for Education, Science and Technology (2014) envisaged a set of measures to strengthen the operating environment for research and align Croatia's science system with the standards of most developed countries. These included evaluation systems, institutional reshaping, good governance and management autonomy for the institutions, and establishing centers of excellence. Unfortunately, many of these are yet to materialize.

Integration, scientific intensity, and larger-scale R&D depend on collaboration across institutions and mobility, aspects on which Croatia needs to catch up. Collaborative research brings more socio-economic impact, fund sharing and knowledge transfer. Fifteen years ago, Croatia committed in its Science and Technology Policy 2006–2010 that it would reshape its science system to make the most of its R&D investments, strengthen cooperation between science, government and industry to create new values, and increase participation in European Framework Programs. The Unity through Knowledge Fund (UKF) – created in 2007 with a specific mission to connect Croatia with the potential of its diaspora of scientific researchers abroad – was about steering collaboration across borders and mobility. The benefits of knowledge transfer and newly established connections were conspicuous in an increased success rate for UKF beneficiaries in FP7. In the period 2007–2010, the success rate of UKF beneficiaries at attaining competitive grants through FP7 was 32 percent, while the national success rate was around 16 percent (including UKF beneficiaries). Also, Croatia began clustering scientific projects into collaborative programs, although with much delay, by establishing integrated centers of excellence in 2014–15. The funding for the centers of excellence came even later, in October 2017, with EUR 50 million awarded from the ESIF. These are, however, partial and insufficient measures to

FIGURE 2.9 *Croatia overproduces publications while exhibiting low scientific efficiency*

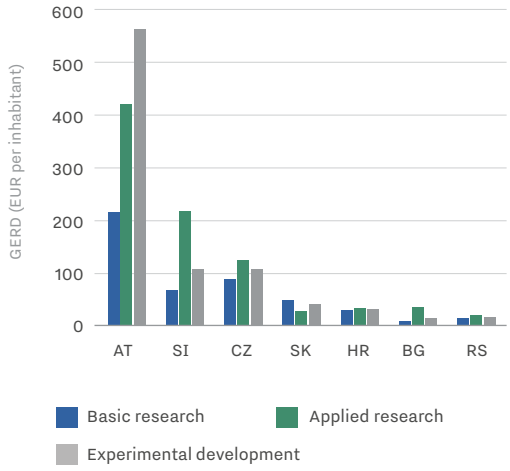


Source: Staff elaboration based on Scimago and Eurostat data.

create real incentives, establish a productive environment for collaboration, and build more internationally recognized and competitive research groups. In this context, high institutional fragmentation of the public research sector is among the primary obstacles to the collaboration efforts and joining the European research network.

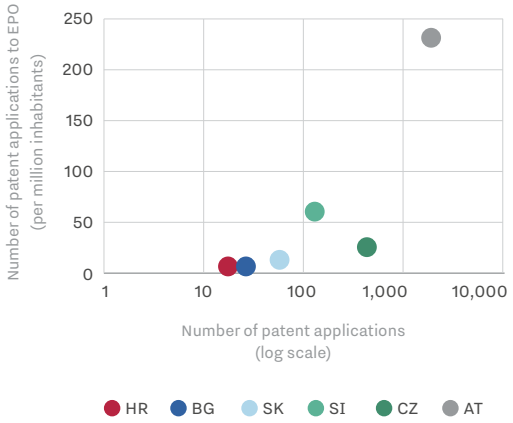
Collaboration between science and industry is sporadic in Croatia, and greater efforts are needed to connect research more closely with innovation development. Only 1 percent of R&D in higher education institutions is funded by businesses, and cooperation between SMEs and universities is low (4 percent of Croatian SMEs collaborate with universities, as opposed to 10 percent in the EU-28).[26] This places Croatia at the bottom among European countries in science-business cooperation. Although Croatia has tried to shift away from predominantly basic research, there are insufficient investments in applied research and experimental development. Such investments are needed for stronger technology transfer (Figure 2.10). Croatian higher education institutions remain oriented toward scientific research compared to commercialization of research results, as reflected in a low number of patents compared to the number of scientific publications and dissertations. Only 57 patents were granted in 2018, of which nine were registered by legal entities.[27] Croatia has the fewest patent applications to the European Patent Office (EPO) among EU Member States (Figure 2.11). While becoming commercially relevant might not be a core pursuit of many scientists, Croatia's lack of patent applications linked to market-oriented research expenditure might be also a sign of mediocre research (and thus limited patentability of research results). It could be also related to the lack of financing sources for institutions to cover the costs of patent filing and lack of incentives for researchers. Other reasons might include limited resources, both human and monetary, of IPR departments at universities.

FIGURE 2.10
The shift to predominantly applied and experimental research has not happened yet



Source: Eurostat.

FIGURE 2.11
Croatia has the lowest number of patent applications (EPO) compared with peers and in EU



Source: Eurostat.

26 Community Innovation Survey data

27 Source: Croatian Bureau of Statistics. Data do not show how many of these nine patents were invented by HEIs.

2.2.1 Scope of the Analysis

This work aims to contribute to better understanding of Croatia's research, technology and development capabilities and the factors that have shaped them between 2012 and 2018. For this purpose, we use a scientometric analysis, a common method of measuring research performance. The analysis examines quantitative and qualitative indicators of the scientific output of R&D performers[28] against the institutional structure and size of Croatia's research sector. The challenge was to select indicators that would shed light on key factors affecting research activity to inform both government policy and R&D stakeholders in their planning and strategy processes. Further work is envisaged to deepen these preliminary insights.

The data come from various local and international institutions and databases. The work relies on two national registries managed by the MSE: (i) the Registry of Research Organizations, which lists all institutions accredited for scientific and higher education activities;[29] and (ii) the Registry of Scientists, registration in which is mandatory for all academic and research staff of public HEIs and the R&D sector.[30] Data related to the CSF are based on the list of awarded grants, with information on beneficiary institutions and allocated amounts. Foreign sources include (i) the European Commission's CORDIS database of grants funded through FP7 and Horizon 2020; (ii) Eurostat data on GERD and GBAORD; (iii) SCOPUS – indexed publications and citation records published in scientific journals by authors with a Croatian affiliation, categorized by subject fields and open access status; and (iv) SCIMAGO – performance indicators related to publication count, citation and H-indices for peer countries.

2.2.2 National R&D Landscape: Institutions and Personnel

Universities are by far the largest employers in the academic sector, so their policies and management – shaped by their institutional structures – affect scientific activity. The largest universities, with the highest number of personnel (Figure 2.12) are not integrated. The legal and administrative autonomy of their faculties weakens their roles and leadership in policy management. The result is that the universities' management have limited authority to initiate changes with meaningful impact on research activity and performance. This scientometric analysis demonstrates that this institutional complexity is a problem. Notably, the performance-based agreements (PBAs)[31] that the MSE has been attempting to introduce (a small share of the overall budget of HEIs and PRIs) are not functioning as intended because negotiations would either need to be held with all the legal entities (including faculties within each university), which is impractical, or be held with universities that do not have a significant say in the current setup. As this analysis will show, PBA funding seems more related to the size of HEIs (that is, their number of personnel) than to quality. As recommended by several independent expert institutions, the organizational setting of HEIs should be simplified to facilitate policy making and streamline access to funding for the top performers.

Women are underrepresented in information and communication technologies (ICT) and engineering. Croatia has overall good gender balance among researchers at the institutional level (Figure 2.13), above the EU-28 average. Croatia is among the better performing countries by the percent of women among doctoral graduates, at 55 percent, compared to 47.9 percent for the EU-28 (EC 2016). However, women are underrepresented in technical fields, notably in ICT and in engineering, manufacturing and

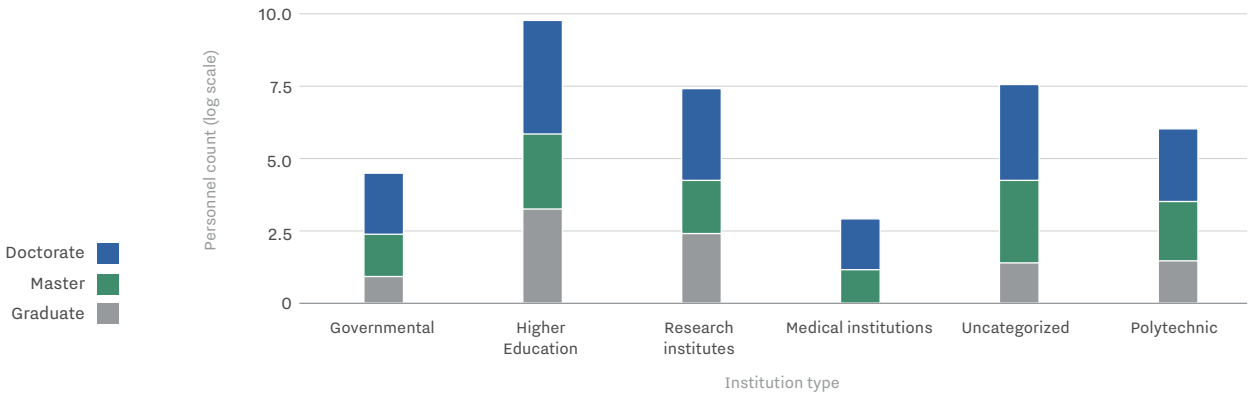
28 As registered in the Registry of Research Organizations

29 Any institution in the registry is assigned a unique ID number, according to the criteria and evaluations performed by ASHE, responsible for accreditation. Privately owned research and education institutions are also eligible for registration.

30 Unique IDs are assigned to persons with higher education degrees upon registration.

31 In Croatian: *višegodišnje institucionalno financiranje* (VIF).

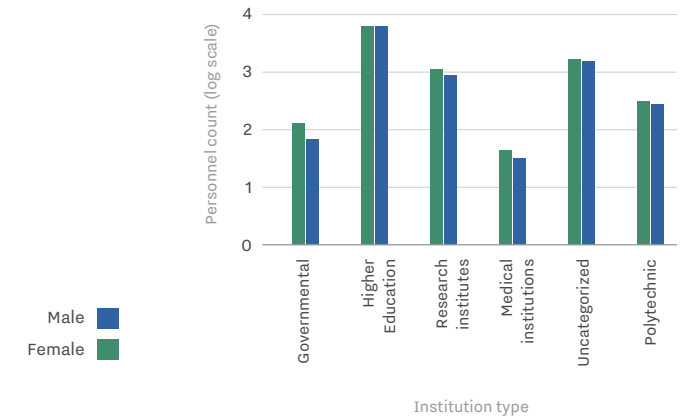
FIGURE 2.12 *As universities are the largest employers of R&D personnel, their setup is crucial to Croatia's R&D performance*



Source: Staff elaboration based on MSE data.

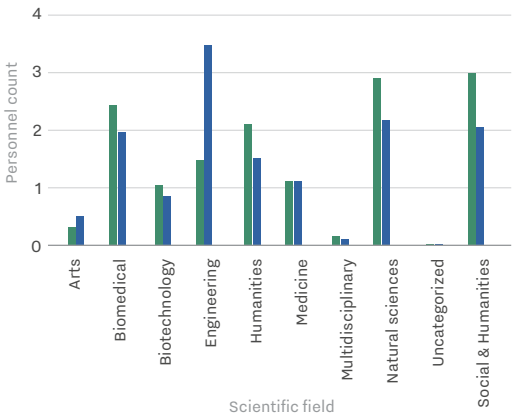
construction, where 22 percent and 33 percent of doctoral graduates are women, respectively (Figure 2.14). Europe is lagging in this indicator with only 21 percent of women among doctoral graduates in ICT and 29 percent in engineering. Here, Croatia should follow the example of CEE countries – Poland, Bulgaria, Serbia, Romania and Turkey – which stand out by marked gender balance in technical fields.[32] The root of the problem is embedded in strong cultural biases that influence schooling, according to which girls are treated as less skilled in mathematics, deterring women from technical studies. Croatia has a unique chance to change this behavior by implementing curricular reform from early schooling through its recently launched School for Life Program.

FIGURE 2.13
There is a good gender balance at the institutional level



Source: Staff elaboration based on MSE data.

FIGURE 2.14
However, women are underrepresented in engineering



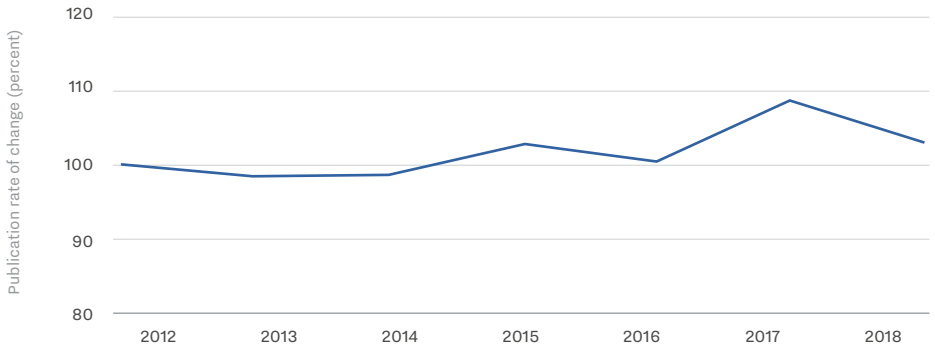
Source: Staff elaboration based on MSE data.

32 Per the EU report "She Figures 2018," only four countries in Europe have good representation of women among ICT doctoral graduates—Bulgaria (56 percent), Serbia (50 percent), Turkey (44 percent) and Romania (43 percent). In the field of engineering, manufacturing and construction, women are well represented only in Poland and Serbia (42 percent).

2.2.3 Quantity and Quality of the Research Work

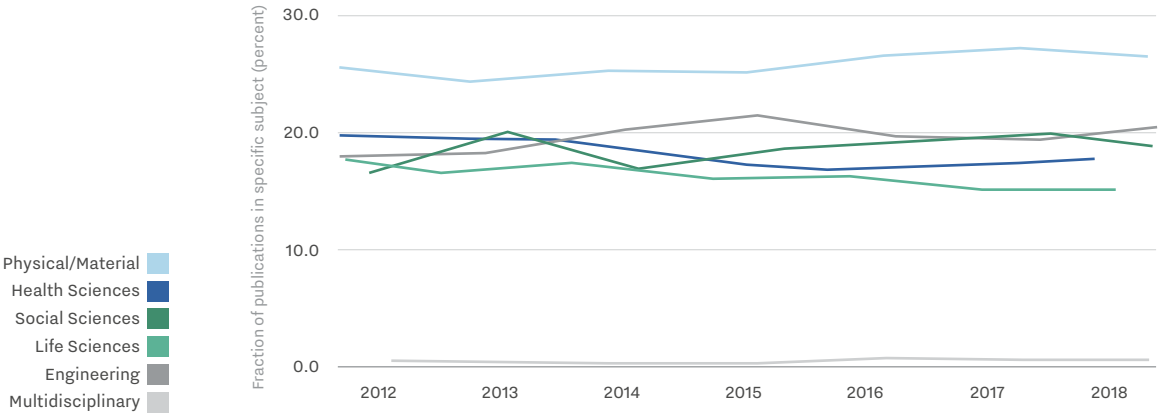
Overall, the number of scientific publications by Croatian scientists is rising (Figure 2.15), but the lack of change in scientific intensity by field suggests a lack of strategic focus. The increase in publications is a global trend and has become speedier with digitalization. This makes measuring scientific impact through citation counts even more important. Publications in medical sciences and life sciences are in a mild decline in Croatia (Figure 2.16), a trend that requires closer examination to understand its causes and potentially correct it. Publications in social sciences are on a mild rise. However, over the last seven years, there has been very modest change overall in terms of growth or decline between fields. The distribution of scientific intensity by field often reflects the priorities of a country or its lead research institutions, so the absence of change in the composition of fields might point to a lack of strategic focus in research orientation and funding, which could go beyond the research sector to the country's development orientation. It may also indicate problems with absorption capacity and, therefore, unpreparedness of the universities and research institutes to respond swiftly to emerging needs and challenges of the society. This probably reduces the potential to innovate based on research results.

FIGURE 2.15 *The total number of publications is growing modestly*



Source: Staff elaboration based on Scopus data.

FIGURE 2.16 *Stagnation in the structure of publications by field and a decline in health and life science publications reveal a lack of strategic focus*



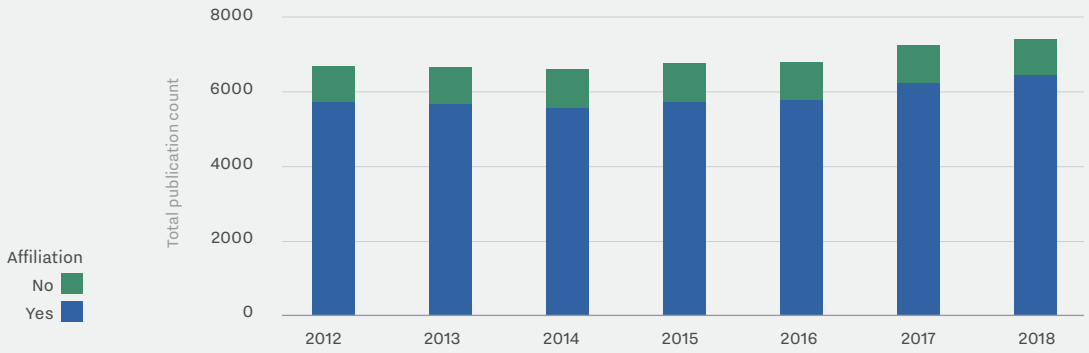
Source: Staff elaboration based on Scopus data.

BOX 2.1 Administrative measures to improve data management

A share of 16.4 percent of publications is assigned to their institutions with ambiguity. There are no enforceable policies on how to spell affiliations when publishing, so some publications are hard to assign to their authors and their institutions in the National Registry of Scientists and National Registry of Research Institutions. The following administrative measures could help overcome attribution issues:

— *Researchers should use common identifications when publishing, such as Research ID or ORCID.*
— *The MSE can apply for Research ID or ORCID directly upon enlisting the researcher in the registry to remove the burden from the researcher and ensure correct identification in the citation databases.*

FIGURE A *Total indexed publications per year*

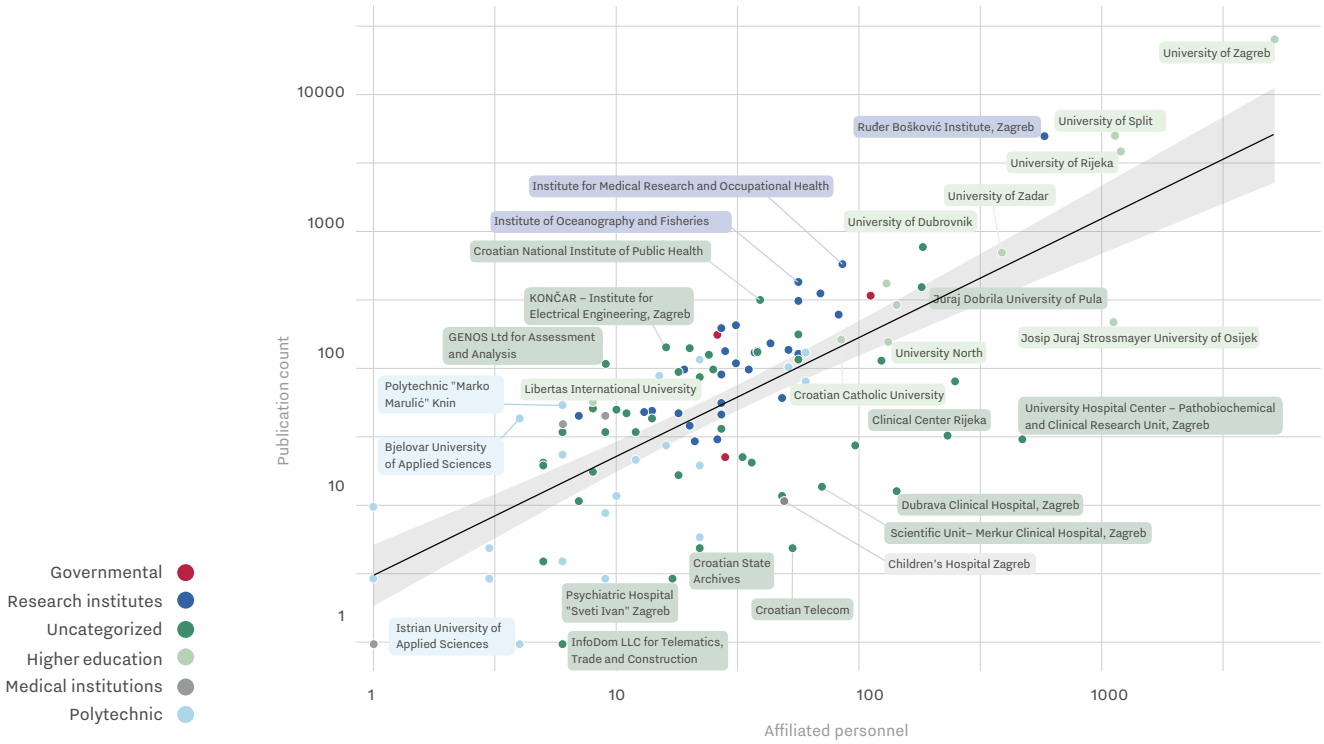


Source: Staff elaboration.

The top three institutions in terms of publication count are also the largest ones. The traditional outlook on research activities would be to compare the paper counts in context of institutional size. As shown in Figure 2.17, the result in Croatia is as expected. However, a closer look suggests that, while the largest institutions publish more papers, there is still a discrepancy vis-à-vis the number of research staff affiliated with these institutions. Institutions with a high volume of published papers do not necessarily generate high impact. This suggests that neither publication count nor the number of personnel should be taken as the main factors in decision-making, especially when allocating funds.

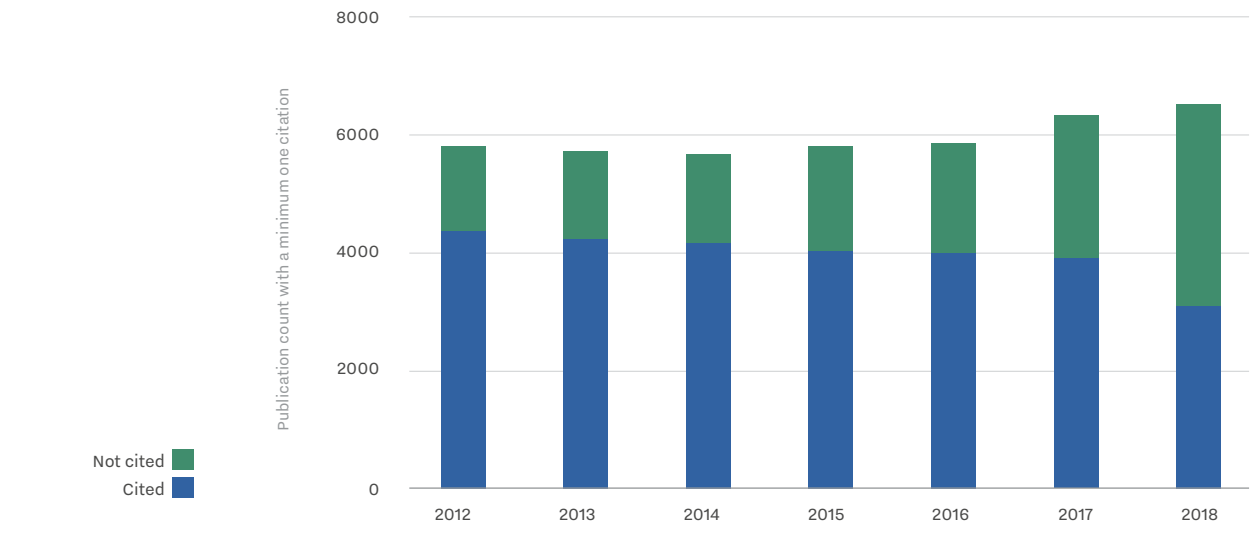
Croatia has a high number of uncited publications, which shows overproduction and a lack of relevance. Uncited publications represent missed opportunities for their authors to reach wider audiences and contribute to their fields of science. Figure 2.18 shows an expected decline in the number of citations per year because it takes some time before newer literature cites a published paper. However, older publications have more opportunities to get cited. Thus, the ratio of cited to uncited publications stabilizes over time. Figure 2.8 provides more context by comparing cited and uncited papers in Croatia and other countries. Croatia stands out with the highest number of uncited papers per researcher. In this context, an increase in the number of publications does not necessarily mean improvement in quality, because uncited papers may not be relevant. The dataset should be further stratified to reveal the most important reasons why Croatia's scientific papers fail to impact their fields. In addition, analyzing immediacy (that is, how long it takes on average for papers in a discipline to get cited) would help to understand the underlying issues in greater detail.

FIGURE 2.17 *Most and least prolific institutions based on the deviation of papers per staff from the regression line*



Source: Staff elaboration based on MSE and Scopus data.

FIGURE 2.18 *A quarter of publications remain uncited five years after being published*



Source: Staff elaboration based on Scopus data.

Croatia has several institutions with major scientific impact, and their success could be further explored. Box 2.2 provides a summary of the approaches to measuring scientific impact used in this analysis. Figure 2.19 and Figure 2.20 present two measures of institutional performance. The first is performance by H-index. Measuring impact by the H-index (which takes into account both publications and citations) against the number of staff reveals champion institutions in terms of scientific impact. Several entities do well on this measure. They include GENOS d.o.o., the Institute of Physics (Zagreb), the Institute of Oceanography and Fisheries (Split), the Croatian Veterinary Institute (Zagreb), Clinical Hospital Split,[33] Ruđer Bošković Institute (Zagreb), and the University of Split, Rijeka and Zagreb. This means that champions come from all institutional types (hospitals, institutes, universities, private companies, and government institutions such as the Croatian Health Insurance Institute). Because the H-index is a composite index expressing the count of publications receiving substantial citations, it favors larger institutions. By contrast, a comparison of median normalized citations – which captures the pure impact acquired through citations over time – with the number of personnel favors more focused institutions with consistent good performance in citation counts (Figure 2.20). A few entities appear as top performers by both comparisons. They are GENOS d.o.o. (a privately-owned R&D company), the Institute of Oceanography and Fisheries (Split), the Ruđer Bošković Institute (Zagreb), and a few others. Further work could examine the top performers to understand and learn from any uncommon behaviors or strategies they use in finding better solutions than their peers amid the same circumstances and challenges.

BOX 2.2 Measurement of publication quality and scientific impact

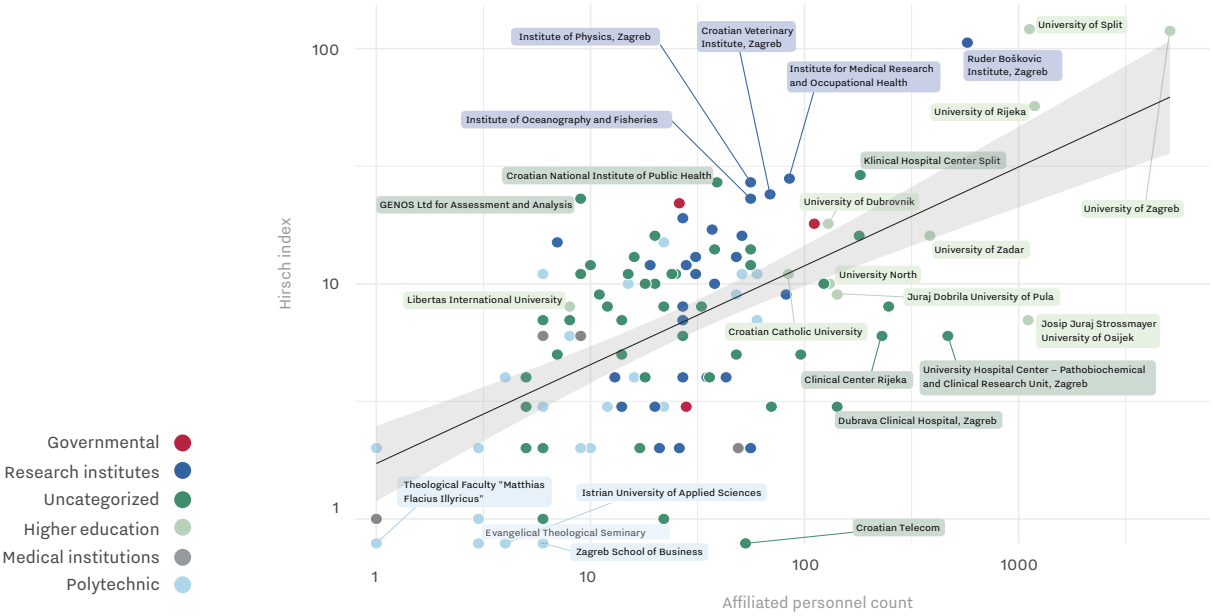
The analysis in this section is based on four complementary measures of the quality of publications and their scientific impact:

- **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.
- **Median citations** – a measure of the central tendency of citations that disregards outliers. For example, a median citation value of 1.0 means that 50 percent of all publications are cited one time or less. Compared to averages, the median is more resistant to extreme values and is more representative of the majority of publications.
- **Normalized citations** – the number of citations divided by publication age (in years). This normalization is performed to facilitate comparison of publications across years.
- **Hirsch index (H-index)** – the H-index is defined as the maximum value of h such that a given 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 fist paper is cited ten 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 is an aggregate measure that combines data on citation and paper count and is preferred over comparing paper counts alone. The H-index can vary across fields due to their particular publishing and citing frequencies.

Source: Staff elaboration based on Hirsch (2005).

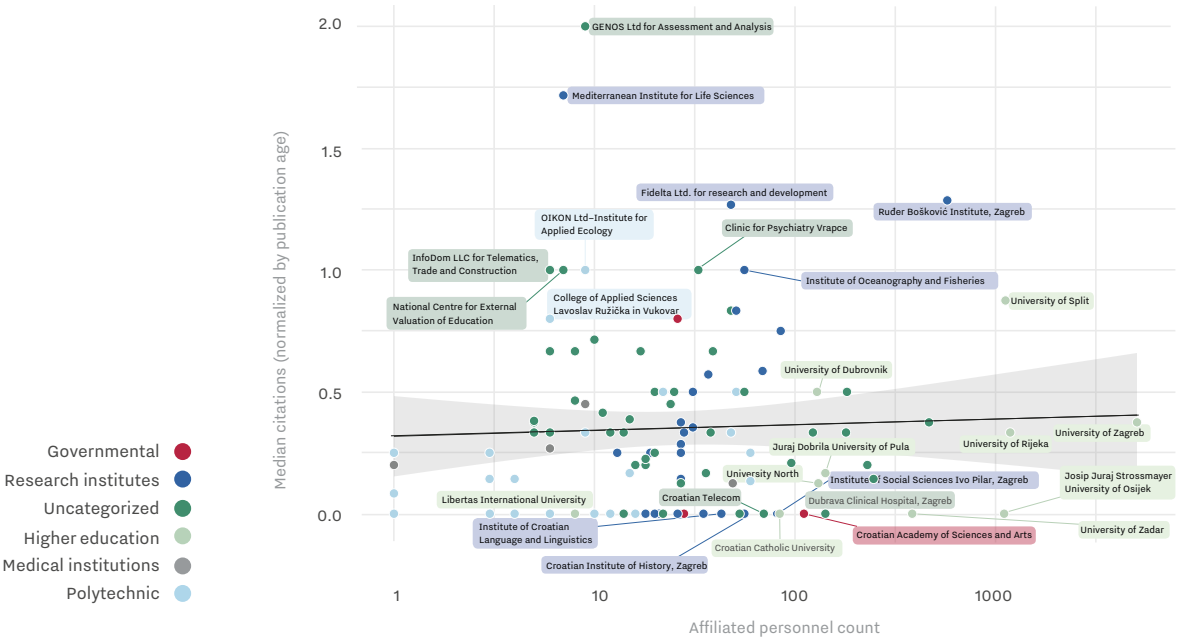
33 Clinical Hospital Split (KBC Split) might have researchers with affiliations to both KBC Split and the University of Split.

FIGURE 2.19 *There are well-performing institutions of various legal structures, and several smaller to intermediary institutions perform better than larger ones with huge visibility (that is, universities)*



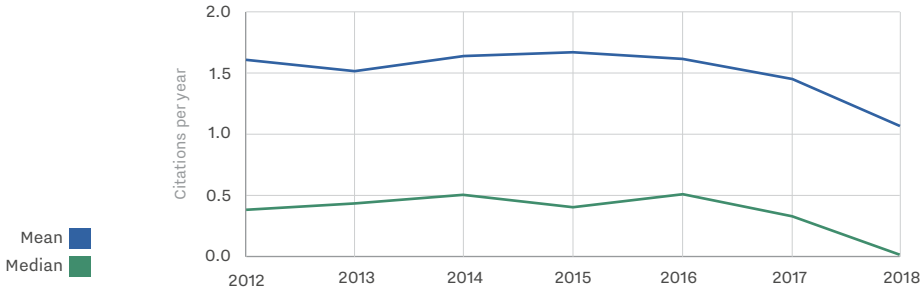
Source: Staff elaboration based on MSE and Scopus data.
Note: Including cited and uncited publications; public universities and the top ten negative and positive outliers from the regression line are labeled.

FIGURE 2.20 *Certain entities appear above the regression line both on the H-index (figure above) and on median citations, indicating consistently strong performance*



Source: Staff elaboration based on MSE and Scopus data.
Note: Including cited and uncited publications; public universities and the top ten negative and positive outliers from the regression line are labeled.

FIGURE 2.21 *Half of published papers get cited once every two years or less*

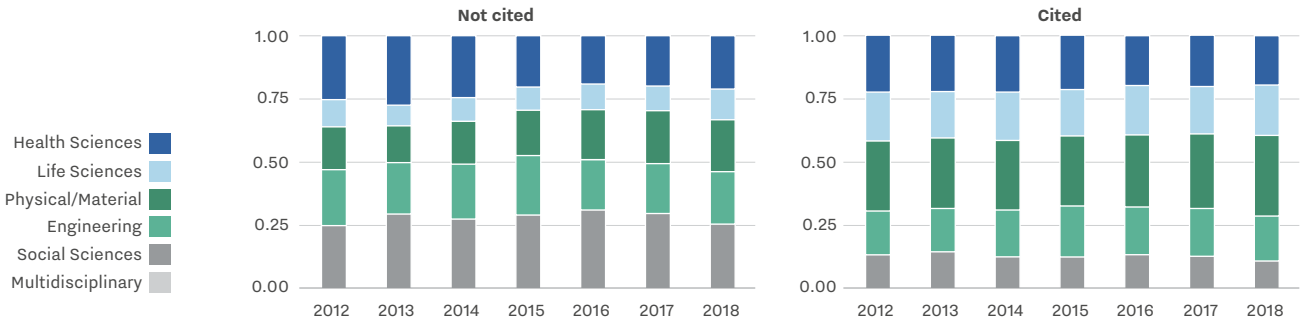


Source: Staff elaboration based on Scopus data.

A look at scientific impact by median and average normalized citations over 2012–2018 suggests overall modest performance, with a few distinct well-performing research groups. Median normalized citations to mature papers hover around 0.5, which can be interpreted as meaning that half of the published papers get cited once every two years or less (Figure 2.21). A value of 0.5 is worryingly low if we consider median normalized citations to be an indicator of the visibility, relevance and impact of the published materials. Average normalized citations are slightly higher, but still in the region of modest performance. On average, publications get cited three times in two years. When excluding well-performing groups (i.e., when using the median rather than the average), the quality of research work is low. The gap between average and median citations indicates that most of the research work in Croatia is performing poorly.

Life and material sciences make up the largest proportion of cited publications, while social sciences and medicine make up the smallest. Life sciences make up the smallest proportion of uncited publications, while social sciences make up the largest share (Figure 2.22). Social sciences papers are also often cited later than life science papers. Medical literature makes up a substantial proportion of uncited papers, but the trend seems to have reduced in recent years. All in all, these findings require the leadership of R&D institutions and policy makers to examine performance issues, including key factors affecting scientific activity and its impact. The analysis needs to involve all stakeholders, including scientists. Traditional paradigms and common perceptions, such as, that social sciences and humanities are "local" in nature and should not even attempt to reach a broader audience (by publishing in international journals or in foreign languages) should be addressed. Assessing the lack of citations to Croatia's medical literature is highly recommended, as this is not consistent with global trends.

FIGURE 2.22 *The proportion of cited publications that come from medicine and social sciences has been declining*

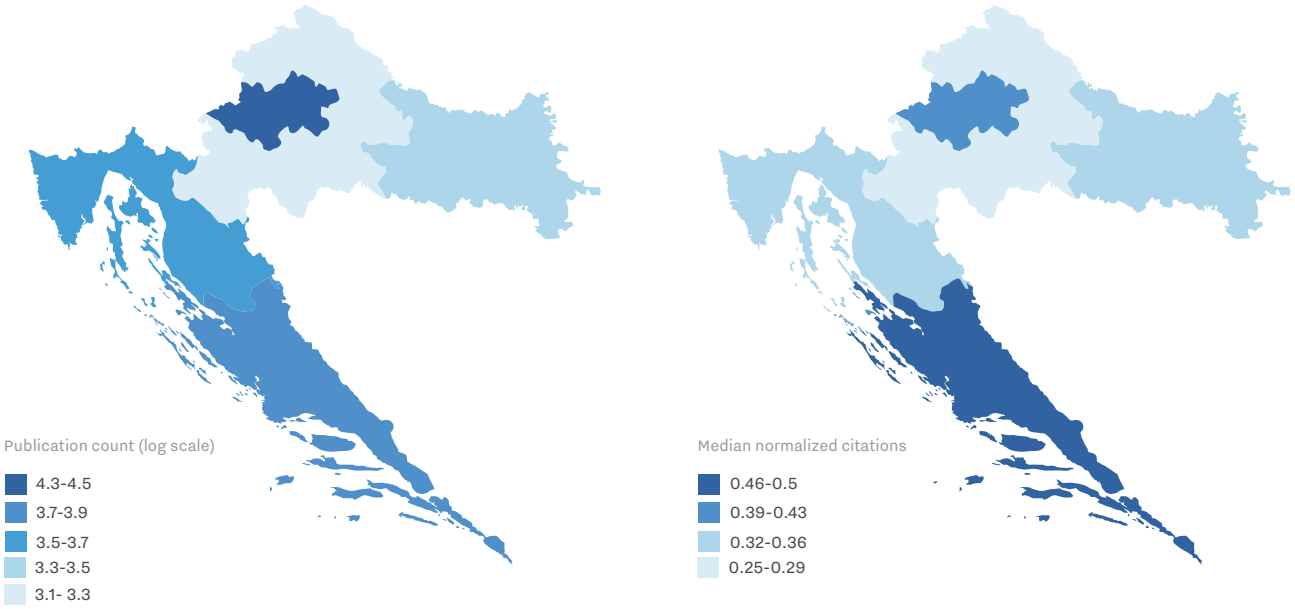


Source: Staff elaboration based on Scopus data.

2.2.4 Regional Dimension of Croatian Science

Zagreb publishes more papers, but publications from Split have more impact. Analysis of the regional distribution of science productivity and impact indicates that most publications are concentrated in Zagreb, which produces ten times more publications than Dalmatia.[34] However, publications from Split have a greater impact measured as median citations (Figure 2.23). Zagreb does have a higher H-index, because that approach reflects the higher publication count in Zagreb, and thus more papers with citations.

FIGURE 2.23 *High publication count does not always go with high median citations*

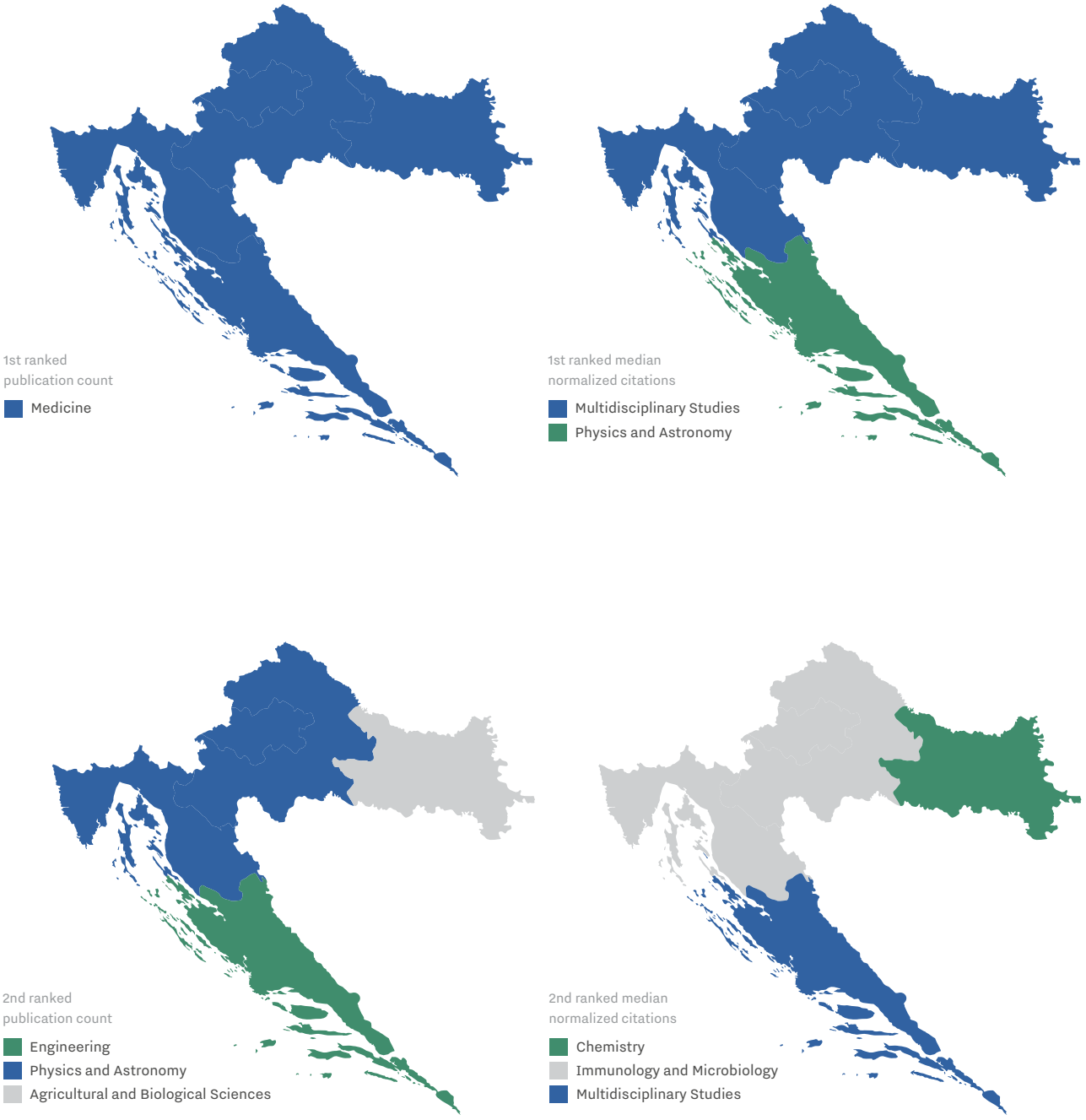


Source: Staff elaboration based on Scopus data.

Medicine is the most prolific discipline, but impact varies by region. The landscape revealed by examining impact generated through citations is strikingly different from that revealed by examining publication counts. Medicine has the highest publication count in every region. However, it does not rank within the top three disciplines by median citations in any region. Second-ranked by publication count are agriculture in Slavonia, physics in Dalmatia and engineering in the rest of the country (Figure 2.24). These publication ranks are disproportionate to the respective citation ranks except in Dalmatia, where physics ranks equally well by count, citations and H-index. Publications in interdisciplinary fields are the most competitive by median citations, but this may be an artifact arising from the modest publication counts in these fields. It is advisable to consider enhancing regional research, technology and development capacity in underrepresented regions that perform well in certain disciplines. For example, Dalmatia seems to be targeting growth in physics.

34 At the same time, Zagreb has 2.3 times more personnel than Dalmatia.

FIGURE 2.24 *Publication count and citations rarely go together by regional distribution*



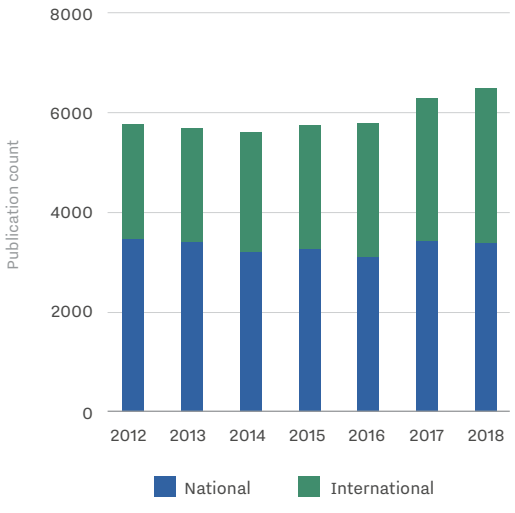
Source: Staff elaboration based on Scopus data.

2.2.5 Collaboration and Internationalization

Croatian science is gradually increasing collaboration with international partners, albeit this needs to become a standard as it improves the impact of its research. Between 40 and 50 percent of publications are authored exclusively by authors with Croatian affiliations (Figure 2.25), which is a very high share in the context of research globalization. Collaboration increases impact through a larger citation count (Figure 2.26). Therefore, it also helps with visibility and integration of Croatian science in global research networks. International collaboration is the gold standard, and publications produced within an international collaboration remain uncited less frequently. However, even national collaboration is better than no collaboration, and papers published by authors from two or more national institutions tend to attract more citations than papers originating from a single institution. The leadership of R&D institutions and the policy need to provide powerful incentives for international collaboration through joint programs. The UKF program, which has embedded international collaboration as its core principle, has proven successful in terms of improved competitiveness of researchers as evidenced in increased integration of Croatian science and participation in the EU Framework programs. While it may take time for some researchers to reach out to their international fellow scientists, strengthening an inter-institutional national collaboration could be the way forward, both to improve the impact of the work and to establish contacts abroad in a more efficient manner. For instance, spending postdoctoral studies in another institution within Croatia is more beneficial than promoting inbreeding by staying within one's own entity for a prolonged period. Last, by producing better research results, international collaboration increases the effectiveness of R&D investments and could lead to more collaboration with businesses and innovation development.

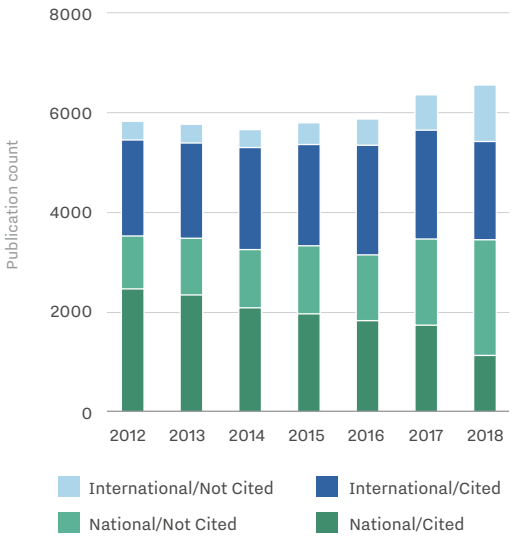
International collaboration increases the impact of research. Most fields benefit from international collaboration, as can be seen from a comparison between citations and publication count for national

FIGURE 2.25
The number of publications with international components is increasing



Source: Staff elaboration based on Scopus data.

FIGURE 2.26
International collaboration reduces uncited publication fractions in the total output



Source: Staff elaboration based on Scopus data.

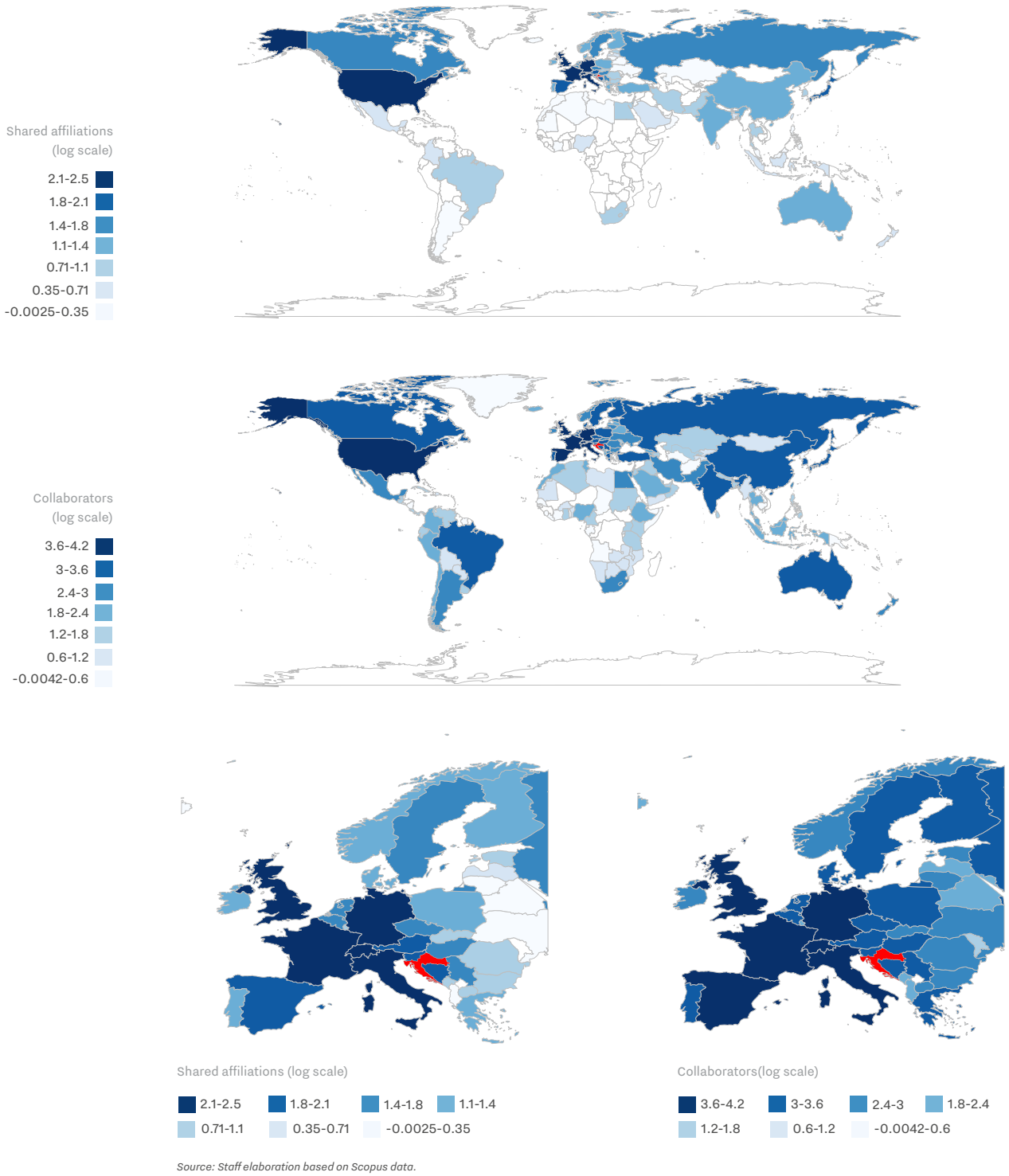
and international papers. Citation performance increases with international collaboration (Figure 2.27). However, there are two opposing trends in terms of publication count. Researchers in the social sciences, humanities and engineering tend to prefer national collaboration, while those in the natural sciences, environmental science and medicine tend to prefer international collaboration. These differences require a deeper dive to launch the discussion about the competitiveness and innovation potential of different classes of science. In the context of globalization and the era of digitalization and artificial intelligence, both social sciences and humanities are expected to be at the forefront of challenges that societies face, so it is inconceivable that they should remain within narrow national research boundaries. Similarly, it is not clear why technical and engineering fields would not be inclined toward international collaboration. Examples and illustrations could be provided from successful countries that chose collaboration across borders to show how international collaboration can improve the impact of research.

Croatian scientists with shared affiliations are the best ambassadors of Croatia to the international research community and lead to many collaborations. Most of Croatian institutions' international affiliations are with the United States of America, followed by four European countries: the United Kingdom, Germany, Italy, and Switzerland (Figure 2.28). A significant portion of affiliations are shared with institutions in the region, notably in Bosnia and Herzegovina, Serbia, Hungary and Bulgaria. This regional collaboration has the potential to improve the capacity of regional research groups and increase the likelihood of connecting with renowned international institutions. In providing incentives for international collaboration, Croatia could target the poorly collaborating disciplines, such as social science and technical fields. Top international collaborating countries are presented in Figure 2.28, showing where the co-authors come from in international publications. Further to that, Figure 2.29 shows connection between countries and ratios of cited and uncited publications.

FIGURE 2.27 *Many fields get more citations when they collaborate internationally*

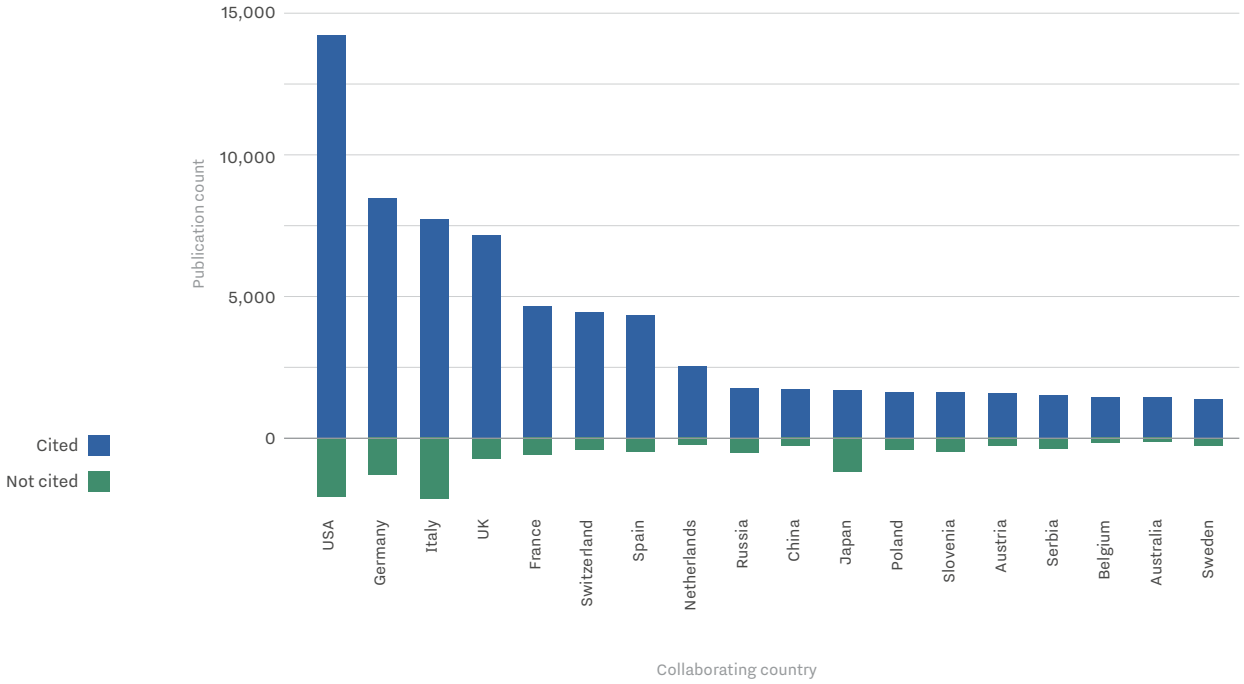
Source: Staff elaboration based on Scopus data

FIGURE 2.28 *International affiliations lead to collaboration*



Source: Staff elaboration based on Scopus data.
Note: International affiliations include scientists with at least one international affiliation in addition to Croatian affiliation.

FIGURE 2.29 *Researchers working with USA and Western European countries are getting cited the most*

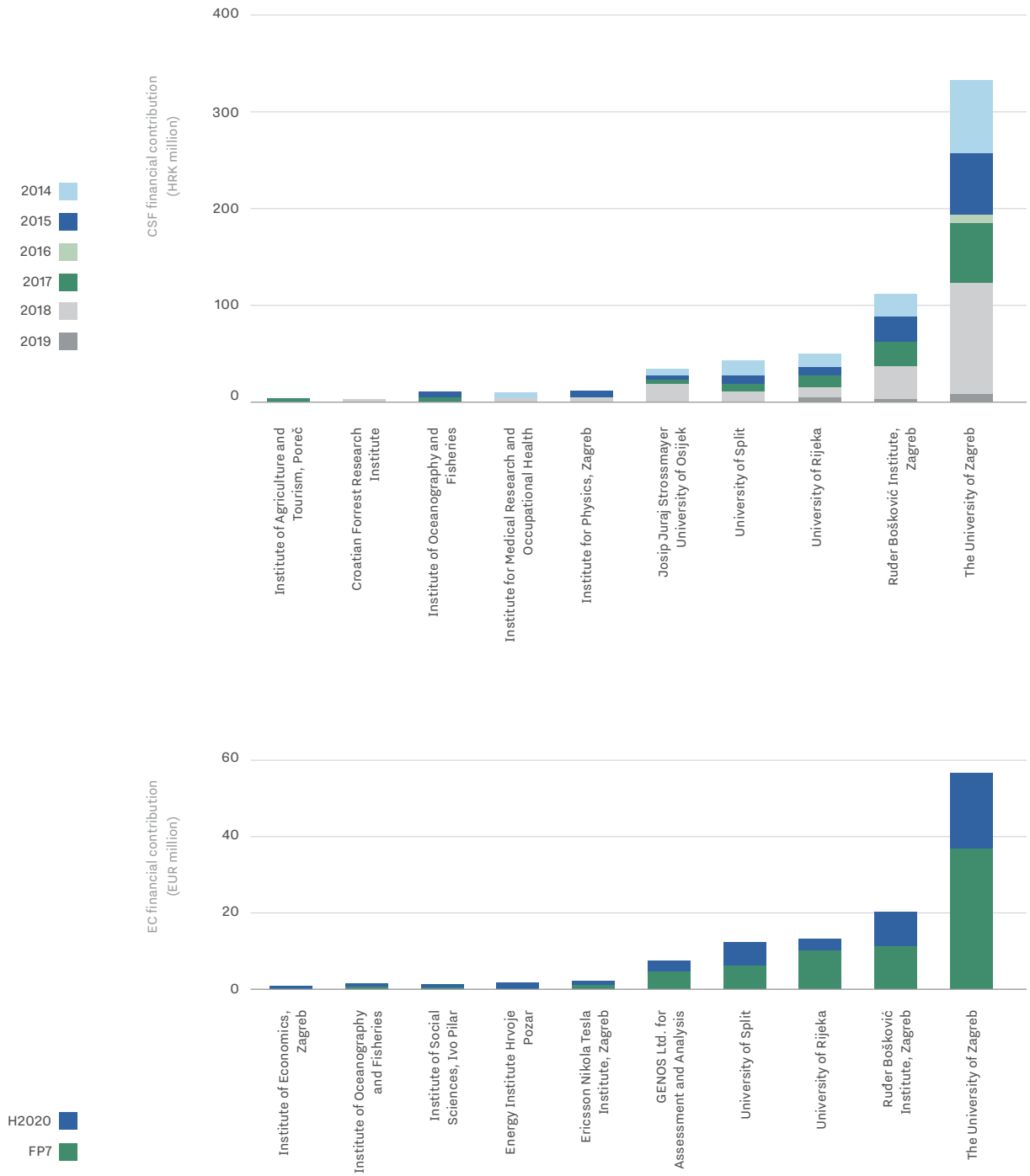


Source: Staff elaboration based on Scopus data.

2.2.6 Funding

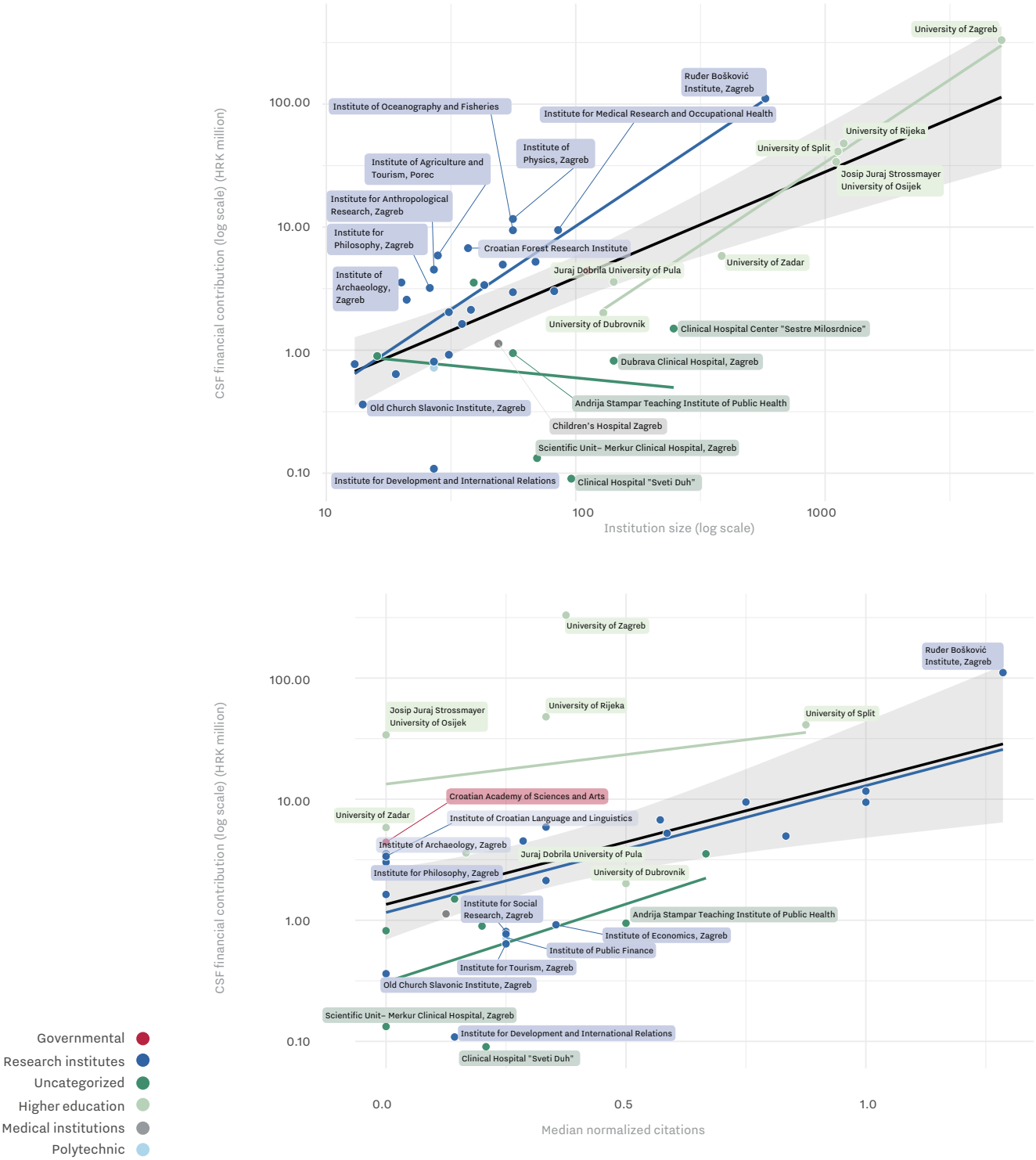
Support programs that should be strictly performance based instead indicate a connection to institution size. For instance, allocation of funds by the CSF seems correlated with the size of the institutional beneficiaries (Figure 2.30). The four largest universities (Zagreb, Rijeka, Split and Osijek) are among the top five beneficiaries, along with Ruđer Bošković Institute. While this makes sense to a degree, there is a mismatch between funding and institutional performance as measured, for example, in median normalized citations (Figure 2.31). In these terms, the University of Zagreb does not have the level of research impact that would warrant the amount of funds it has been awarded. The Ruđer Bošković Institute, the University of Split, and the Institute of Physics in Zagreb, by contrast, appear to be getting less funding than their research impact might justify. Figure 2.31 also shows that the correlation between CSF contribution and institution size varies based on institution type, as evidenced by the different slopes of the regression. Similar results are visible from citation counts on publications compared to MSE funding agreements (Figure 2.32) – HEIs, except Split, are strikingly underperforming in terms of their research impact relative to the funding they get. One should be careful drawing conclusions solely based on the correlation between funds awarded and institutional size. There are many more aspects to be considered, and even in the highly competitive FP7 and H2020, one may observe similar connections, although not to the same extent as with the national funding. Still, the CSF is the main source of national R&D funding, and grants should be awarded according to strictly competitive criteria. It is advisable to thoroughly evaluate the CSF's selection policies and procedures and examine their connection to headcount-based funding. Among other reasons, CSF selection includes national panels in its first stage, and this process may be influenced by larger universities.

FIGURE 2.30 *Financial support appears to be correlated with institution size, though less so in FPs (FP7 and H2020)*



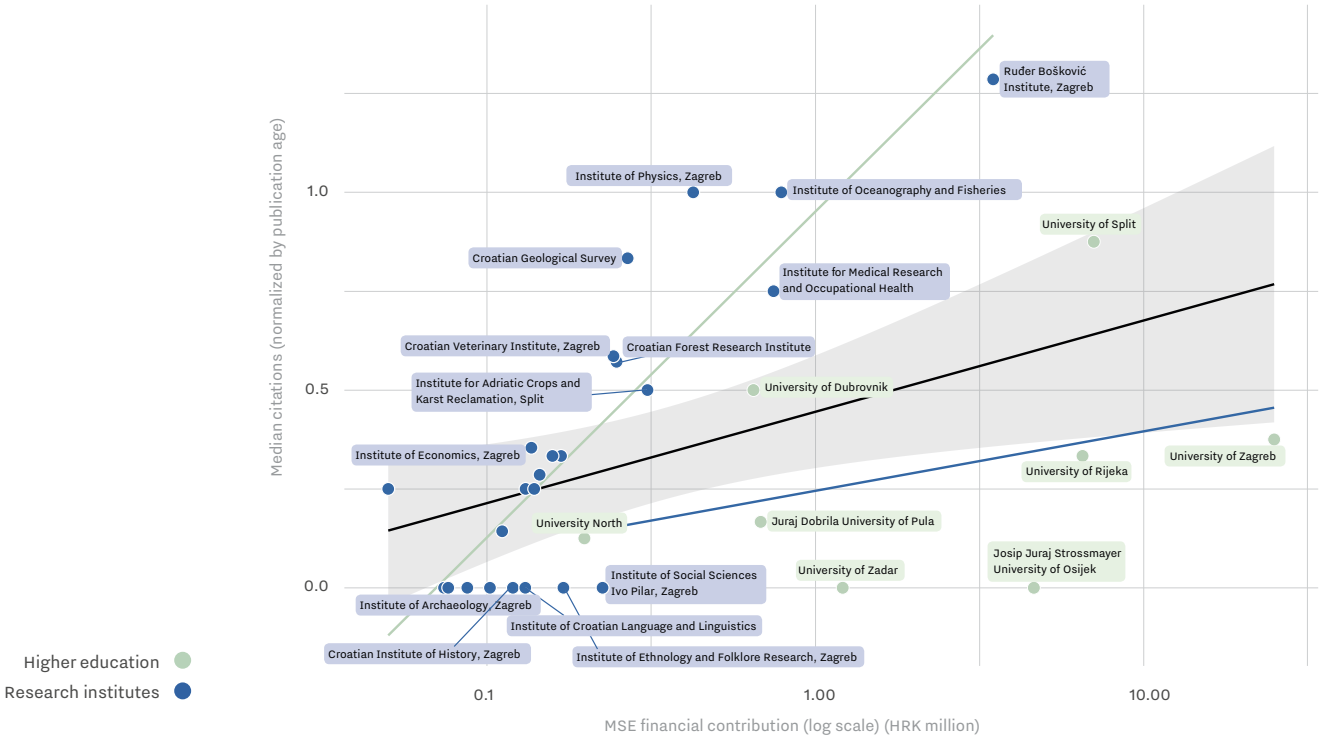
Source: Staff elaboration based on CSF data.

FIGURE 2.31 *There is a mismatch between institutions receiving a given amount of CSF funding and the level of citations coming from those same institutions*



Source: Staff elaboration based on MSE and CSF data.

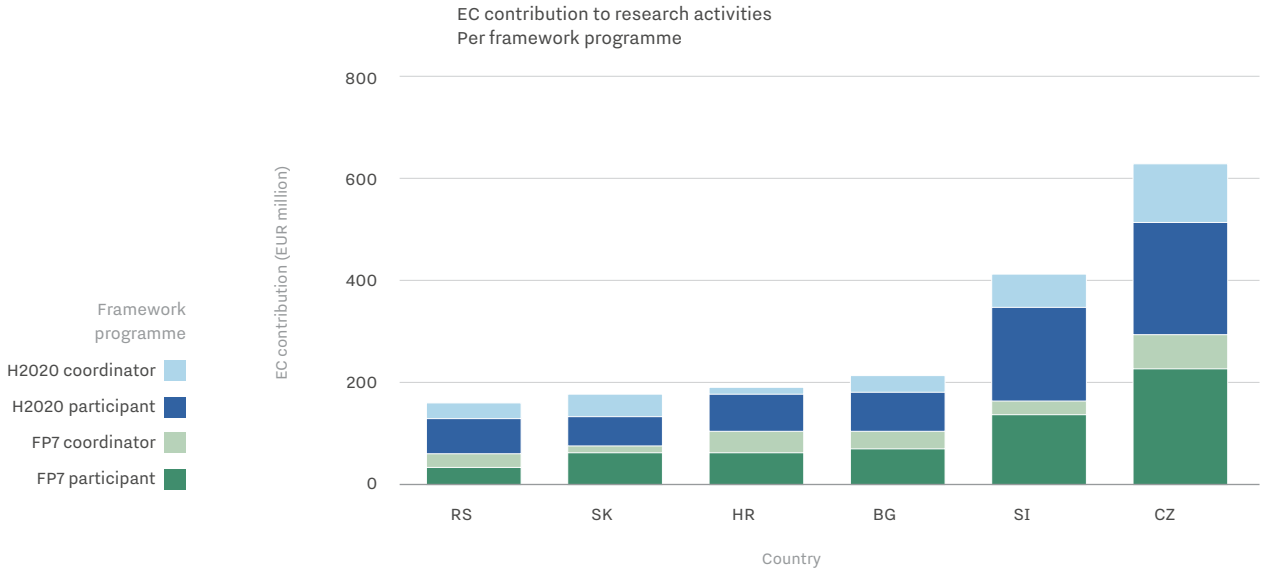
FIGURE 2.32 *Most HEIs underperform considering the amount of performance-based funding they receive*



Source: Staff elaboration based on MSE and Scopus data.

Croatia's participation in competitive EC Framework Programs is low. Three of the largest universities (Zagreb, Rijeka and Split) are major beneficiaries, followed by Ruđer Bošković Institute and a privately-owned R&D company (GENOS) that clearly stands out in terms of the amount of funding it has attracted from the EC. Among peer countries such as Slovenia, the Czech Republic and Bulgaria, Croatia has been the least successful in attracting Horizon 2020 funds. The share of funding that Croatia attracted as a coordinator is significantly lower than the allocation it reached as a partner. Improving Croatia's performance requires stronger efforts by R&D leadership to motivate research groups to present projects and improve the success rate. One clue is that, even though Croatia has attracted less funding in Horizon 2020 than in FP7, its overall success rate is higher (see Section 3.2). The difference suggests that the incentives are lower to apply for funds directly with the EC framework. More research is needed to understand the reasons for the lack of incentives to apply for Horizon 2020. It might have to do, for example, with insufficient absorption capacity of research groups, their lack of connectivity with international partners, or the availability of less competitive funding accessible nationally through ESIF. Countries that are science powers have established national competitive funding instruments to build capacity and motivate their research communities to apply for EC funds. An example is France, which prepared a government action plan to improve its success rate on Horizon 2020 back in 2016 because it was second-ranked among Horizon-eligible countries. If Croatia strengthens its focus on performance-based funding and commits to the rigor competitively awarding national funds, it would certainly improve its competitiveness in the EU setting as well.

FIGURE 2.33 *Croatia is appearing as coordinator much less in H2020 compared to FP7*



Source: Staff elaboration based on CORDIS.

3 BENCHMARKING AND INNOVATION PERFORMANCE

3 BENCHMARKING AND INNOVATION PERFORMANCE

Achieving innovation-driven productivity gains and economic growth requires efficient and effective creation of innovation outputs. After assessing the importance of RDI for productivity and growth and reviewing the conditions affecting firms and researchers, this section benchmarks the evolution and current state of innovation outputs in Croatia. It does so by putting Croatia's innovation performance in the European context and by examining the ability of Croatia to attract transnational competitive EU funding.

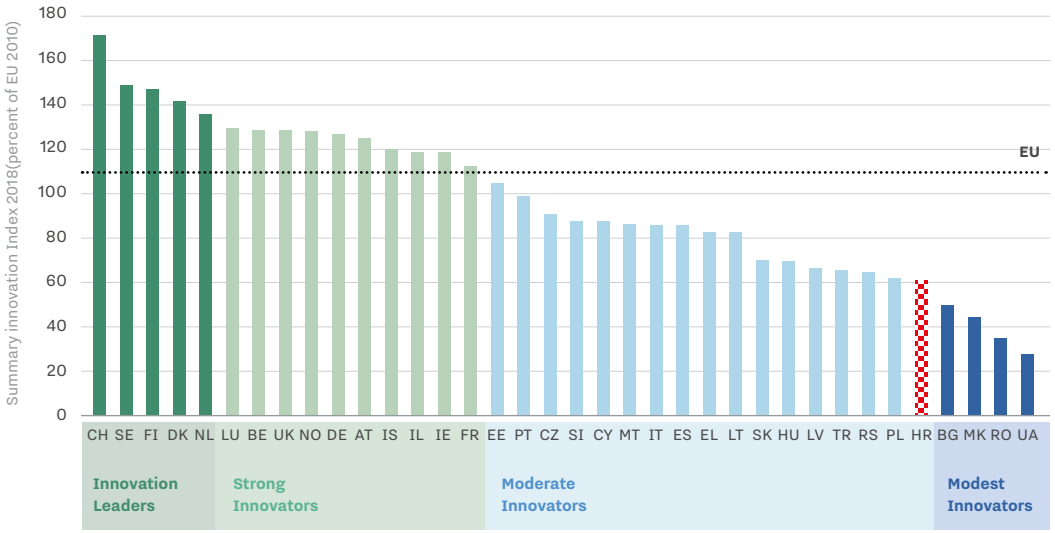
3.1 Croatia's Innovation Performance in the European Context

- Innovation in Croatia has been stagnant, and the country is falling behind most of its EU peers. Particularly troublesome are the low business R&D expenditures and low quality of research.
- Innovation output is low, driven by a lagging knowledge-intensive services sector and low patenting intensity.
- R&D intensity is low, and Croatia is diverging from the EU 2020 target for GERD, unlike its peers.

Croatia is falling behind the EU in multiple aspects of innovation performance. Croatia has made no progress in improving its innovation performance in the last several years, falling behind many of its peers and standing just above half of the EU average. The summary innovation index of the European Innovation Scoreboard 2019 places Croatia at the bottom of the group of so-called moderate innovators, ranking 32nd of 36 countries (Figure 3.1).[35] The index measures innovation performance along four dimensions: framework conditions, investment, innovation activities, and impacts. Croatia's poor performance can be attributed to low scores within the investment component and low scientific productivity, public-private collaboration, creation of intellectual assets, and access to early-stage finance (Figure 3.2). For example, even though there has been a marked improvement in the number of international scientific co-publications, Croatia's share of among the top 10 percent most cited publications worldwide is low (27.9 percent of the EU average). Cooperation in terms of

35 The EU-28 plus Norway, Iceland, Turkey, Serbia, Macedonia, Switzerland, Israel, Ukraine.

FIGURE 3.1 *Croatia is at the bottom of the group of moderate innovators*



Source: European Innovation Scoreboard 2019.

public-private co-publications has deteriorated from 87.4 percent of the EU average in 2010 to 65.5 percent in 2017. A similar impression may be drawn from the *Global Competitiveness Report 2019*, which ranks Croatia 73rd (of 141 countries) on innovation capability, its lowest score among all of the competitiveness indicators measured.

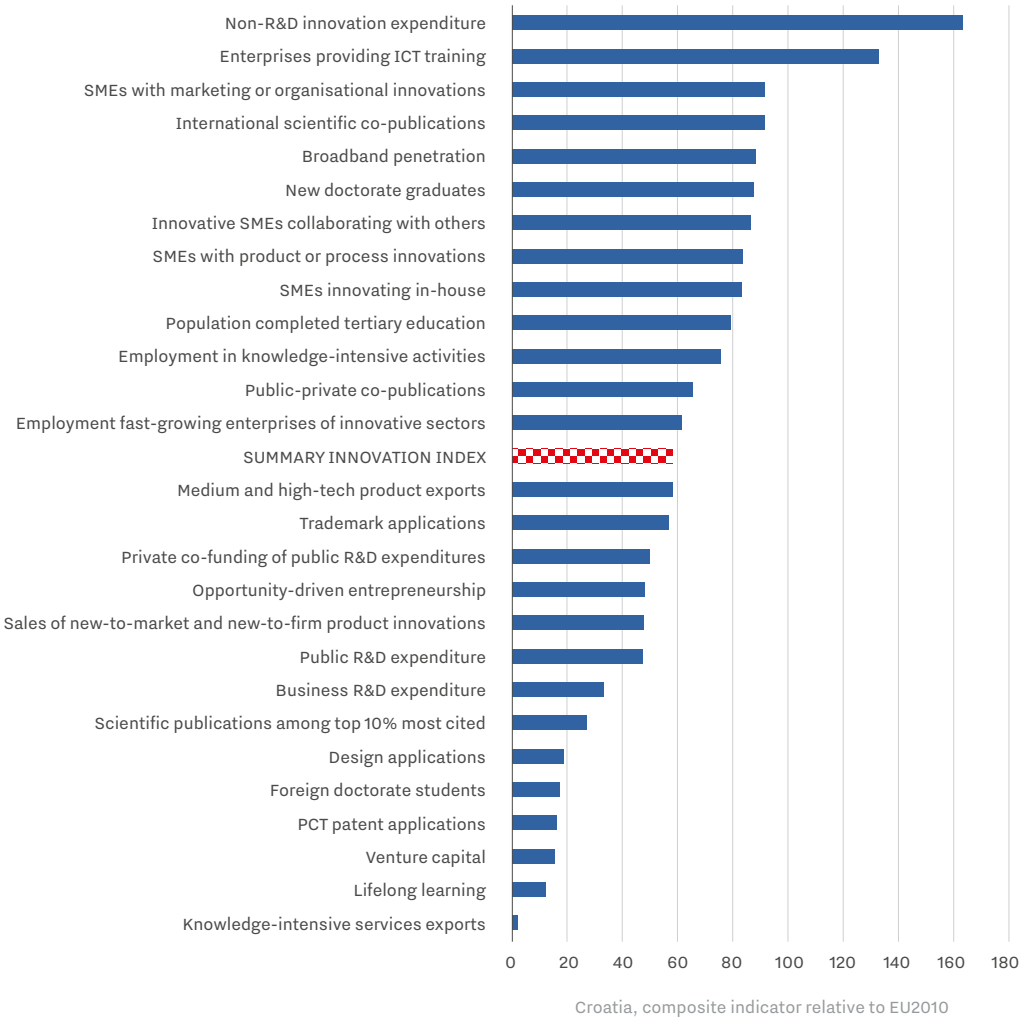
Croatia is not creating enough knowledge assets and appropriable ideas. Ownership of proprietary knowledge assets (such as patents, trademarks, and designs) matters because they enable a type of product differentiation and competitive advantage that cannot be easily replicated. In this setting, monopolistic competition is likely to generate longer periods of demand growth for the innovative firm. Although the overall production of intellectual assets has improved slightly between 2010 and 2018, it remains at 29.2 percent of the 2010 EU average, with particularly low performance in terms of applications for patents (16.6 percent) and designs (19.1 percent). The country is in the bottom quintile on patenting intensity (applications to the European Patent Office). With approximately 0.64 patents per billion GDP (in PPS),[36] Croatia is underperforming relative to the EU-28 average of 2.52 patents per billion GDP (in PPS). In 2017, Croatia's trademark and design applications were 36 and 32 percent of Slovenia's, and 33 and 23 percent of the EU-28 average.[37]

In terms of aggregate innovation output, Croatia ranks last in the EU. The EC Innovation Output Indicator (IOI) is an aggregate measure derived from four components – technological innovation, employment in knowledge-intensive activities, competitiveness of knowledge-based goods and services, and employment dynamism in fast-growing enterprises in innovative sectors (Vertesy 2017). Despite some improvement in Croatia's IOI between 2012 and 2016, the country still ranks last in the EU, largely due to low exports of knowledge-intensive services and more muted growth of fast-growing

36 Purchasing Power Standards.

37 European Innovation Scoreboard 2019.

FIGURE 3.2 *Croatia lags in terms of investment in R&D, creation of knowledge assets and quality of publications*

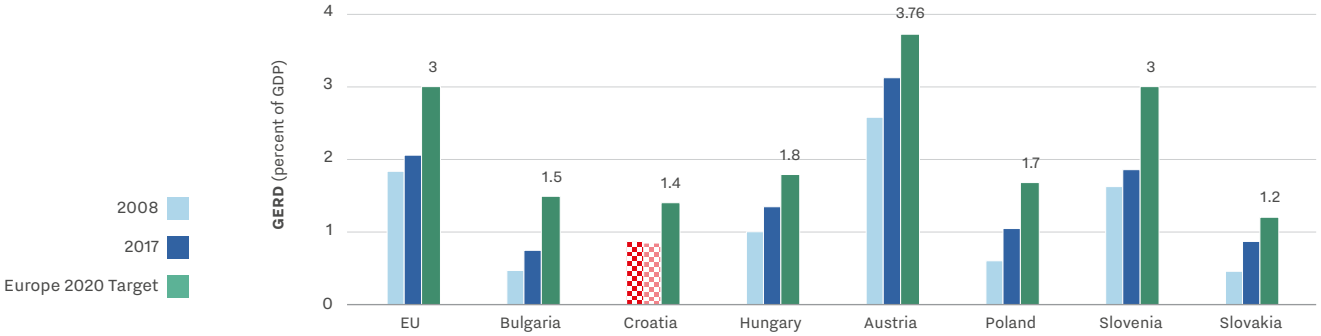


Source: European Innovation Scoreboard 2019.

enterprises compared to peers. The IOI is positively correlated with R&D intensity and GDP per capita, indicating that innovation performance is a function of the quality and quantity of spending as well as prevailing structural conditions (European Commission 2018).

Croatia is not getting closer to meeting R&D intensity targets set as part of the Europe 2020 strategy. Although Croatia's Europe 2020 target for GERD is among the lowest in the EU (only 1.4 percent of GDP), there has been no progress toward meeting it (Figure 3.3). Relative to GDP, GERD in Croatia was higher in 2008 than in 2017. EU-wide R&D intensity is growing too slowly to meet the Europe 2020 target of 3 percent. However, countries like Slovakia, Poland and Greece demonstrated the most progress thanks to an injection of RDI financing from ESIF (Eurostat 2019). Croatia also has access to ESIF funding, and the Europe 2020 target would be achievable if absorption was sufficiently high and support mechanisms were more effective. To meet its target, Croatia would need to grow its R&D intensity by 10.7 percent annually (European Commission 2018).

FIGURE 3.3 *Croatia is not progressing toward its Europe 2020 target*



Source: Eurostat.

Opportunity-driven entrepreneurship in Croatia is among the lowest in the EU. Opportunity-driven entrepreneurship is measured as the share of new entrepreneurs who claim to be driven by seeing a market opportunity as opposed to a necessity to create income. Opportunity-driven entrepreneurship can be viewed as an indicator of the likelihood that newly established firms will engage in innovation. Croatia's opportunity-driven entrepreneurship score was 1.3 in 2018, corresponding to half of the EU average in 2010. And despite using new technologies, Croatian entrepreneurs lag the EU in terms of innovativeness of products (Global Entrepreneurship Monitor 2017).

3.2 Analysis of Performance in Transnational EU programs for R&D and Innovation

- Croatia lags EU and regional peers in attracting most EU funding for research and innovation, including the largest EU funding program – Horizon 2020.
- Croatia's limited success in attracting internationally competitive funding (despite a relatively high success rate of eligible proposals) indicates weaknesses in the research pipeline and reflects shortcomings in its RDI system and insufficient collaboration with top institutions worldwide.
- Future efforts should be targeted toward building up the pipeline of research projects by supporting young researchers and fostering international collaboration, as well as encouraging international collaboration in the private sector and among SMEs.

Croatia's poor performance in attracting centrally managed EU funding for innovation is an indicator of its lack of international competitiveness in research and innovation. The low intensity of Croatia's engagement demonstrates that the Croatian institutional system and human resource base is not well prepared to compete in Europe with their expertise, ideas, and innovative projects. It also indicates the lack of openness and attractiveness of the national research system and the level of

internationalization of the national economy. This is particularly important when comparing the progress of Croatia to other EU-13 countries[38] whose institutions evolved out of closed research landscapes.

Croatia's EU accession in 2013 opened the Croatian science and technology sector to cooperation and funding from an array of competitive sources of financing for R&D and innovation projects. As an EU Member State, Croatia has become eligible for many financing opportunities from centrally managed EU programs for the development of national research and innovation systems. Croatia entered the EU simultaneously with the start of Horizon 2020 (H2020), the most ambitious and competitive European program for R&D funding, worth EUR 80 billion in total. Besides H2020, Croatia also participates in several other centrally managed EU programs. They include EU territorial cooperation programs (Interreg), the EU program for the Competitiveness of Enterprises and SMEs (COSME), and the EU program for international cooperation in market-oriented R&D and innovation projects (Eureka) (Box 3.1). Croatia was also a participant in Framework Programme 7 (FP7) – the predecessor of H2020 – which provided funding in the amount of EUR 45.4 billion. However, as a Member State, Croatia was able to contribute to the programming, evaluation and shaping of H2020 policies and goals.

BOX 3.1 Overview of transnational EU funding programs for RDI

Horizon 2020

Horizon 2020 is the EU's eighth framework program (FP) for research and innovation financing implemented in the 2014–2020 period. With an overall budget of EUR 80 billion, it is the largest and most competitive RDI funding program. Participation is open to both public and private sector participants, and project proposals undergo a rigorous review and evaluation. Only 12 percent of eligible proposals succeed. The program is delivered through several funding schemes:

- **European Research Council (ERC) grants** - frontier research for individual researchers and research groups;
- **Marie Sklodowska Curie Actions (MSCA)** - career development of researchers through training and mobility;
- **Research and Innovation Actions (RIA)** - collaborative projects (for researchers from different countries as well as researchers and industry) addressing specific challenges which may result in new knowledge or technology;
- **Innovation Actions (IA)** - collaborative close-to-the-market projects;
- **Coordination Support Actions (CSA)** - coordination and networking of RDI projects, programs and policies;
- **SME Instruments** - Grants and financial instruments for innovation projects of individual SMEs or consortia of SMEs; and
- **Fast Track to Innovation *(pilot)*** - industry-driven consortia (3-5 participants) for close-to-market innovation activities.

38 EU-13 consists of countries that joined the EU in 2004, 2007 and 2013. These include Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia, and Slovenia.

BOX 3.1
(continued)

The program also offers the possibility of pooling national resources through co-funding and adding H2020 resources to the pooled resources. For example, the **European Joint Programme Co-fund (EJP)** supports coordinating national research programs by pooling resources for research and innovation projects, coordination and networking, training, and demonstration and dissemination activities.

Eureka and Eurostars

Eureka and Eurostars are programs for international cooperation in industrial R&D and innovation, with the aim to bring increased value to the economy, higher growth and more job opportunities. Eureka is an intergovernmental network established in 1985. Its aim is to enhance European competitiveness by fostering innovation-driven entrepreneurship in Europe between small and large industry, research institutes and universities by facilitating access to finance for companies involved in its projects. Eureka projects are financed from the national budget of the respective countries of collaborating organizations. Eurostars is a joint program between Eureka and the European Commission, co-funded from the national budgets of 36 participating states and by the European Union through Horizon 2020. The program has a total public budget of EUR 1.1 billion (2014–2018).

COSME

COSME is a program for SME support through grants and financial instruments with a total budget of EUR 2.3 billion (2014–2020). Grants are provided to public and private entities to deliver SME support projects, particularly in the areas of entrepreneurial culture and SME growth. Financial instruments are delivered through two main facilities:

- **Loan Guarantee Facility** - which supports guarantees and counter-guarantees to financial institutions to help them provide more loans and lease finance to SMEs, and
- **Equity Facility for Growth** - which invests in risk capital funds that provide VC and mezzanine finance in the expansion and growth stage of SMEs.

COSME focuses on projects strengthening the competitiveness and sustainability of the EU's enterprises, particularly SMEs, and encouraging entrepreneurial culture and promoting the creation and growth of SMEs.

Interreg V (2014–2020)

Interreg programs aim to reduce the inequalities between the countries and regions of the European Union in terms of their economic and social development. There are three types of Interreg programs – cross-border (type A, for actions involving countries that share a border), transnational (type B, for broader regions) and interregional (type C, covering all member states). Not every country has access to all programs, and not every program addresses all strategic objectives of the Europe 2020 Strategy. Thematic objectives 1 and 3 (related to RDI and business competitiveness) are addressed in 49 programs with 3,186 projects and an investment of EUR 6.8 billion.

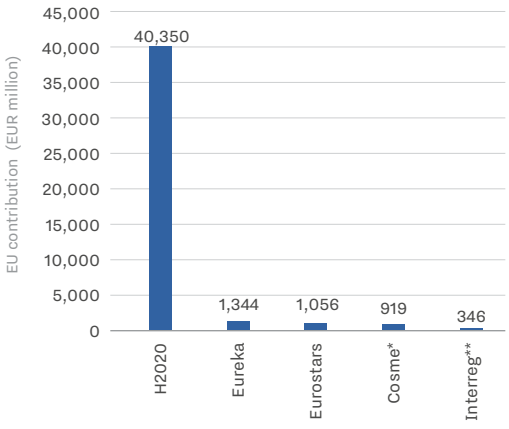
Source: Staff elaboration based on European Commission (2014), ec.europa.eu, eurekanetwork.org, interreg.eu, keep.eu.

Croatia's overall performance in internationally competitive programs for science and innovation is among the lowest in the EU. This is especially significant when it comes to the EU's eighth FP financing R&D and innovation, H2020. With one year left before program closure, Croatia is yet to surpass the amount it absorbed during the seventh FP, and it also performs poorly compared to peers. In recent years, Croatia has improved the quality of its proposals, as demonstrated by a higher-than-average success rate of eligible proposals. However, the volume of eligible proposals has not increased, resulting in a negative effect on overall absorption. Not only the research sector but also the private sector performed poorly in the FP. The private sector's participation in programs targeted to business innovation, such as Eureka and Eurostars, was also low.

Synergy effects of ESIF that would contribute to improving the performance of Croatian RDI institutions in EU programs have not yet occurred. Despite an allocation of nearly EUR 1 billion in OPCC for RDI and SME competitiveness in Croatia, there has been no effect on higher participation in Horizon 2020 and other internationally competitive programs. The reasons for this stagnation may be different for the public research sector and the private R&D sector, but it is likely that the overall weakness of the RDI system – with few pockets of excellence – and stagnating investment in R&D are at the core of the problem.

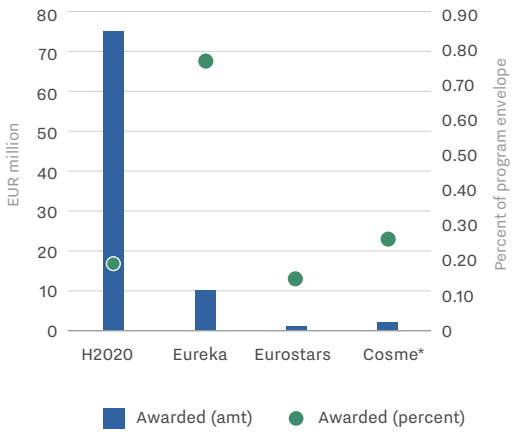
Since joining the EU, Croatia has made limited progress in attracting internationally competitive funding for RDI. Of the EUR 45.8 billion in EU contributions available across five programs (Figure 3.4), Croatia has absorbed only around EUR 145.5 million or 0.3 percent. By far the largest program is Horizon 2020 (H2020), which so far has awarded EUR 40.3 billion[39] in RDI funding for research institutions and enterprises. The remaining four programs (Eureka, Eurostars, COSME, and Interreg) make up around 8 percent of the total funding. Croatia has so far drawn EUR 76 million from H2020 (0.2 percent of total funding, Figure 3.5), below the amount drawn under FP7 (EUR 91.7 million or 0.2 percent, Box 3.2).

FIGURE 3.4
Total committed EU funding for RDI and entrepreneurship by program



Source: EC and staff calculations.
*Note: * Excludes the allocation for financial instruments*
*** Includes five Interreg programs with Croatian participation, budget allocations for TO1 and TO3 only.*

FIGURE 3.5
Croatian participation in centrally-financed schemes

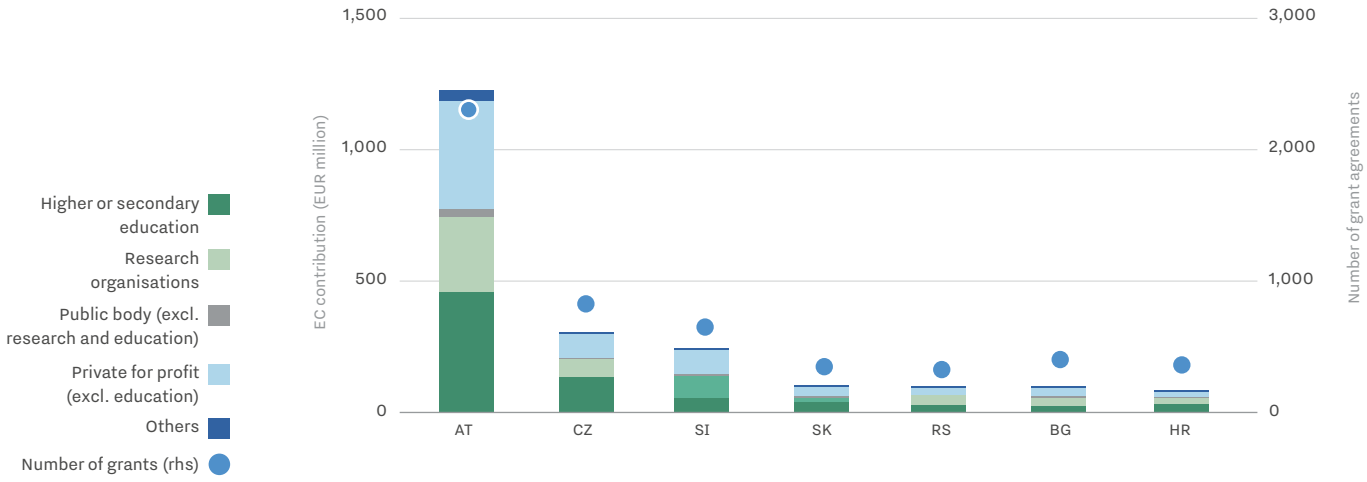


Source: EC Financial transparency system and staff calculations.
Note: There is no data on the absorption of Interreg funds by Croatian beneficiaries

39 EU contribution as of end-2018.

Croatia is at the bottom in the EU in terms of participation in internationally competitive RDI funding programs. In Horizon 2020, Croatia ranks 25th of 28 in the total amount of awarded funds (EUR 76 million) and 24th in awarded funds per capita. Among its peers, Croatia has received the least total funding and is below Bulgaria, Slovakia and Serbia, which all have a similar number of researchers (Figure 3.6). With 359 grant agreements signed and 496 organizations involved in projects, Croatia is the second-lowest ranked among EU peers, ahead of Slovakia, but behind Bulgaria and Slovenia.

FIGURE 3.6 *Croatia has the lowest absorption of H2020 funds among peers*



Source: Community Research and Development Information Service (CORDIS), 2019.
Note: "Others" include foundations, associations, and other NGOs

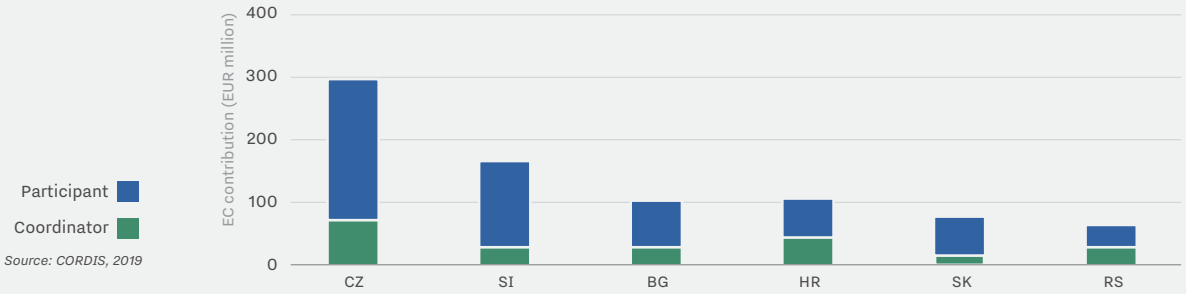
BOX 3.2 Participation of Croatia in the Seventh Framework Programme (FP7)

The Seventh Framework Programme for Research and Technological Development (FP7) was the EU's flagship research and innovation funding program in the 2007-2013 period. The program financed a total of 25,741 projects with more than 134,000 participants from the EU and worldwide. The program provided financing in the amount of EUR 64.5 billion, of which the EU contribution was EUR 45.4 billion. FP7 helped build research networks and encouraged finding solutions from a range of perspectives, disciplines and research cultures.

Croatia's limited success in attracting FP7 funding indicates a relatively low baseline competitiveness of its RDI projects, especially when it comes to the private sector. Over the lifetime of the FP7 program, 412 beneficiaries from Croatia received EUR 91.7 million (0.2 percent of the EU contribution), mostly in ICT, biotechnology, food safety and the environment. This puts Croatia in 25th place in EU-28 in terms of number of participants and in 22nd place in terms of project value. The success rate of Croatian applicants was 17 percent – below the EU average of 20.5 percent. SME participants made up 20 percent of the beneficiaries and received EUR 17.1 million in funding, which is the lowest amount among Croatia's EU peers. Croatia's performance in FP7 was weak even when controlling for country size. The annual per capita contribution from FP7 in Croatia was EUR 3, which was in line with the EU-13 average but was still far below peers such as Slovenia and Estonia, which had over EUR 10 per capita, and the EU-15 average of EUR 14.

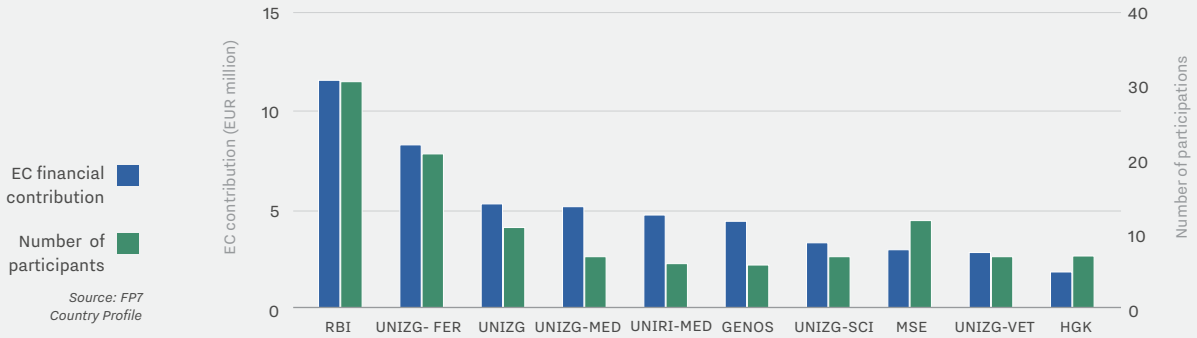
BOX 3.2
(continued)

FIGURE 3.7 *Croatia's participation in FP7 was among the lowest compared to peers*



Source: CORDIS, 2019

FIGURE 3.8 *The most successful institutions in FP7 were RBI and faculties within the University of Zagreb*



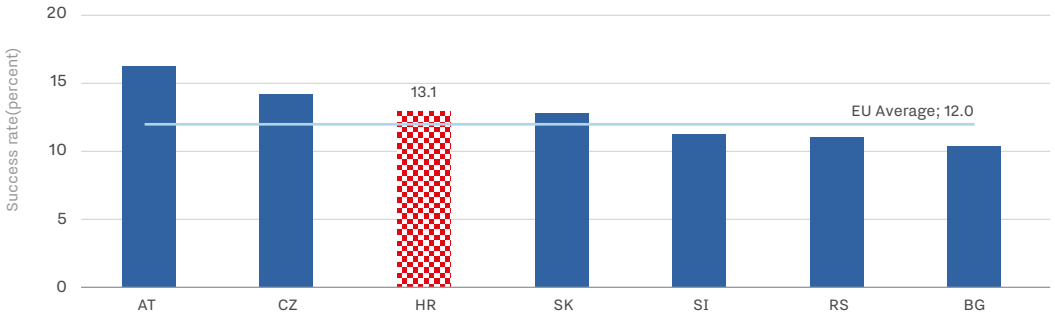
Source: FP7 Country Profile

Source: European Commission 2015.

Croatia's underwhelming performance in FPs is consistent with the experience of other EU-13 countries. EU-13 countries struggle to attract funding compared to EU-15 applicants. In 2014–2017, participants from EU-13 countries represented 8.5 percent of the participants in Horizon 2020 and received 4.4 percent of the overall funding (European Commission 2017), which is a slight improvement compared to FP7 (7.9 percent and 4.2 percent respectively). A 2018 study exploring the innovation gaps in EU-13 countries found that participation remains unbalanced, even after 20 years of access to FPs (EPRS, 2018). The study found that FP performance is uneven within the EU-13. Good performers include Slovenia, Estonia, the Czech Republic and Hungary. Croatia belongs to a less successful group alongside Bulgaria, Poland, Romania and Slovakia. Participation is also uneven when considering the funding scheme – EU-13 countries are generally less successful in programs targeting research excellence and innovation (for example, ERC, MSCA, and RIA/IA; see also Box 3.1).

One of the likely reasons that EU-13 countries performed poorly in FP7 was lower formal and substantive quality of project proposals. The ineligibility rate for proposals from EU-13 countries is higher, indicating weaknesses in their ability to meet formal requirements. Croatia's share of ineligible proposals in FP7 was 2.7 percent, below the EU-13 average (3.3 percent) but above that of EU-15 (1.9 percent). The overall success rate of EU-13 applicants in FP7 was 17.8 percent, 3 percentage points below that of EU-15 applicants, indicating that the substantive quality of EU-13 projects was also lower.

FIGURE 3.9 *The absorption of funds is low despite an improved success rate*



Source: CORDIS 2019.

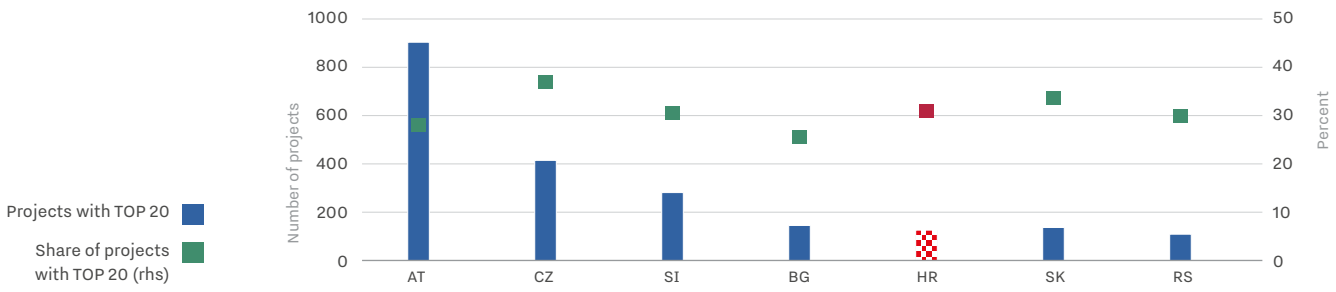
The difference in the quality of submitted projects is even wider if we consider project coordinators. Proposals with a project coordinator from an EU-13 country had an 11.7 percent success rate, compared to 18.3 percent for projects with EU-15 coordinators. Croatia's success rate in FP7 was below that of the EU-13 average, both overall (16.9 percent) and as a coordinator (10.6 percent).

Efforts to improve the participation of Croatian researchers in H2020 have resulted in an increase in the quality of applications but not in the number of submissions, indicating a lack of growth in research groups able to produce excellent science. Croatia undertook several policy measures to foster the quality of applications for Horizon 2020, including grants for preparation of proposals (up to HRK 40,000) and allowing H2020 project leaders at universities to hire additional PhD students. The success rate of proposals from Croatia in Horizon 2020 is 13.1 percent, above the EU average of 12 percent (Figure 3.9). This is also above the success rate of proposals from Slovenia, Bulgaria, Slovakia, Poland and Serbia. However, the number of applications (3,397) and eligible proposals (2,619) is also the third lowest among peers, ahead of only Slovakia and Serbia. Proposals coming from Croatian institutions have improved in quality, but their number is still too low considering the number of researchers in the country. This indicates that: (i) there are only a handful of research groups in Croatia that produce excellent research, and (ii) the incentives to submit projects remain weak – obtaining internationally competitive grants is not a necessary precondition for career advancement at any level.

Croatia's participation in FPs is hampered by an overall weak collaboration network and lack of connections with top research institutions. Collaboration, especially with the very top research institutions, raises the quality of research proposals and provides an opportunity for learning and knowledge sharing (EPRS, 2018). In FP7, project proposals prepared in collaboration with top institutions had a significantly higher success rate across all countries. In Croatia, collaborating with a top FP7 institution was associated with a 20.7 percent success rate, five percentage points higher than for proposals without such collaborations. And while Croatia slightly increased the number of participations with top institutions in Horizon 2020 compared to FP7, its share is similar to that of Serbia (Figure 3.10).

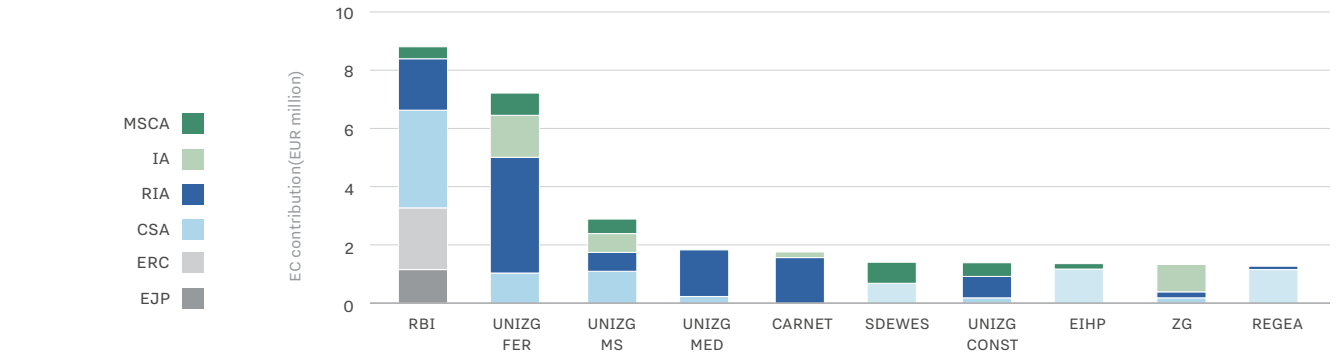
Systemic weaknesses of the RDI framework are likely an underlying issue for Croatia and its inability to take full advantage of FPs. Legacy constraints on Croatia's innovation system reduce its capacity to be more active in FPs. As noted in previous sections of this report, Croatia does not invest sufficiently in R&D and suffers from a high degree of institutional fragmentation and lack of coordination in RDI policies. The heavy emphasis on teaching in public research institutions contributes to a lack of competitive research, hampers internationalization and encourages brain drain.

FIGURE 3.10 *Croatia's collaboration with Top 20 institutions in Horizon 2020 is limited*



Source: CORDIS 2019.

FIGURE 3.11 *Ruđer Bošković Institute and faculties within the University of Zagreb are the most prolific public sector recipients*

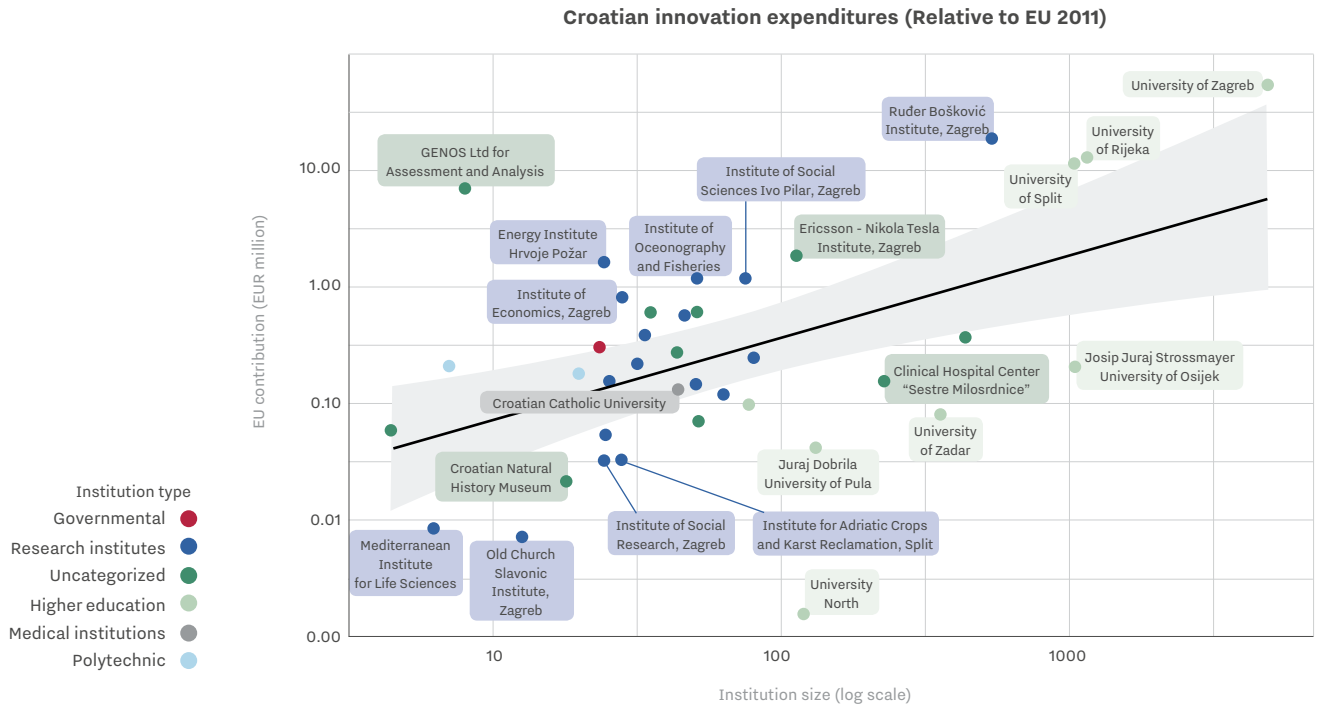


Source: CORDIS 2019.
Note: Acronyms correspond to the following institutions: RBI – Ruđer Bošković Institute, UNIZG – University of Zagreb, FER – Faculty of Electrical Engineering and Computing, MS – Faculty of Machinery and Naval Architecture, MED – Faculty of Medicine, CARNET – Croatian Academic and Research Network, SDEWES – international Center for Sustainable Development of Energy, Water and the Environment, CONST – Faculty of Construction, EIHP – Energy Institute Hrvoje Požar, ZG – City of Zagreb, REGEA – Regional Energy Agency of Northeastern Croatia

The scarcity of principal investigators (PIs) in ERC schemes and complete lack of participation in teaming programs are indicative of the low competitiveness of the Croatian research sector. The higher education sector makes up 31.7 percent of overall Horizon 2020 funding, followed by research organizations with 26.5 percent. However, Croatia has only two ERC PIs and no project contracted in the *Teaming* program, which are signs that public universities and institutes in Croatia have low capacities to perform top-quality research and participate in international collaboration. The most successful research entities have been Ruđer Bošković Institute, followed by STEM schools within the University of Zagreb (Figure 3.11). This is correlated with institution size, because larger institutions tend to receive more funding. However, some institutes and private research companies can attract more funding than larger universities and institutes (Figure 3.12).

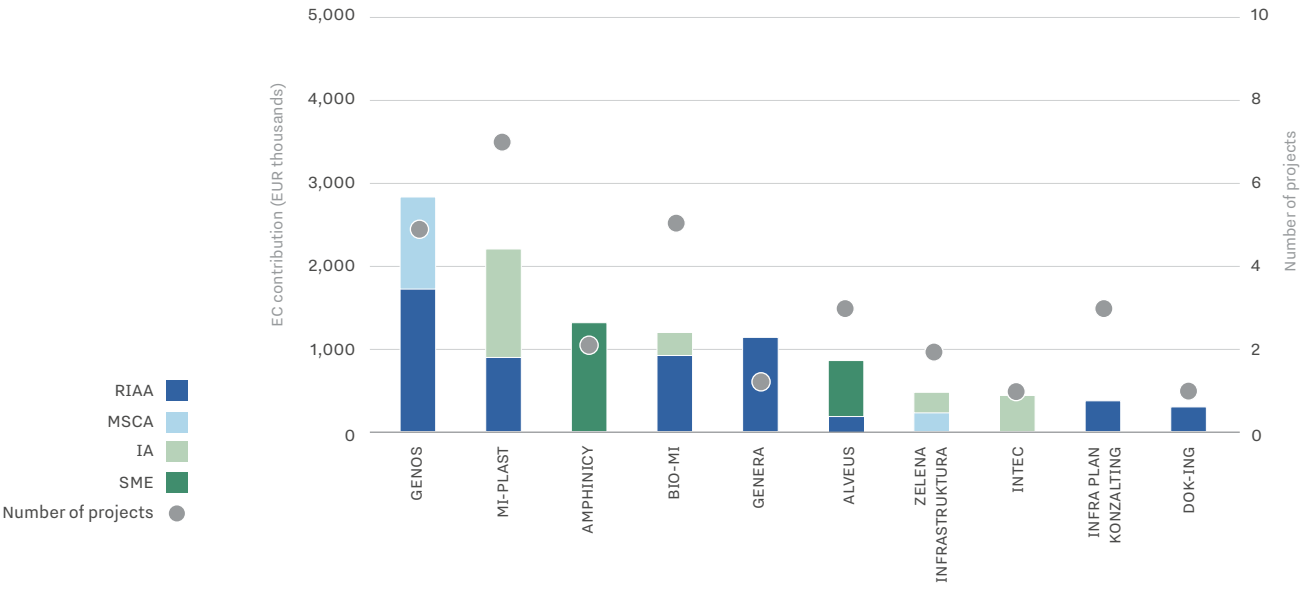
The private sector participates in H2020 to a lesser degree. The private sector has attracted 28.8 percent of funding in H2020 compared to a program average of 30.6 percent and an EU average of 31.1 percent. Among top private sector beneficiaries are biotech, clean technology and robotics companies (Figure 3.13). Only 72 SMEs participated in the Innovations in SMEs program (EUR 14.3 million, or 18.9 percent), the lowest participation among peers (Figure 3.14). The program allows for participation of consortia of SMEs, which could be leveraged to increase private sector engagement in R&D activities.

FIGURE 3.12 *Larger institutions receive more funding, though some smaller institutions can also attract a relatively large amount of funds*



Source: Staff elaboration based on CORDIS and Croatian Registry of Research Institutions HEI and R&D Institutions and Registry of Scientists.

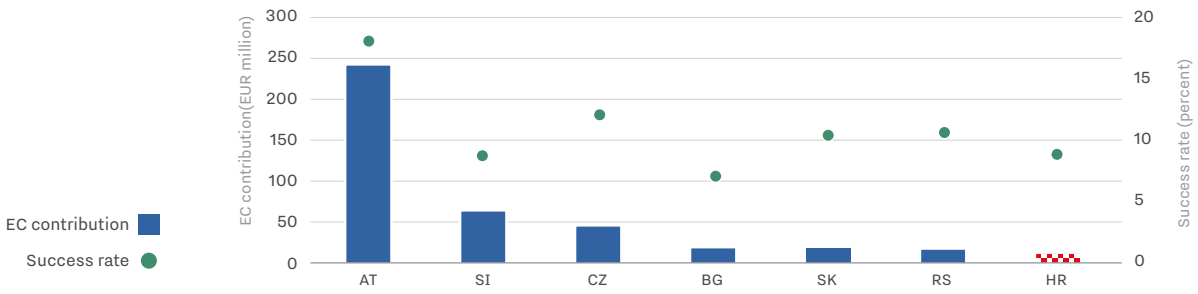
FIGURE 3.13 *The top 10 private sector beneficiaries mostly participate in RIA programs*



Source: CORDIS 2019.

FIGURE 3.14

The participation of SMEs in H2020 programs is the lowest among peers

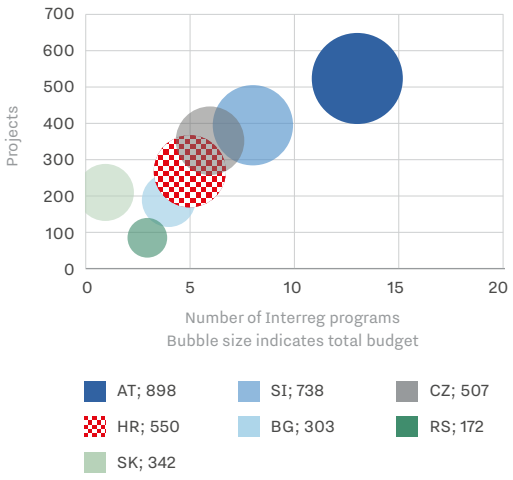


Source: CORDIS 2019.

In addition to H2020, Croatia participates in five Interreg programs relevant for R&D and business innovation. Within Interreg V-A, Croatia cooperates with Italy and Hungary, while within Interreg V-B, Croatia participates in the Danube, Adriatic-Ionian, and Central Europe initiatives. These five programs have earmarked funding for innovation and competitiveness. For example, the Adriatic-Ionian program addresses innovation through a dedicated priority axis – *Innovative and smart region* – in which Croatia participates in 13 of 14 approved projects (EUR 15.8 million) addressing innovation in maritime and aquaculture, tourism and social innovation. Croatian institutions lead three projects – *BLUE_BOOST*, led by the Chamber of Economy, providing innovation vouchers for industry-science collaboration in fisheries; *FOST INNO*, led by the University of Rijeka Faculty of Tourism, aimed at capacity building for innovation in tourism; and *SEADRION*, led by the University of Zagreb Faculty of Machinery and Naval Architecture, which supports exploring the use of seawater as a renewable energy source. In terms of program size, Croatia is positioned in the middle compared to peers, behind the Czech Republic, Slovenia, and Austria (Figure 3.15).

FIGURE 3.15

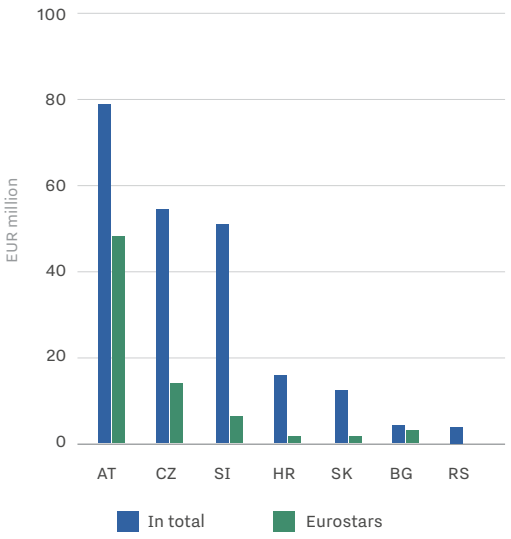
Participation in Interreg programs supporting research and competitiveness is in the middle compared to peers



Source: EC 2019.

FIGURE 3.16

Participation in Eureka and Eurostars projects is low



Source: EC 2019.

Low participation in the Eureka and Eurostars programs reflects a lack of internationalization and collaboration among innovative private enterprises in Croatia. Croatia has been a member of the Eureka and Eurostars network since 2014 and has absorbed EUR 16.1 million for 34 projects, of which only EUR 1.6 million has been from Eurostars (Figure 3.16). Only 19 SMEs and one university participated in Eureka and Eurostars projects.

Participation in the COSME program has been limited to smaller allocations fostering the development of business and innovation support services, youth entrepreneurship and peer learning. From 2015 to 2018, Croatian beneficiaries received around EUR 2.3 million in grants for business innovation services and fostering youth entrepreneurship. This corresponds to only 0.4 percent of the EC commitment of EUR 512.8 million to COSME over the course of 2014–2018 in 1,560 contracted projects. Almost a third of Croatia's grants were absorbed by technology parks, another third by the Chamber of Economy, and the rest were awarded to HAMAG-BICRO, universities and NGOs.

PART TWO
POLICY MIX

METHODOLOGY

The PER methodology uses the concepts of *relevance*, *consistency*, and *coherence* of the STI policy mix as a policy optimization framework. The policy mix represents the combination of policy instruments that determine the quantity and quality of STI investments in the public and private sector. The optimal policy mix, which maximizes impact from public expenditures in STI, should be relevant, consistent, and coherent (Correa 2014). The *relevance* of the policy mix is specific to the country context, the needs of the NIS and the economy at large. The analysis of the policy mix draws on the findings of the *Needs Assessment* to determine the relevance of public expenditures in STI. *Consistency* refers to the alignment of public expenditures with high-level objectives. *Coherence* pertains to assessing whether public expenditures are complementary and whether there are any redundancies in the system.

The review of the institutional framework explores the functions, roles and responsibilities of institutions involved in STI policy design and implementation. This analysis consists of two components. The first component reviews the process of STI policymaking and examines mandates of ministries, agencies, and councils in the STI governance framework. This includes a review of the contribution of each body in the policymaking cycle, including formulation, implementation and supervision. The second component of the analysis reviews the roles and responsibilities of institutions in the governance of ESIF funding and assesses the alignment of the ESIF governance framework with desired STI outcomes.

The methodology for the budget analysis entails benchmarking aggregate R&D expenditures in Croatia, reviewing budget accounts for STI, and examining budgets of PROs to determine their alignment with policy needs. Data sources include EUROSTAT Science, Technology and Innovation database, national budget accounts published by the Croatian Ministry of Finance, as well as data on budgets of PROs provided by MSE. Measures of aggregate R&D expenditures (such as GERD, GBAORD, and government-funded BERD) are used to assess the magnitude of budget allocations for STI and the extent to which public STI expenditures leverage expenditures in other sectors of the economy. National budget accounts for STI in MSE and MEEC are classified into functional categories (e.g. R&D salaries, research infrastructure, project financing, etc.) to determine the composition of public expenditures in STI and assess their alignment with policy needs and priorities. In addition, the budget analysis examines the budgets of PROs as the main providers of public research, with focus on the level and share of performance-based financing.

For project financing, the methodology involves assessing the consistency between STI support programs and their coherence with the policy environment. The data source for this exercise is the portfolio mapping, a systematic set of program characteristics collected from calls for proposals, instructions for applicants, and similar documentation. The unit of analysis is a program, which allows for more granularity in the analysis of expenditures compared to the analysis of aggregate budgetary data. The portfolio mapping allows for assessing resource allocation to different outcomes, objectives, target beneficiaries and type of R&D activities; program size and concentration of funds; mechanisms of intervention; and types of state aid. The consistency analysis uses these elements to determine:

- The division of roles among institutions responsible for STI financing;
- The presence and magnitude of complementarities between different programs;
- Instrument homogeneity, that is, concentration of instruments with similar characteristics;

— The magnitude of budget allocation;
— Funding predictability, assessing whether the support is likely to continue in the future;
— Overlaps and opportunities for program consolidation.

Similarly, the analysis of coherence is focused on assessing the alignment between the demand for innovation as identified in the *Needs Assessment*, the country's STI policy priorities, and the composition of the portfolio of programs. It does so by exploring:

— The alignment between policy priorities and the portfolio of programs, i.e. whether the mix of support programs responds to market failures, opportunities, and challenges of the national innovation system;
— The distribution of spending: (i) between the private sector and PROs; (ii) direct versus indirect support to business R&D; (iii) basic versus experimental research; (iv) operating costs versus capital investments;
— Analysis of gaps in the policy mix, i.e. areas with demand for funding that is not met by the current policy mix;
— Assessment of alternative mechanisms to achieve policy objectives, such as grants, loans, vouchers, and similar and how they may impact spending effectiveness.

4 INSTITUTIONAL LANDSCAPE OF THE NATIONAL STI SYSTEM

4 INSTITUTIONAL LANDSCAPE OF THE NATIONAL STI SYSTEM

The institutional landscape for STI policymaking is an important determinant of the efficiency and effectiveness of public spending for STI. This section explores the functions, roles and responsibilities of institutions involved in STI policy and financing. It provides the context necessary to understand the analyses of budget financing and project financing that follow this section.

- There are many institutions involved in the life cycle of a single innovation program, from design to implementation and execution. In addition to the complexities this brings at an institutional level, it is burdensome for the final beneficiaries, who have to deal with multiple institutions to participate in a support program.
- There is an evident mismatch between the governance system for innovation policy and the one for innovation financing.

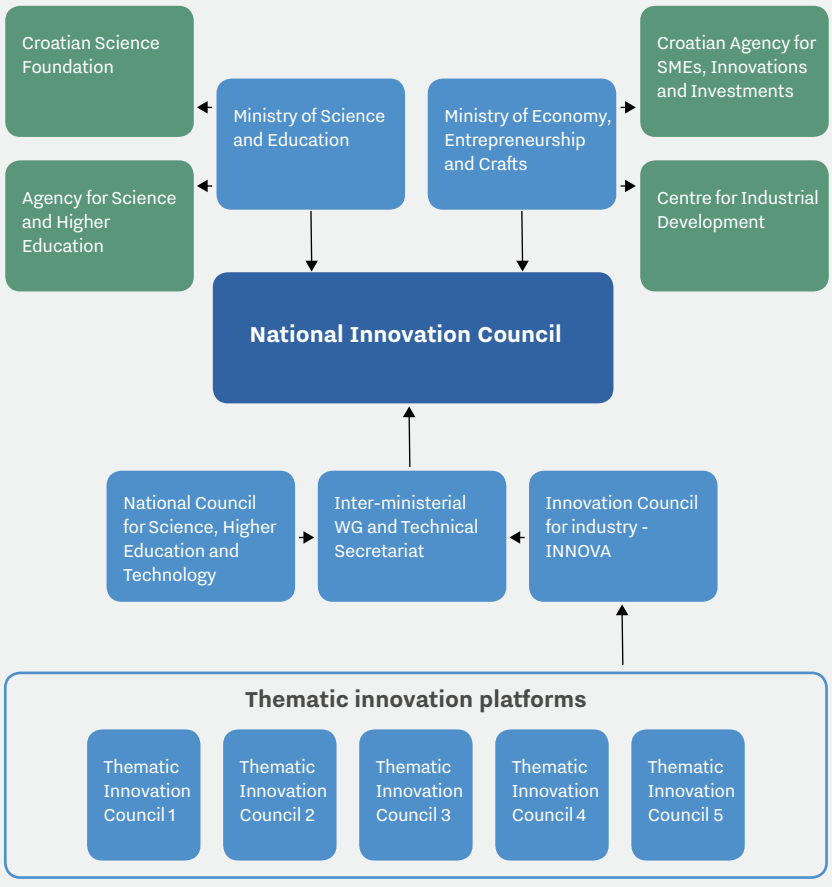
Croatia's STI system has undergone significant changes since the country's accession to the EU and has faced certain challenges. These changes can be observed from the perspective of innovation policymaking and innovation financing. Until 2013, the MSE had the leading role in innovation policymaking. Since the EU accession, this agenda has been shared with the MEEC. In addition, the preparation for the ESIF funding called for reorganizing the institutional structure, which has sometimes brought about institutional volatility, including loss of institutional memory or a lack of capacity.

The developments in the STI system have resulted in a complex institutional framework where new bodies have been set up while the existing ones have taken on new roles. The innovation institutional framework has seen the emergence and mergers of bodies at various levels. Particularly at the implementation level, old and new bodies have taken on new roles. The former innovation agency BICRO was merged with former SME agency HAMAG, creating the Croatian Agency for SMEs, Innovations and Investments, known as HAMAG-BICRO. The change moved the merged institution away from the competencies of the MSE toward those of the MEEC. The Center for Industrial Development (CIRAZ) under the Croatian Chamber of Economy (HGK) was created with an assigned role in innovation policymaking, and certain bodies have begun participating in innovation policy and financing without having relevant experience. New advisory bodies were recently established in addition

to the usual STI councils. To an extent, some of these changes took place in an attempt to improve innovation policymaking in the country; however, many were related to implementing ESIF. All in all, these changes have led to a complex institutional framework, which requires strong coordination and collaboration to be sustained and effective.

The Smart Specialization Strategy (S3) is at the center of the national innovation system. S3 was a prerequisite for Croatia to absorb ESIF in relation to the Cohesion Policy's Thematic objective 1 *Strengthening research, technological development and innovation*. Because this is a major source of investment into the RDI sector with S3 as its strategic framework, a structured institutional setup was formed within the existing innovation policy organization. S3 introduced new bodies, and a key national coordination role was given to the National Innovation Council. The work of this Council – which gathers high ranking officials from the relevant ministries, councils and, chambers – is further supported by the inter-ministerial working group for operational management and the technical secretariat. Figure 4.1 illustrates the setup for innovation policy making.

FIGURE 4.1 *Key actors of the Croatian innovation policy in the light of recent developments*

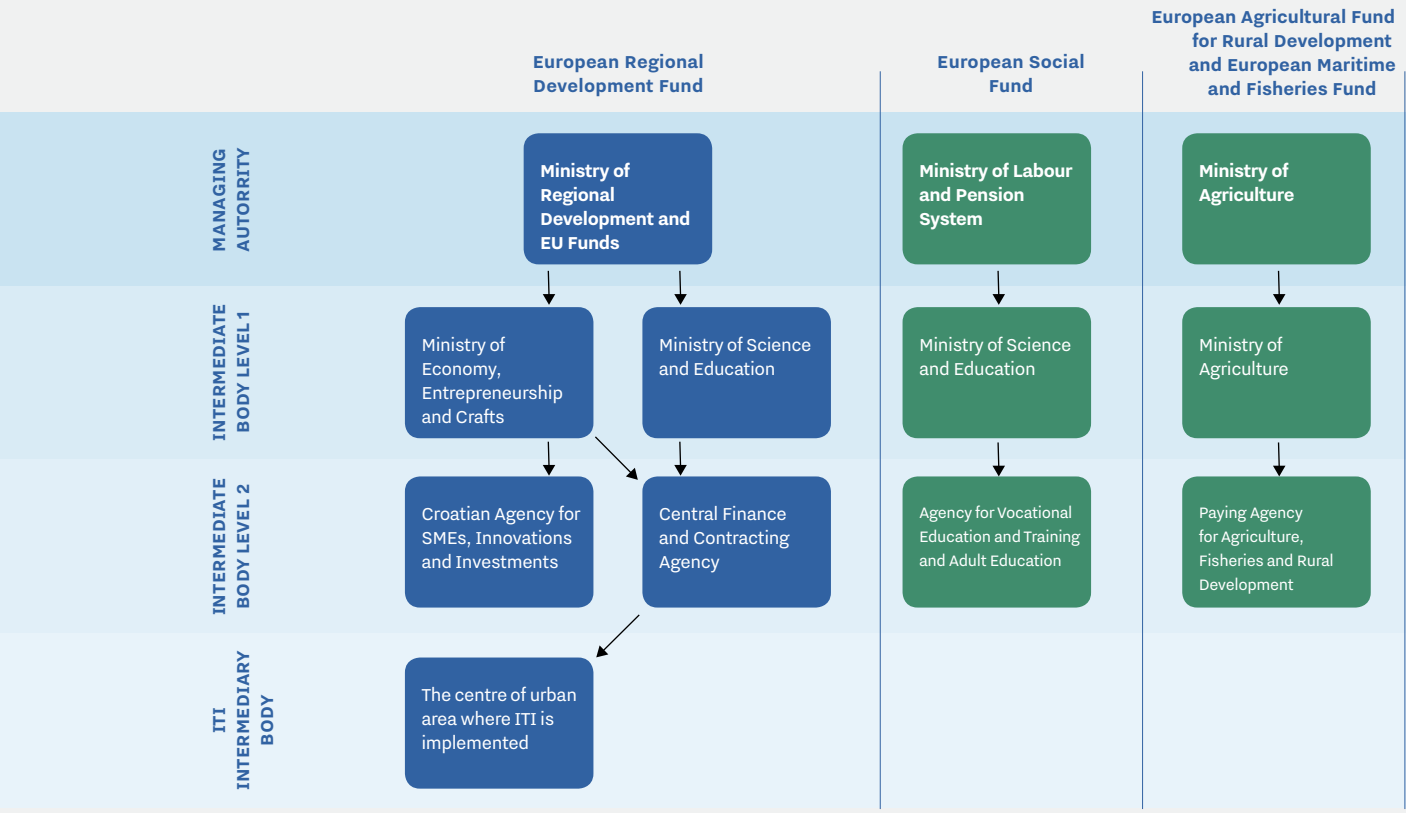


Source: Staff elaboration based on the Croatian Smart Specialization Strategy 2016-2020.

The newly founded advisory councils should ensure a bottom-up approach in informing innovation policy and supporting the STI framework, but the real question is how this will work in practice. On the one hand, the National Council for Science, Higher Education and Technology has further strengthened its role in advising policy through its position in the S3 structure. However, this council was active until early 2018, then did not meet until a constitutive meeting in mid-2019. On the other hand, the new Innovation Council for Industry with its cascading councils should enable the bottom-up approach and entrepreneurial discovery process to take place. Thematic Innovation Councils form part of Thematic Innovation Platforms, where one Council is constituted for each thematic priority area of S3 according to the *triple helix* model which foresees the participation of the business community, the scientific and research community, and the public sector. This appears to be a cumbersome advisory structure that can be challenging to manage.

The move from innovation policy to innovation funding led to a very different institutional setup. On a policymaking level, the MSE and the MEEC lead the agenda. However, when the innovation policy is translated into innovation financing, the landscape looks different. Other institutions are involved, playing various roles. Figure 4.2 is a very simple attempt to recognize those involved in innovation financing. There are at least three parties involved in the management of a single program: Managing

FIGURE 4.2 *Review of ESIF innovation funding*



Source: The World Bank based on Croatian regulation.[40]

40 Amendment to the Ordinance on Bodies in Systems of Management and Control of Usage of European Social Fund, European Regional Development Fund and Cohesion Fund in Relation to the Objective "Investment in Growth and Jobs," OG 15/2017 and Correction to the Amendments, OG 18/2017.

Authority (MA), Intermediate Body 1 (IB1) and Intermediate Body 2 (IB2). In addition, some programs have so-called *beneficiaries*, that is, institutions responsible for implementing projects or distributing certain funding. For these programs, there are four layers of institutions between the funding source and the final beneficiary. Moreover, some institutions involved in innovation financing have limited experience with innovation programs. Finally, for innovation programs to be designed and implemented well, strong collaboration and communication by all involved is needed, which is not always happening in practice.

The ESIF funding for innovation is regulated through a variety of operational programs requiring coordination between several ministries. The largest funding earmarked for STI comes from the ERDF through the related Operational Program *Competitiveness and Cohesion* (OPCC) with the Ministry of Regional Development and EU Funds as the MA. The allocations for the priority axes *Strengthening the Economy through Application of Research and Innovation* and *Business Competitiveness* (under which the most important STI financial instruments, and others, are funded) amount to almost EUR 665 million and EUR 970 million[41] respectively. Besides ERDF, funding is also absorbed through the European Social Fund (ESF), the Rural Development Programme and the Operational Programme for Maritime Affairs and Fisheries, which are under the responsibility of two other ministries. Therefore, monitoring the implementation of EU-funded investments into STI requires sound inter-ministerial coordination.

Ministries performing the IB1 role engage in the design of programs, but they also have numerous other changing roles. Different departments in a single ministry can function as IB1s, beneficiaries, and policy makers. This requires coordination between those acting as IB1s and beneficiaries, between those acting as IB1s and other departments responsible for financing STI through the national budget, and so on. In addition, with the availability of ESIF funding, certain roles have been transferred. For example, programs the CSF previously carried out with national funding have been transferred to ESF funding. Changing the financing source under the existing setup has put additional administrative strain on the CSF. By contrast, HAMAG-BICRO has moved certain programs from World Bank financing to national budget financing without undue complications. It appears that moving from one financing source to another is not very complicated in general. However, moving to ESIF funding requires arranging the institutional structure per the ESIF institutional landscape and its cumbersome procedures.

The institutions acting as IB2s have different capacities. The agency acting as IB2 is responsible for verifying expenditures and monitoring the fulfillment of contractual obligations by final beneficiaries. The Central Finance and Contracting Agency (CFCA) is responsible for a good part of the innovation financing under the OPCC, in relation to both the MEEC and the MSE. HAMAG-BICRO also performs this role. With ESF funding, the role of IB2 is performed by the Agency for Vocational Education and Training and Adult Education (DEFCO). While the role of IB2 can be very technical, performing it well depends on good understanding of innovation financing. Unfortunately, understanding of innovation financing is limited in both the CFCA and HAMAG-BICRO, with certain exceptions. HAMAG-BICRO gained relevant experience with innovation programs back when it was only an innovation agency (BICRO). However, it has since expanded with significant new staff.

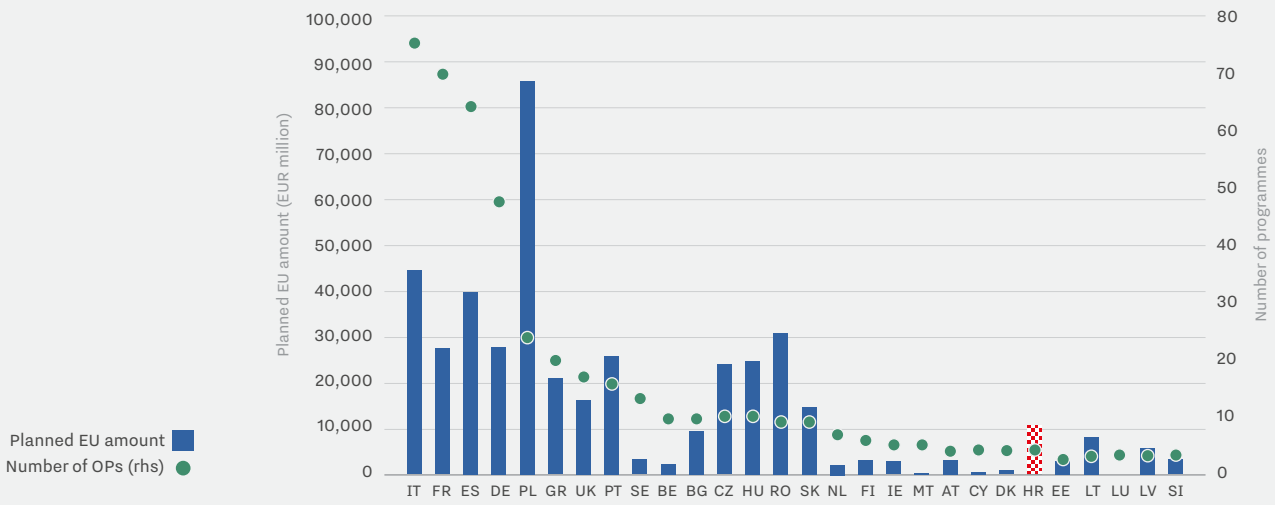
41 This amount refers to Thematic Objective 3 of OPCC, but at least a third is dedicated to innovation financing, while the rest is focused more on SME competitiveness.

BOX 4.1 Lessons learned from mission to Slovenia

A mission to Slovenia conducted as part of the Croatia PER in STI allowed for additional insights and exchange of experience between policymakers on STI policy design and implementation. Slovenia has made significant progress in its innovation performance and investment. In 1990, Slovenia and Croatia emerged from a similar STI system, had a very similar research sector and similar level of R&D intensity in the industrial sector. However, by 2003, Slovenia invested 1.25 percent of GDP in R&D, intensifying to 2.58 percent of GDP a decade later. Meanwhile, Croatia's R&D intensity has stagnated over a long period of time. The mission discussed the institutional setup for STI policy, ESIF financing, framework conditions in the research sector, science-industry collaboration, technology transfer and business innovation.

Certain differences in the institutional setup for STI policymaking and financing in Slovenia appear to allow for more effective spending of ESIF for innovation. As in Croatia, the STI agenda is split between the Ministry of Education, Science and Sport and the Ministry of Economic Development and Technology, but in Slovenia each of them target specific technology readiness level (TRL) phases and this division is very clear to all those involved. Slovenia does not have a separate OP for ESF funding, but rather ERDF, ESF, CF are combined under one OP (as is also the case in Estonia, Latvia, and Lithuania, Figure 4.3). As a result, both ministries collaborate with only one Managing Authority. Regardless of the lead institution in charge of a program, its design, implementation and monitoring is usually done within a single institution. As public procurement is often a bottleneck, there is a team that works only on large tenders. On the business innovation side, Slovenia has a four-tiered support network for entrepreneurs and start-ups which provides services free of charge, financed through ESIF funds.

FIGURE 4.3 *Review of ESIF innovation funding*

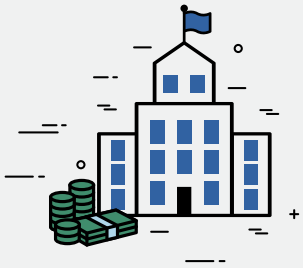


Source: European Commission, ESIF 2014-2020 Finance Implementation Details dataset, 2019.

5 BUDGET FINANCING

5 BUDGET FINANCING

The policy mix for STI should correspond to the needs identified in the Needs Assessment. The policy mix in Croatia is a combination of budget financing for public HEIs and PRIs, together with project-based financing. This section explores overall budget spending on R&D, and delves deeper into the institutional financing component of the STI budget by analyzing the structure and amount of national funding for HEIs and PRIs.



- Total budget spending on R&D in Croatia (including from the EU and national sources) has increased since 2013 but is still at half the level of the EU in per capita terms.
- Access to ESIF funding has allowed Croatia to increase budget spending on R&D, which provides an opportunity to increase gross expenditures on R&D (GERD) in the next few years.
- However, among its peers, Croatia has the lowest ratio of GERD to government budget appropriations or outlays on R&D (GBAORD), indicating a limited multiplicative effect of government spending on gross R&D expenditures.
- The bulk of national financing for STI is delivered through public funding of HEIs and PRIs by MSE. It covers salaries of academic staff and researchers, as well as other salaries and overhead. Recently introduced performance-based funding is an attempt to stimulate research excellence through a more meritocratic and transparent distribution of funds. However, these arrangements are still optional and constitute a small portion of the financing of PROs.
- The national financing for RDI projects has halved from 2013 until 2019 (to EUR 40 million) likely due to substitution with ESIF funding. This substitution is not entirely equivalent because ESIF funding has a more complex governance framework and imposes a greater administrative burden on both institutions and potential beneficiaries.

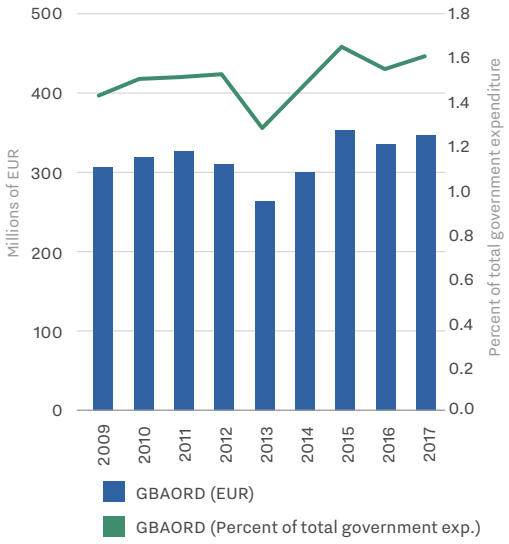
5.1 Budget Allocations for Research and Development

Croatia has increased its budget allocations on R&D, but not enough to converge with EU budget spending on R&D per capita. Croatia's GBAORD hovered around the EUR 350 million mark between 2015 and 2018, only a EUR 50 million increase since the steady-state level prior to EU accession (Figure 5.1). This is equivalent to less than half the EU average in per capita terms, despite a higher-than-average proportion of R&D allocation in the overall budget (Figure 5.2).

Spillover effects of budget spending on R&D in Croatia are very limited, reflecting the inability of the STI system to transform public investments into R&D spending. Croatia should take advantage

FIGURE 5.1

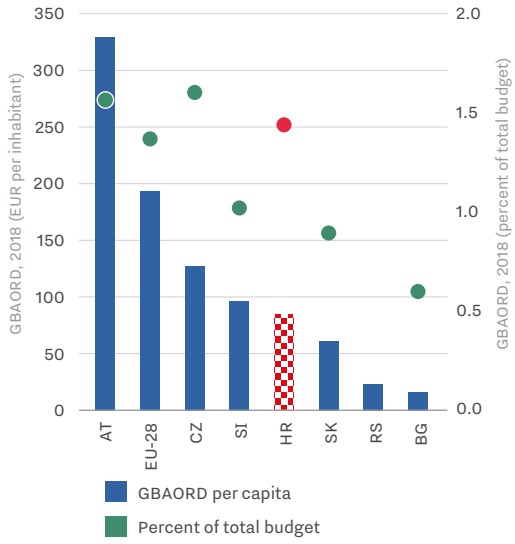
Government R&D spending has been stagnating in recent years



Source: EUROSTAT, 2019.

FIGURE 5.2

Croatia spends a relatively high proportion of its total budget on R&D, but this translates to a low amount in per capita terms



Source: EUROSTAT, 2019.

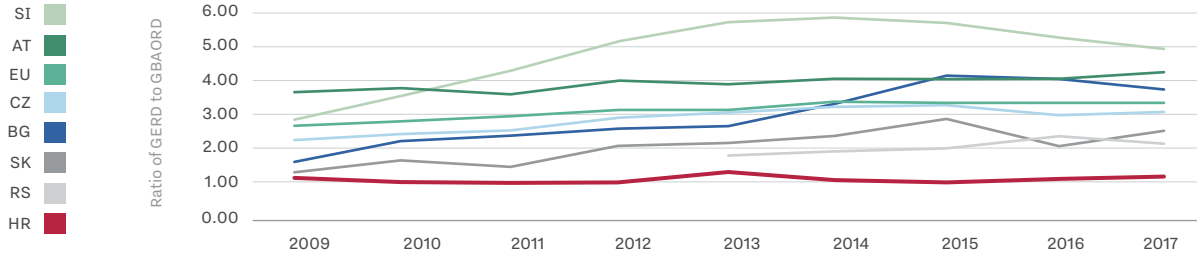
of the opportunity presented by the ESIF financing, as captured in GBAORD, to make sure that the public investments attract further private investment in R&D. However, this effect has so far been limited, as evidenced by the low ratio of GERD to GBAORD (Figure 5.3). The ratio of GERD to GBAORD[42] captures the multiplicative effect that budget spending on R&D has on overall spending on R&D. Croatia's ratio is 1.2.[43] In other words, in Croatia, a EUR 1.0 budget allocation on R&D generates EUR 1.2 in overall R&D spending. Croatia's ratio is by far the lowest among its peers. The EU average is 3.2. Moreover, all of Croatia's peers have increased their GERD/GBAORD ratios over the past decade. Croatia's lagging GERD/GBAORD ratio indicates a serious structural failure in Croatia's STI system. Public spending on R&D is not generating positive spillovers to the degree observed in other countries. The portion of GBAORD intended for businesses is expected to have a higher multiplier effect, but this is not happening in Croatia, as government spending on BERD in Croatia has been historically low (Figure 5.4).

A substantial inflow of ESIF funding could increase GERD, but this effect can be maximized only through well-targeted interventions and reforms in the framework conditions. Around EUR 500 million ESIF funding was allocated in 2019 to MSE and MEEC (Figure 5.5 and Figure 5.6). Although funding for MEEC also includes financing for competitiveness under TO3, there is still a substantial amount of funds potentially available to support innovation. The magnitude of the potential impact of these financial inflows on GERD is difficult to estimate. However, the limited spillover effects in the past decade (Figure 5.3) should moderate expectations. Taking full advantage of ESIF funding will require well-targeted interventions coupled with structural reforms.

42 In EUR per inhabitant. This analysis comes with a caveat based on differences between the data sets. GBAORD is based on budget data, not actual expenditures. GERD is based on actual domestic expenditures. In addition, there is a time difference: GBAORD data is available sooner than GERD data.

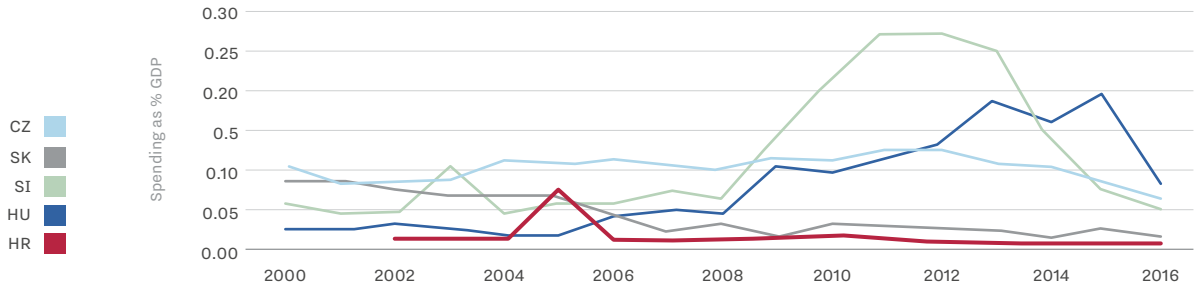
43 Croatia's consistently low ratio of GERD to GBAORD may also be a result of misclassification of government spending into spending for R&D, which may overestimate GBAORD.

FIGURE 5.3 *Spillover effects of government spending are the lowest among peers*



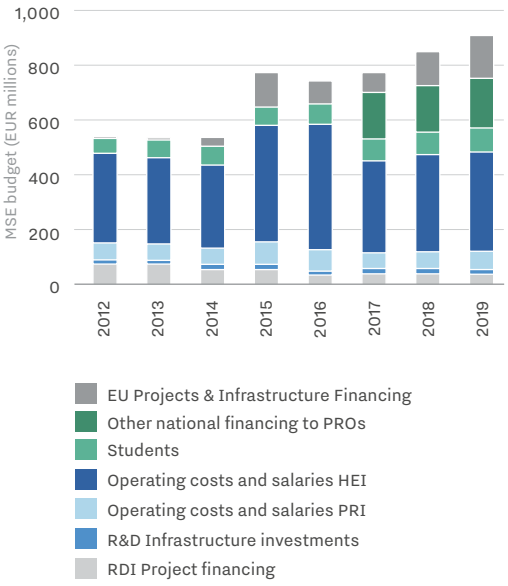
Source: Staff calculations based on EUROSTAT, 2019.

FIGURE 5.4 *Government spending on BERD has been historically low*



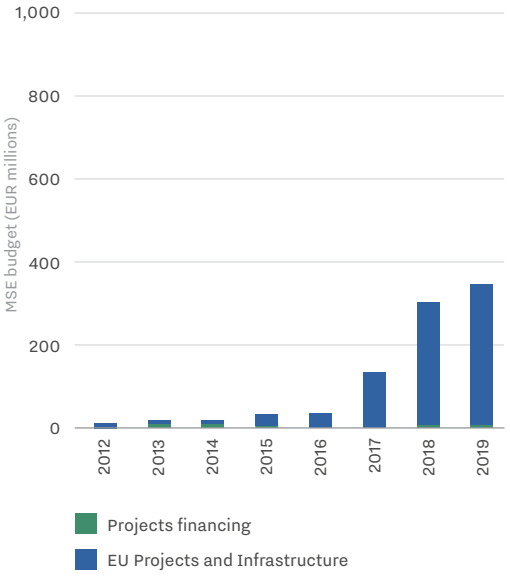
Source: OECD.

FIGURE 5.5
Disaggregation of budget allocations in MSE



Source: Staff elaboration based on national budget data.

FIGURE 5.6
Disaggregation of budget allocations in MEEC



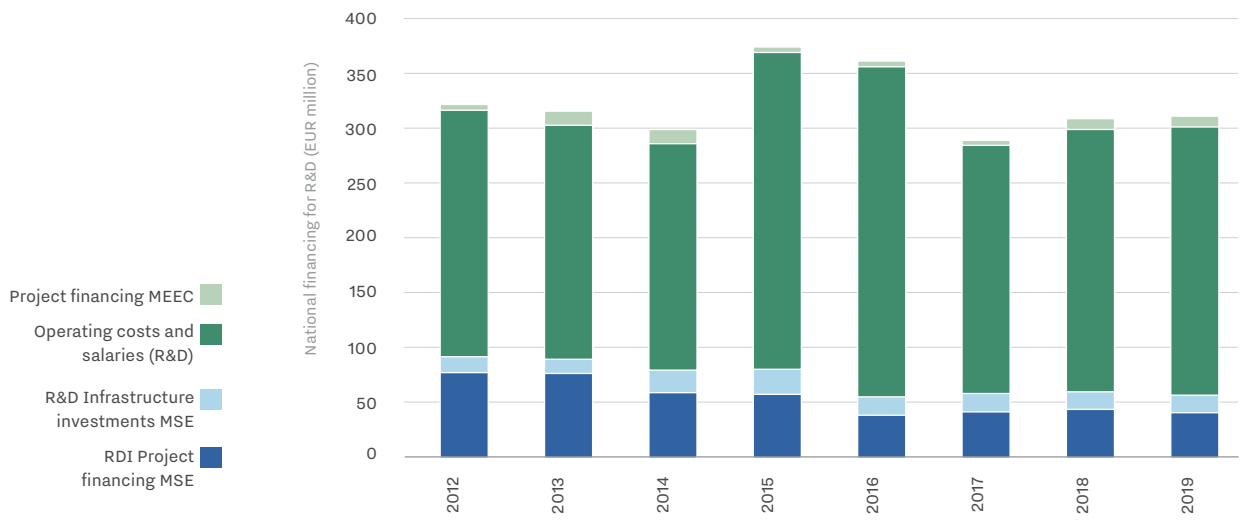
Source: Staff elaboration based on national budget data.

5.2 Structure of National Spending in HEIs and PRIs

National financing of STI in Croatia is mainly allocated by MSE as institutional funding to HEIs and PRIs, which makes the task of separating spending for educational and research purposes challenging. The *National Council for Science, Higher Education and Technological Development* determines the criteria for allocation of budget funds for scientific activities based on a proposal provided by its expert body, the *Council for Financing Scientific Activity and Higher Education*. The MSE ultimately drafts a budget proposal taking into consideration requests made by research and education institutions in line with the criteria set by the council. Budget funds allocated to HEIs and PRIs are then used for various purposes such as the salaries of researchers and staff, utilities, and maintenance. The *Collective Agreement for Science and Higher Education* suggests that the workload of academic staff should be roughly split equally between research and educational activities. However, this is not consistently implemented in practice, making it challenging to estimate R&D spending in HEIs.

Public funding for STI from national sources is increasingly used to cover salaries and operational costs, while project-based financing is declining. An estimated 80 percent of funding for R&D in 2019 was dedicated to R&D salaries and operational costs,[44] compared to 70 percent in 2012 (Figure 5.7). This came at the cost of reducing RDI project financing in MSE, which is likely influenced by the availability of ESIF funding for project financing. However, national funding provides more flexibility, and ESIF funding cannot fully substitute for it. Project-based funding from MSE is implemented by the CSF, which designs programs for research projects (see Section 6 for more details). MEEC allocates a very small portion of funds from the state budget for RDI programs (around 2 percent in 2019), relying almost exclusively on ESIF funding.

FIGURE 5.7 *Operating costs and salaries dominate in the structure of RDI spending*



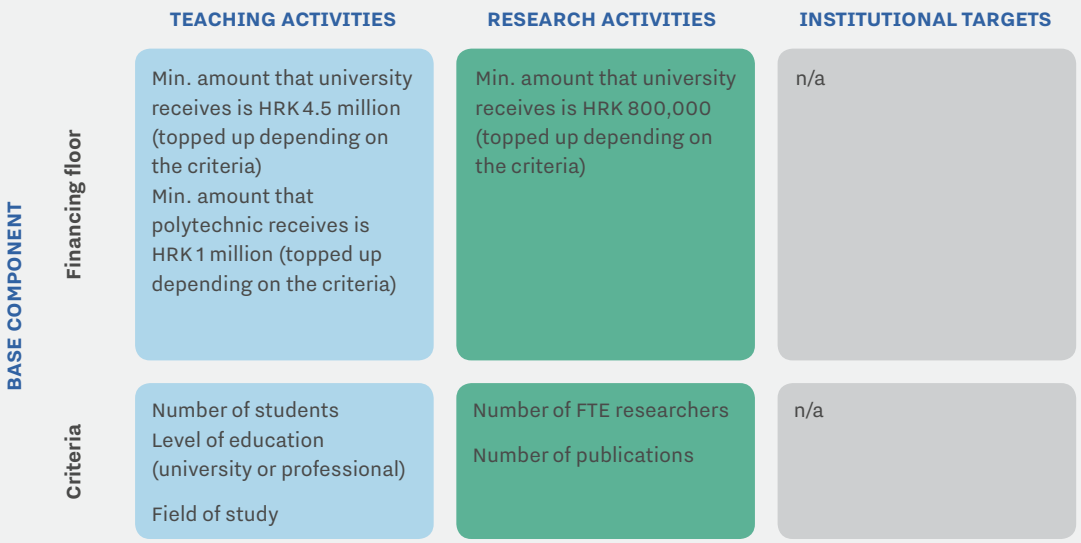
Source: Staff elaboration based on national budget data
Note: Operating costs and salaries (R&D) were estimated by assuming half of the allocation for HEIs is related to R&D.

44 R&D salaries and operational costs were estimated as the sum of PRI costs and half of HEI costs, based on the assumption that half of the workload of academic staff is dedicated to research activities, as stipulated in the *Collective Agreement for Science and Higher Education*.

The consistently high share of budget earmarked for operating costs and salaries indicates structural issues stemming from the institutional framework and governance model of the public research sector. Salaries and operating costs are allocated from MSE to HEIs and PRIs irrespective of their performance. MSE covers salaries and operating costs for 105 research institutions, the majority of which are financially and legally independent faculties associated with universities (see Section 2.1 for more information). This arrangement creates significant obstacles to resource reallocation or resource sharing between faculties. University integration would be one measure toward ensuring a more efficient and effective use of resources that would improve Croatia's ability to pursue research excellence.

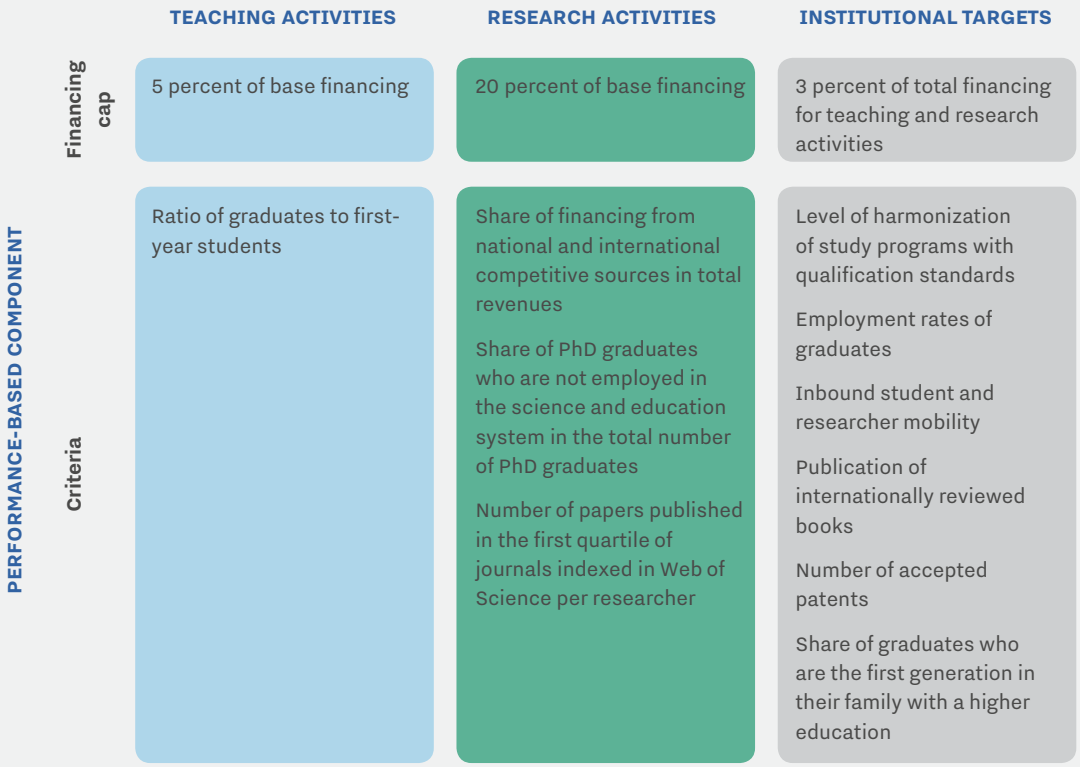
Recently introduced voluntary funding agreements are predominantly based on administrative criteria that still favor quantity over quality, while the performance-based component is limited. The funding agreement framework introduced in 2018[45] allows co-financing material expenses in teaching and research activities as well as achievement of institutional targets (Figure 5.8). Seven of eight public universities, as well as ten polytechnics and schools of professional education opted to sign such agreements. Base funding remains the dominant financing source in funding agreements, with transparent allocation criteria. Performance-based financing is capped at 5 percent of base financing for teaching activities, 20 percent of base financing for research activities, and 3 percent of total financing for achieving institutional targets.

FIGURE 5.8 *Funding agreements in HEIs remain mostly driven by number of students and researchers with a limited performance-based component*



45 In 2010 and 2011, in cooperation with the World Bank and public universities, MSE started developing the concept of program agreements, and started implementing them in 2012. This framework was in force until the academic year 2017/2018.

FIGURE 5.8
(continued)



Source: Staff elaboration based on the Decision on program financing of higher education institutions in Croatia for the academic 2018/2019, 2019/2020, 2020/2021 and 2021/2022. (OG 87/2018).

Administrative criteria for allocating funds to HEIs persist, though recent attempts at performance-based funding are encouraging. Funding agreements cover only around 2 percent of the total public funds distributed to HEIs, and the performance-based funds are subset of those. At the same time, 84 percent of the public funds distributed to HEIs are related to salaries and other costs (Figure 5.9). The share covered by funding agreements has been increasing steadily since 2016. Because this share includes performance-based funding, the increase is a step in the right direction. The trend should be continued to move institutional financing toward a more transparent and meritocratic system. However, when we examine the amount distributed through funding agreements to each PRO (see Figure 5.11 for universities and Figure 5.12 for institutes), we observe three things. First, there is a strong connection between institution size and funding amount. Second, very small amounts are distributed to a large number of PROs. This pattern results from the fragmentation in the system and naturally raises the question whether such small funding amounts can be efficient and effective. Third, the funding of some of the well-performing PROs (as discussed in Section 3.3) has been increasing lately, which is an encouraging sign (even though it is still very small).

FIGURE 5.9

Funding agreements play a small but growing role in public financing of HEIs

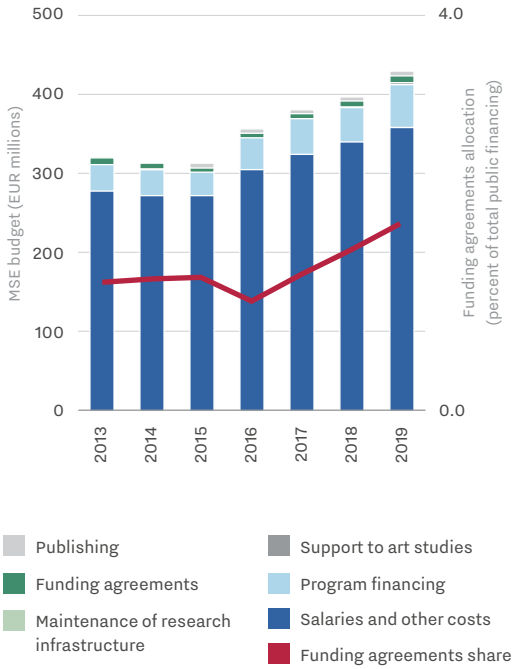
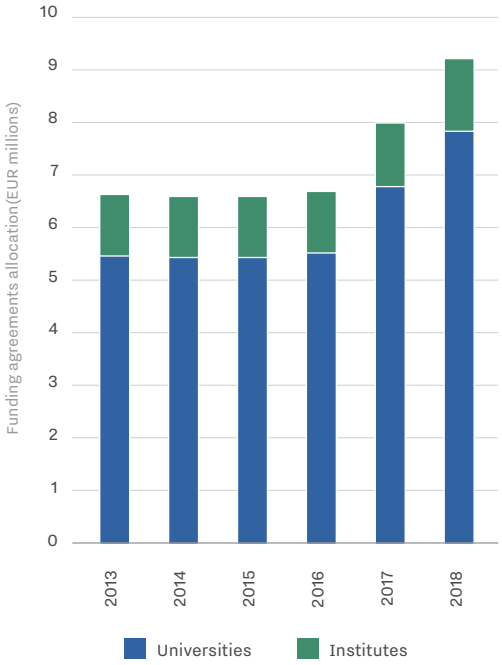


FIGURE 5.10

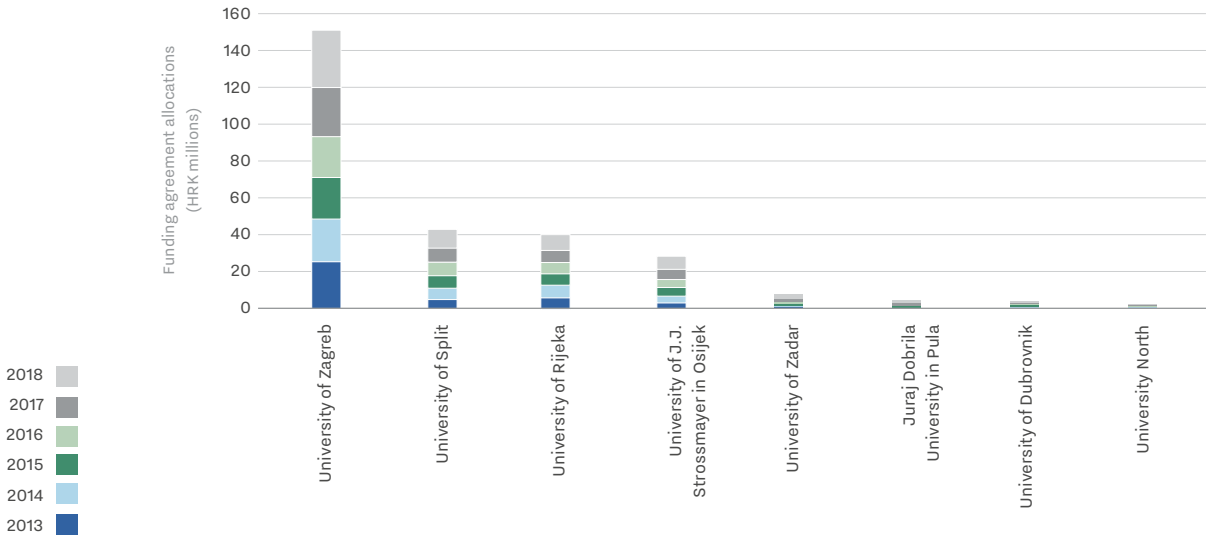
Most budget under the funding agreements (which includes performance-based funding) goes to HEIs, with a smaller amount shared among PRIs



Source: Staff elaboration based on MSE data.

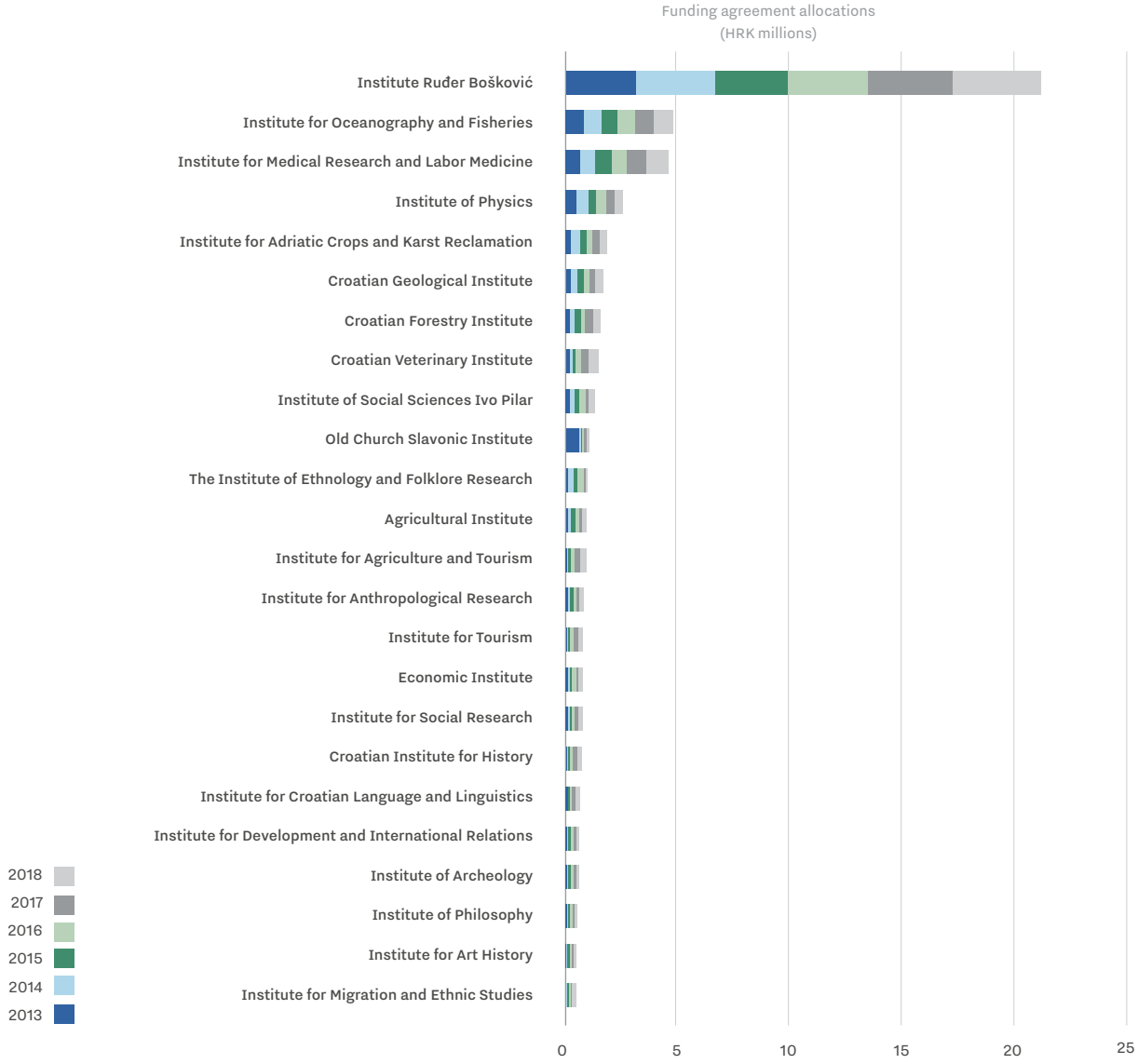
FIGURE 5.11

There is still a strong connection between institutional size and funding, making the performance based component in total funding negligible



Source: Staff elaboration based on MSE data.
Note: The chart shows funding to universities.

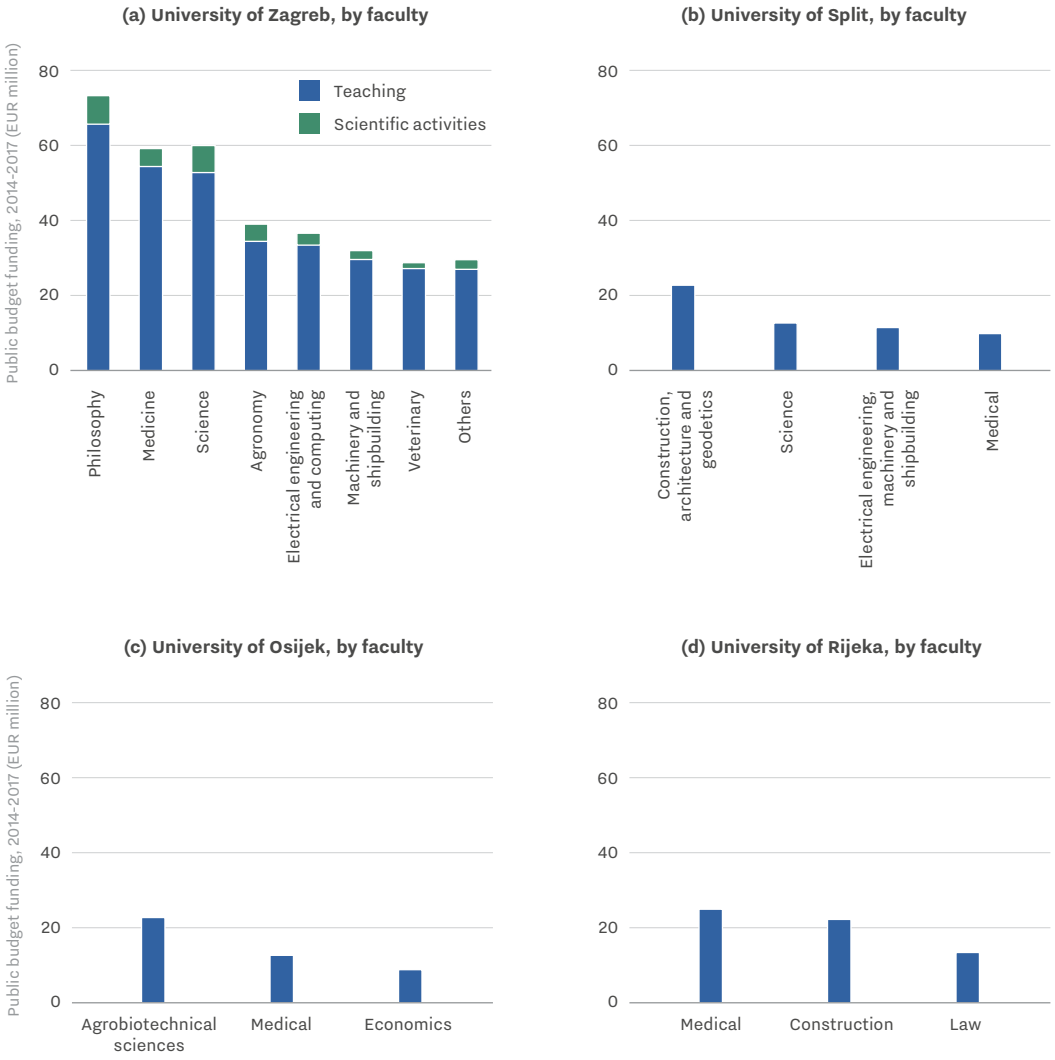
FIGURE 5.12 *As a result of the fragmented landscape of PRIs, a large number of institutes receive small amounts of funding*



Source: Staff elaboration based on MSE data.
Note: The chart shows funding to institutes.

Public spending in universities focuses heavily on teaching rather than scientific activity, with a preference toward fields with larger student bodies. Data on funding purpose, available for the University of Zagreb only, reveal that most public funding is spent on teaching, with only a minor share spent on scientific activities. The largest recipients of public funds include a mix of STEM and non-STEM fields. Figure 5.13 shows the faculties with largest budgets in the top four universities in Croatia. At this time, it is not possible to ascertain whether faculty funding is correlated with scientific productivity and quality. However, the regional distribution of citations along with the top fields presented in Section 2.2 suggest that there may be some discrepancies between funding and quality of science.

FIGURE 5.13 *Faculties with the largest budgets in the top four universities in Croatia*



Source: Staff elaboration based on budget data of faculties.
Note: Each figure shows the faculties from the corresponding university that, together, make up 50 percent of the university budget for faculties.

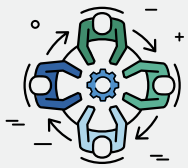
6 PROJECT FINANCING

6 PROJECT FINANCING

Prior to EU accession, project financing played a minor role in the STI policy mix in Croatia, with limited resources from the national budget and bilateral financing. However, after 2014, Croatia gained access to substantial resources from ESIF, giving project financing a more prominent role in the policy mix. Due to the late adoption of the Smart Specialization Strategy, which was an ex-ante condition for the use of ESIF, Croatia was able to tap into this funding only after March 2016. The substantial increase in funding, coupled with the institutional complexity and coordination difficulties documented in Section 4, have made the task of understanding the exact composition of the policy mix challenging. This section presents the findings of a comprehensive and granular exercise to map all project financing in Croatia, revealing the big picture of what STI instruments are really supporting and whether STI policy effectively addresses the challenges in the system. This section also includes an initial qualitative review of STI programs and analyzes the profile of beneficiaries.

6.1 Portfolio Mapping Analysis

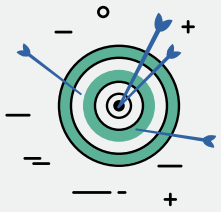
— The quantitative analysis of the portfolio of project-based financing for STI was performed by mapping the characteristics all 68 STI support programs along 244 variables organized into 25 categories.



Program governance

— Project-based financing (EUR 1.1 billion) constitutes a large portion of the STI funding policy mix, mostly thanks to a substantial allocation from ESIF. Despite the fact that full membership started in 2014, Croatia unlocked ESIF financing only after the delayed adoption of its Smart Specialization Strategy in 2016.

— Five ministries and implementing agencies have roles in distributing project-based funds, a form of institutional complexity that can give rise to coordination challenges.



Coherence of program objectives

— The objectives supported by STI programs in the portfolio are, to some extent, at odds with the needs of the STI system. Most notably, there are not enough programs supporting business R&D, access to finance, and technology transfer.

— Many programs support research excellence, but there have not yet been any visible results in terms of impact on performance or research and innovation outputs. Under Horizon 2020, Croatia has yet to match the amount of funding it absorbed under FP7, and Croatian institutions take the role of coordinator less.

— Skills and human capital are underrepresented and most often bundled with research excellence objectives.

— The portfolio of support programs for the business sector is heavily skewed toward interventions to improve productivity in existing firms, while diversification and new ventures are supported to a lesser degree.

— There is also a strong emphasis of government spending on non-R&D innovation, even though Croatia already spends substantially more on non-R&D innovation than the EU average.

— Some of the largest programs are too broad to effectively achieve their stated objectives, which has resulted in overly complex program design in some cases. These would warrant a more targeted approach so that program design could be tailored taking into consideration the needs and capacities of target beneficiaries and the desired outcomes.

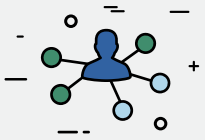
Mechanisms of intervention

— Overall, there is a lack of variety in the support instruments to finance innovation. The portfolio is overwhelmingly based on grant support, which may not always be the optimal mechanism to elicit the behavioral changes needed for the STI system to work more efficiently.

— Vouchers are underutilized and have seen a low take-up due to limitations related to eligible service providers. For innovation vouchers, eligible service providers are limited to registered research organizations, which is an overly restrictive requirement, especially if firms need specialized knowledge in intellectual property rights and closer-to-market innovations.

— Only one recently introduced support program (Venture Capital Fund) is devoted to closing the gap in early stage financing of innovation. Initial feedback suggests that there is a demand for the program, and that it could even spur migration of start-ups to Croatia.

— The effects of two recently introduced indirect support instruments – R&D tax breaks and public procurement for innovation – are yet to be seen. The intensity of R&D tax breaks is structured around the stages of R&D and firm size, with higher support awarded to earlier stages of research and smaller firms. Public procurement for innovation has not yet been utilized.



Targeting of beneficiaries

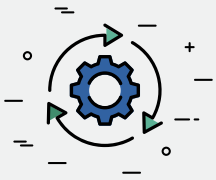
— The majority of programs for business innovation are intended for small and medium enterprises, but some programs bundle small and medium enterprises together with large firms, making program design more challenging. Medium-sized firms are most likely to obtain financing.

— Only a handful of programs support earlier stages of the life cycle, and most of the financing is ending up in mature firms.

— Few programs target knowledge-intensive services, with the majority of programs having a horizontal perspective.

Targeting of R&D stages

- Many programs cover a seemingly wide range of R&D and TRL phases. In fact, 15 programs cover five or more stages. However, elements of program design (such as selection criteria, results framework, or eligible partners) might create a bias toward very early or very late stages of R&D.
- The division of the private and public RDI agenda between MEEC and MSE naturally biases their respective work programs. MEEC programs tend not to focus on early stages of R&D (primarily seen in small and young firms). By contrast, MSE programs tend not to focus on commercialization of research (such as technology transfer and proofs of concept).
- A significant portion of *de minimis* programs (around 20 percent) support R&D activities, which is a limiting factor when attempting to support and follow projects from idea to commercialization. *De minimis* support is capped at EUR 200,000 over three years, which may be insufficient to support an idea through all its development stages.



Implementation challenges

- Many programs, including some of the largest ones, have experienced implementation delays. This is mainly due to complex program design and slow evaluations, which in some cases have taken several years. Language restrictions have made finding experts in frontier fields very difficult.

6.1.1 Scope of the Analysis

This section presents a comprehensive analysis of all STI support programs in Croatia. The analysis covers all STI support programs (68 in total) over the period 2014–2020 spanning five ministries, six implementing agencies, and four local governments. The programs to be covered were agreed upon in advance with institutions responsible for carrying out the bulk of STI policy implementation. During data collection, the World Bank team identified additional programs that were relevant for the analysis. In addition, the analytical exercise includes ten programs from the 2007–2013 period implemented by MSE. These are not part of the analysis of the current policy mix but were nevertheless included in the data collection to provide a point of reference for MSE and a solid basis for the Functional Analysis component of the project. The full list of covered programs is provided in Appendix III.

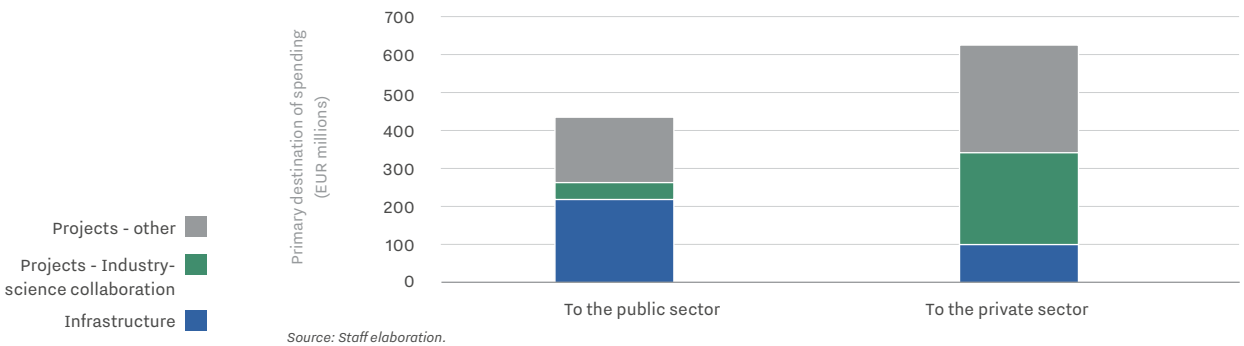
The analysis is based on data collected through desk review of program documentation, which was subsequently verified by program managers in relevant institutions. Most of the information in the analysis is publicly available and extracted from calls for proposals, instructions for applicants, attachments to the calls, and contract templates. Data on awarded contracts was also included where available. The data was organized into a so-called *portfolio mapping*, a tabulated representation of characteristics of individual STI programs that allows for quantification and analysis of the whole portfolio of project-based financing. The portfolio mapping framework in Croatia was constructed based on the experience of PERs conducted in Poland, Brazil, and Colombia, but was tailored to fit

the Croatian context and capture issues that are relevant to Croatia, while still maintaining core elements that would allow cross-country comparison. The end result was a framework with 244 variables organized into 25 categories (Appendix II). The following section presents the main findings of the quantitative analysis of the portfolio of STI project-based financing.

6.1.2 Overview of the Portfolio

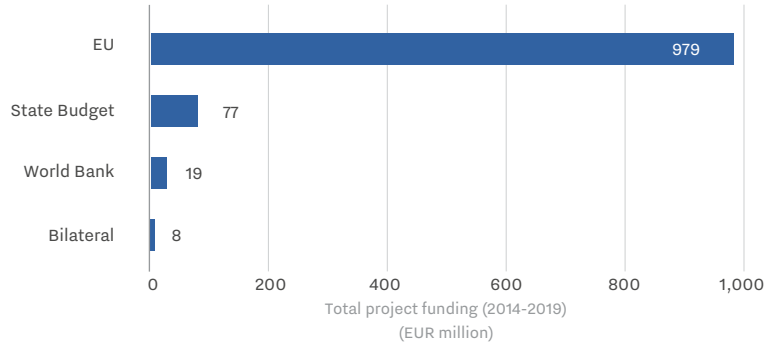
Project-based financing for STI has gained in importance since EU accession and is now comparable to institutional financing in terms of budget. The budget for project-based financing from 2014 until now comes at just under EUR 1.1 billion, which is slightly below the national RDI budgets of MSE and MEEC combined for the same period (see Section 5). Most of the funding (around EUR 640 million) is aimed at supporting the private sector, mostly through projects, but also industry-science collaboration and infrastructure. Support to the public sector (around EUR 440 million) was mostly directed toward research and delivered through infrastructure investment, with a lower share of direct project funding and funding for collaboration (Figure 6.1). Most of the project-based financing (90 percent) is derived from ESIF, with a smaller contribution of World Bank, bilateral and national budget funding (Figure 6.2). The national and bilateral funding are mostly implemented through CSF, while HAMAG-BICRO is implementing one nationally-funded program (MEEC national funding for Proof of Concept Private).

FIGURE 6.1 *Most of the project financing goes to the private sector*



Source: Staff elaboration.
Note: Foresight, INI and Clusters Competitiveness (EUR 19.5 million) are excluded.

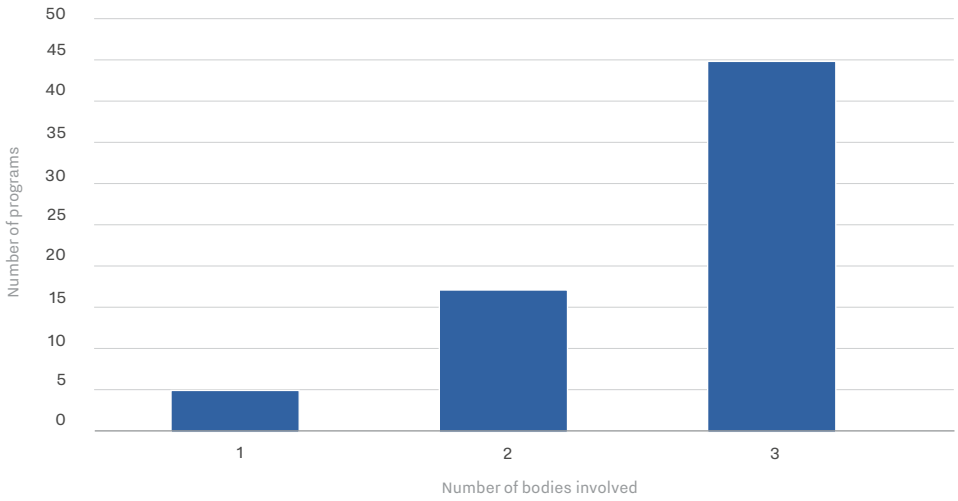
FIGURE 6.2 *Project financing was predominantly funded from EU sources*



Source: Staff elaboration.

The increased inflow of ESIF funding in project-based financing presents an opportunity but has also proven challenging to implement. Compared to other sources of financing, ESIF funding comes with a lot of strings attached and a higher burden on both the public administration and the beneficiaries, as outlined in Box 6.1. Such complex application processes are often costly for beneficiaries, which may deter firms that have limited access to resources, while attracting firms that are able to cover the cost of the application process, often using the help of consultants. Croatia implements ESIF funding through five separate operational programs (OPs), of which four (*OP Competitiveness and Cohesion, OP Efficient Human Resources, Rural Development Programme* and *OP Maritime and Fisheries*) cover the STI agenda. Nonetheless, the funds that make up ESIF (the ERDF, ESF and CF; see also Section 4) dominate in the innovation financing portfolio. This fragmentation of the STI agenda into multiple OPs is not obligatory.[46] Each OP has a separate MA and two tiers of intermediate bodies. Multiple institutions are involved in the implementation of a single program, and the distribution of functions between them varies from program to program. These structures exist in parallel with the national innovation policy governance architecture, making policy implementation all the more difficult. To make things even more challenging, Croatia could only access ESI funds for innovation after adopting its Smart Specialization Strategy 2014–2020, which it completed in 2016. As a consequence, Croatia has effectively had only three years to implement support programs, and a shorter time for project implementation. Regardless, according to EU rules, these programs should all be completed by 2023.

FIGURE 6.3 *The life cycle of most programs involves three bodies*



Source: Staff elaboration.
Note: Bodies include MRDEUF, MEEC, MSE, MEPE, MAGRI, HAMAG-BICRO, CFCA, DEFCO, CSF, APPRRR, and EPEEF.

46 For example, Slovenia has one OP that combines funding from ERDF, ESF and CF. See Box 4.1 for more details.

BOX 6.1 Procedural complexities in implementing ESIF financing

To implement ESIF financing, Croatia adopted a set of detailed procedures delineated in its Common National Rules (CNR). Separate procedures are defined for open calls, restricted calls, direct awards, allocations for public-private partnerships, large projects, and vouchers. The CNR also defines separate procedures for allocating grants with and without elements of state aid. Every type of call includes a different set of activities, but open calls are the most relevant for RDI projects. Several bodies participate, including the MA, IB1, IB2 and Monitoring Committee (MC). For each call, the MA, IB1 and IB2 designate a Competent Authority (CA), which may be different for different programs, and may be either IB1 or IB2 from phase to phase. This may lead to slow processing and coordination among different bodies.

Open calls consist of the following steps (with responsible institution in brackets):

1. Preparation of the Program Annex, a document defining procedures and details of the program (IB1)
2. Definition of selection criteria and selection methodology (*IB1*, approving: *MA, MC*)
3. State aid program submitted and approved (*IB1*)
4. Preparation of the Call for project proposals (*IB1*)
5. Launching of the Call for project proposals (*CA*)
6. Pre-selection, if applicable (*CA*)
7. Public outreach (*CA*)
8. Registration of project proposals in MIS
9. Administrative check (*CA*)
10. Applicant eligibility check (*CA*)
11. Project/activity eligibility check (*CA*)
12. Project quality assessment (*CA*)
13. Expenditures eligibility check (*CA*)
14. Decision on financing (*CA*)
15. Ensuring access to information for applicants (*CA*)
16. Notice to applicants on the status of the project proposal (*CA*)

Selection process

The phases of project award procedure are implemented in such a way that a single phase for each individual project proposal can start while the previous phase is still ongoing but cannot be completed before the previous phase is completed. The CNR prescribe eligibility criteria, as well as ten categories of selection criteria. The selection criteria are either mandatory or mandatory only if applicable. Mandatory criteria are value for money, financial sustainability, implementation capacity of the applicant (and, if applicable, the partner), design and maturity of the project, promoting equal opportunities and social inclusion, promoting sustainable development, and contribution of the project proposal to solving specific development problems in a specific territory. Criteria that are mandatory only if applicable are links to other projects relevant to the sector concerned, scope and strength of the partnership, and innovativeness in the project implementation plan.

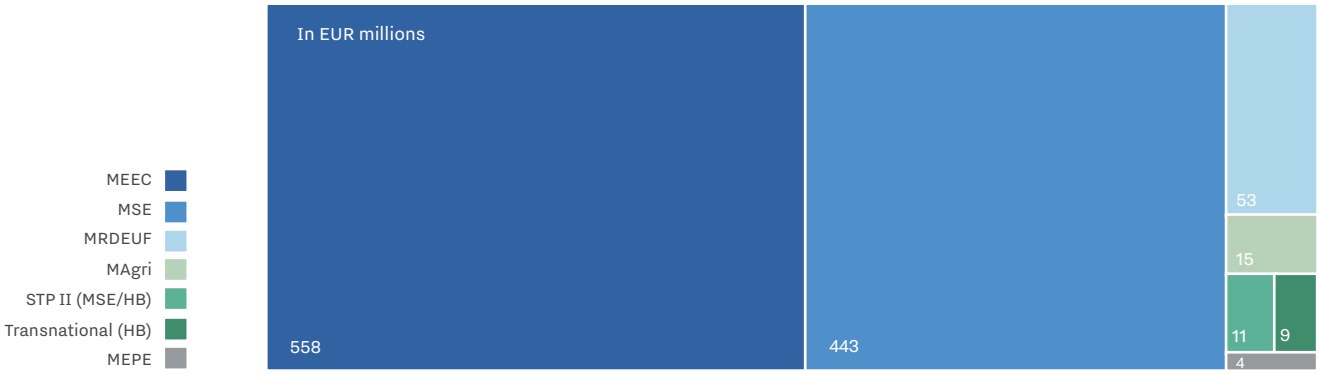
Grant award

The financing decision may not occur before the expiry of a standstill period to resolve any complaints, which may last up to *45 working days*. The CA prepares a Grant Agreement within 45 calendar days from the date of the Financing Decision. The total duration of the award procedure (from application deadline to financing decision) should not exceed 120 calendar days.

Source: Staff elaboration based on Common National Rules.

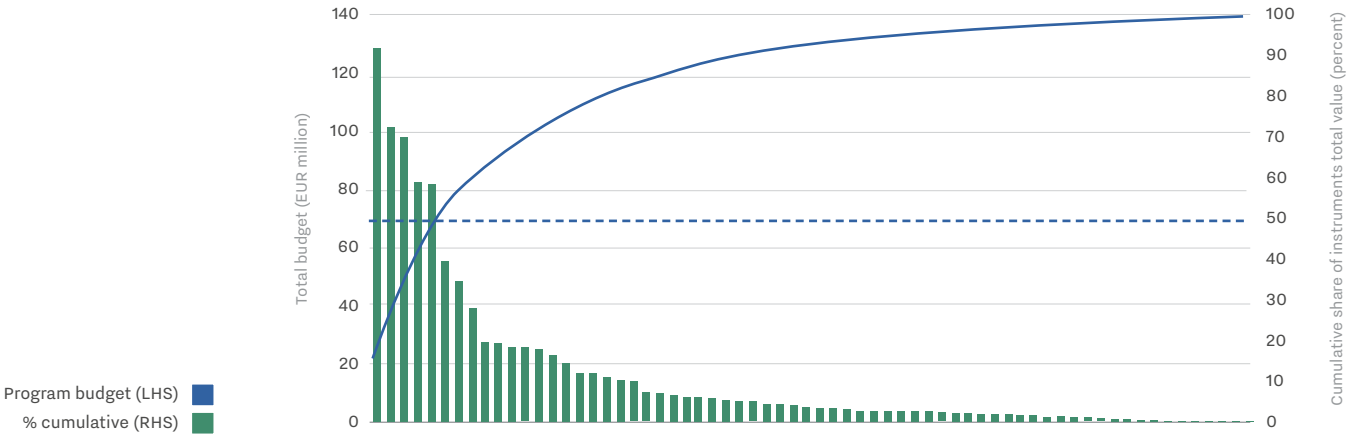
The lead role in distributing project-based funds is split between five ministries and six implementing agencies, illustrating how institutional complexity can give rise to coordination challenges. Five ministries (MSE, MEEC, MAGRI, MRDEUF and the Ministry for Environmental Protection and Energy) and two implementing agencies (HAMAG-BICRO and CSF) have leading roles in program design. However, MSE and MEEC are in charge of the bulk of the budget (Figure 6.4). Other institutions are also involved, including the Ministry of Labor and Social Protection as the MA for ESF-financed programs and CFCA, DEFCO, the Agency for Payments in Agriculture, Fisheries and Rural Development (APPRRR) and the Environmental Protection and Energy Efficiency Fund (EPEEF) as IB2.

FIGURE 6.4 *MEEC and MSE allocate most of the funds*



Source: Staff elaboration.

FIGURE 6.5 *Six programs account for 50 percent of the overall funding*



Source: Staff elaboration.

There is a high concentration of funding in half a dozen programs, while the rest are very small. Half of all project financing is concentrated in only six programs, which calls for closer consideration (Box 6.2). The largest projects appear to suffer from poor targeting and complex design, which often result in delays in project selection. At the same time, the portfolio of STI programs also features very small programs, with a budget of EUR 1 million or less. Some of these pertain to contributions to large transnational programs such as the EUREKA, Eurostars, and Interreg programs.

BOX 6.2 A closer look into the six largest STI support programs in Croatia

Increasing the development of new products and services that result from research and development activities – IRI (approx. EUR 130 million)
The MEEC designed this program to provide grant support for R&D projects in the business sector in amounts from EUR 24,700 to 7.28 million. The program covers all stages of R&D and is open to companies of all sizes, although the selection criteria favor projects that are closer to commercialization. Although the broad coverage of the program could be interpreted as flexibility, in practice, the program is complex and not easily accessible to applicants. The program is implemented by two institutions (MEEC and HAMAG-BICRO). HAMAG-BICRO is in charge of administrative control, while MEEC is responsible for application evaluation. The program has supported 87 projects to date.

Support for development of centers of competence – CEKOM (approx. EUR 102 million)
MEEC designed this program to provide grant support for collaborative R&D projects for special legal forms – Centers of Competence (CEKOMs) – in the amount of EUR 1 million to EUR 15 million. The call was published in August 2016 and closed in December 2017, but evaluation is yet to be completed and the first results were disclosed only in November 2019. Since the evaluation of projects is in its third year, it may call into question the innovativeness of the proposed projects. The program envisages four models for cooperation:
(1A) CEKOMs as knowledge dissemination organizations;
(1B) CEKOMs as consortia of enterprises and PROs with effective collaboration;
(2) CEKOMs as innovation clusters with at least 3 enterprises;
(3) CEKOMs as managers of innovation infrastructure.

CEKOMs are envisaged as legal structures with very detailed long-term R&D plans. It is very hard for innovative companies to commit to such plans, considering that they compete in a very fast-changing environment.

Investments into organizational reform and infrastructure of RDI sector (approx. EUR 98 million)
This program financed infrastructure investments for pre-selected beneficiaries from the public RDI sector, which received funding for feasibility studies in the previous programming period. The purpose of the call was to support the institutional reform of the RDI sector by tying organizational reform to investments in research infrastructure. Organizational reform was supported by financing the costs of external consultants and accreditation services, among other things. The program financed 22 projects, and their completion is expected by October 2022.

Development of business infrastructure (approx. EUR 83.2 million)
The program was published in September 2016 to support the expansion of existing and the construction of new business infrastructure, with local authorities and existing Business Support Organizations (BSOs) as target beneficiaries. The program finances only construction costs and equipment, but the quality of services to be provided within the infrastructure was considered in the selection process. The program financed 48 projects and is expected to be completed in September 2020. A complementary call supporting the provision of services in BSOs was published in July 2019. However, the STI system could have benefited from investments in services in BSOs from an earlier stage. Networking and other business support services, human capital development and maintenance costs of the infrastructure are an integral part of BSO projects.

BOX 6.2
(continued)

Innovations in S3 areas (approx. EUR 82.4 million)
The goal of the program is to support the investment of SMEs in their business activities focused on manufacturing and commercialization of innovative products and services that are new to the market in S3 thematic priority areas. A prerequisite for starting the commercialization is the existence of a completed prototype product tested in a real environment (TRL 8). Eligible project activities must be targeted at commercializing an innovative product or service that is new to the market, primarily through organizational and process innovation. The program was launched in July 2018, and the selection process is yet to be completed.

Children's Center for Translational Medicine Srebrnjak (approx. EUR 56.2 million)
This is a strategic project directly awarded to Children's Hospital Srebrnjak to invest in new research infrastructure that combines basic and clinical research that would contribute to the development of new diagnostic, treatment, and preventative measures and the development of new pharmaceuticals. The project is expected to be completed by March 2022.

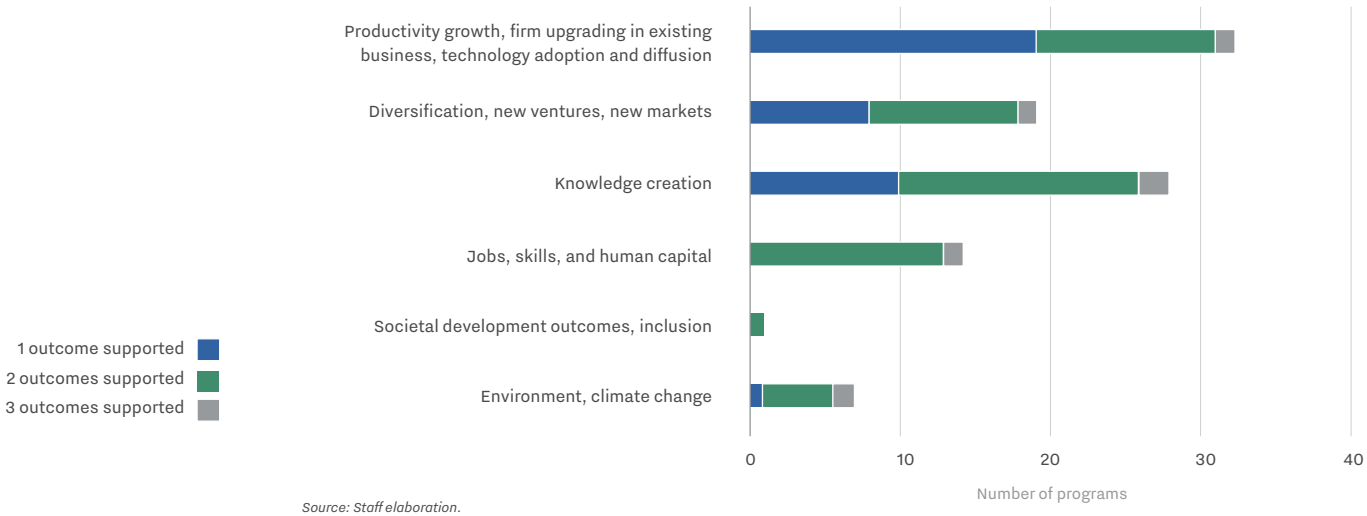
Source: Staff elaboration based on program documentation.

6.1.3 Poor Targeting and Lack of Program Focus

The portfolio of support programs is heavily skewed toward interventions to improve productivity in existing firms, rather than supporting diversification and new ventures, which can bring higher productivity gains. The objective of increasing productivity in existing firms is pursued by the highest number of programs overall. It is also the target of the highest number of programs that are focused on a single outcome (Figure 6.6). Similarly, most funding is concentrated in existing firms and knowledge creation in the research sector (Figure 6.7). However, the Needs Assessment laid out evidence showing that increased investment in R&D-based innovation is correlated with higher productivity gains in younger firms rather than in incumbents. Further, "Diversification, new ventures and new markets" as an outcome is most often bundled with productivity upgrades in existing firms (Table 6.1). However, the needs and capabilities of new ventures and existing businesses are vastly different. It is questionable whether a single program could properly address the needs of either group.

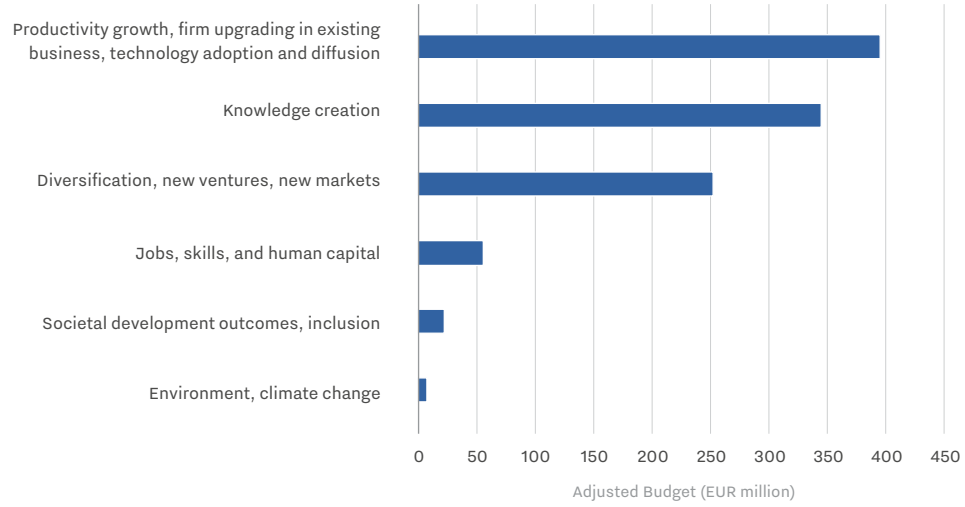
Programs aimed at improving jobs, skills, and human capital are less represented and are more likely to be bundled with other outcomes, especially knowledge creation. Most of these programs finance research projects of young researchers or aim to improve the capacity of researchers to implement such projects. The low presence of programs dedicated to human capital is a result of the low focus on innovation in the ESIF funding for jobs, skills and inclusion channeled through the ESF, which is delivered through a separate OP managed by the Ministry of Labor and Social Protection. This OP is separate from the ERDF-financed one, creating challenges with regard to coordination and comprehensiveness in the country's overall innovation portfolio.

FIGURE 6.6 *Most programs aim to support firm upgrades in existing markets and knowledge creation*



Source: Staff elaboration.
Note: One program may have multiple outcomes.

FIGURE 6.7 *The adjusted budget is higher for programs intending to support existing firms rather than diversification*



Source: Staff elaboration.
Note: The budget for each outcome was adjusted by dividing the total budget of a given program with the number of outcomes it supports.

Table 6.1 *Correlation of occurrence between different outcomes*

	Productivity growth, firm upgrading in existing business, technology adoption and diffusion	Diversification, new ventures, new markets	Knowledge creation	Jobs, skills, and human capital	Societal development outcomes, inclusion	Environment, climate change
Productivity growth, firm upgrading in existing business, technology adoption and diffusion	1					
Diversification, new ventures, new markets	0.07	1				
Knowledge creation	-0.73	-0.39	1			
Jobs, skills, and human capital	-0.48	-0.32	0.61	1		
Societal development outcomes, inclusion	-0.12	-0.08	0.15	-0.06	1	
Environment, climate change	0.02	-0.19	-0.05	-0.03	-0.04	1

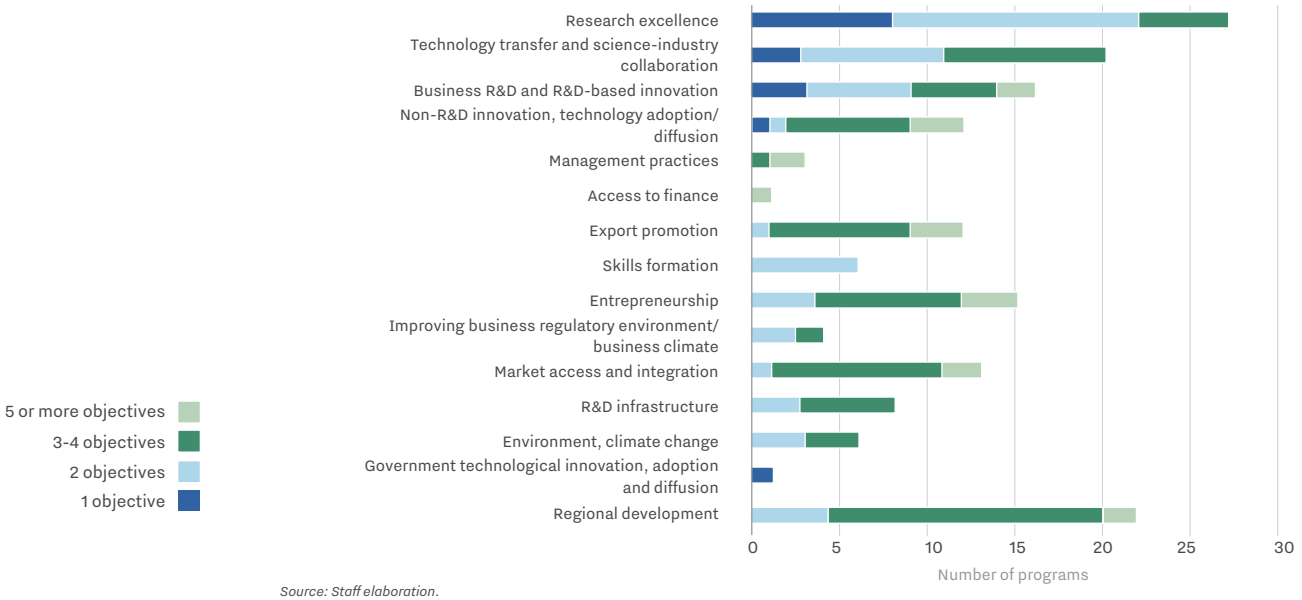
Source: Staff elaboration.

Substantial funding has been allocated to research excellence – through support for both research projects and infrastructure – but improvement in research performance has yet to materialize. Research excellence is the objective of the greatest number of programs (Figure 6.8), and it is supported with a substantial amount of funds (Figure 6.9). It is also the most targeted objective, occurring in 8 programs that have a single objective. Research excellence is supported through direct funding of research projects. There is also a substantial amount of funding dedicated to preparing for and constructing research infrastructure. The majority of funding for this purpose comes from OPCC, but its results framework is more oriented toward increasing the quantity of research than toward increasing its quality. Despite the availability of support, the research sector is not displaying good results (Section 2.2), suggesting that there are other structural constraints dampening research performance (Section 2.1). Interventions to reform the research sector will be necessary to maximize the impact of the available funding.

A large portion of the portfolio supporting the business sector is dedicated to non-R&D innovation even though R&D innovation is lagging in Croatia and would likely be more effective at raising productivity. Although there are a substantial number of programs supporting business R&D (Figure 6.8), a large portion of the budget covers non-R&D innovation (Figure 6.9). Non-R&D innovation is important for increasing productivity in incumbent firms and building capabilities for innovation. However, the *Needs Assessment* showed that Croatia is significantly ahead of the EU in the area of non-R&D innovation, but lags significantly behind in the area of R&D innovation (Figure 1.13, Section 1.2). This discrepancy is all the more problematic considering that, when R&D innovation does occur, it is associated with higher productivity gains (Section 1.3).

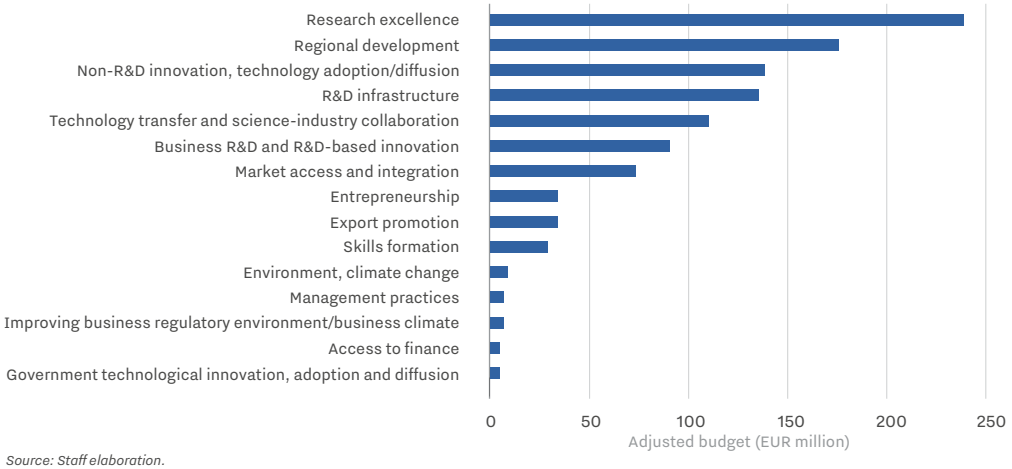
There is a gap in the policy mix when it comes to support for managerial capabilities and technology extension services. Only three programs support management practices and they are, on average, bundled with five other objectives (Figure 6.8). Along with other technology extension services (export promotion and market access), management practices are never the core focus in any support program and are always combined with several other objectives. At the same time, there are significant gaps in the managerial capabilities of firms in Croatia – especially in family-managed firms, older firms and firms outside of Zagreb[47] – that warrant a more focused effort to improve management practices.

FIGURE 6.8 *Research excellence is the most frequent objective*



Source: Staff elaboration.
Note: One program may have multiple objectives.

FIGURE 6.9 *Public RDI programs appear with higher budget since they target less objectives and the funding is not too spread out (per the analysis approach)*



Source: Staff elaboration.
Note: For programs with multiple objectives, the budget is adjusted by dividing the program budget equally among different objectives.

47 See Appendix I for a review of managerial capabilities of SMEs in Croatia.

Many programs award additional points for lagging regions, diluting their main objectives. While a few programs contributed to balanced regional development by having separate allocations for lagging regions, most programs awarded additional points for projects from different regions. Various classifications of lagging regions were used. One had four categories covering counties, while another had eight categories pertaining to local governments. In some cases, beneficiaries could receive up to 20 percent of the total score based on their place of residence.[48] Awarding additional points to projects from specific regions may seem like an easy way to support regional development, but it is ultimately ineffective because it fails to tailor program design to the specific needs of the lagging region, which are likely different from the needs of the rest of the economy.

Science-industry collaboration is receiving support, but technology transfer is not. Although technology transfer and science-industry collaboration appear to be represented through a substantial number of programs, they are two distinct objectives, and only the latter one is truly supported. Of the 24 programs supporting technology transfer and science-industry collaboration, only one program directly supported technology transfer offices.[49] The others are related to projects for industry-science collaboration and infrastructure that would allow industry-science collaboration. The one program that supported technology transfer offices was not sufficient to transform the system because it was not complemented with stable support from national sources for technology transfer and business development at universities. The *Needs Assessment* showed that technology transfer remains a weakness of the Croatian STI system, with low commitment by PROs toward commercialization and creation of intellectual property (Section 2.1). In order to work well, technology transfer in PROs needs to be encouraged more, and relevant activities should be adequately funded to enable hiring permanent staff as well as consultants.

Access to finance is greatly neglected in the innovation agenda, occurring in only one program in the portfolio. The *Needs Assessment* identified significant gaps in innovation financing, particularly at an early stage (Section 1.5). The only measure that is attempting to close the gap on this front is the program funding a venture capital fund with a business acceleration component, which is implemented by a private sector fund manager (Fil Rouge Capital). This program not only provides the right financing and soft support for technology start-ups but could also kickstart a wave of inward migration of innovative start-ups from the region.

6.1.4 Overreliance on Grants and Lack of Instrument Variety

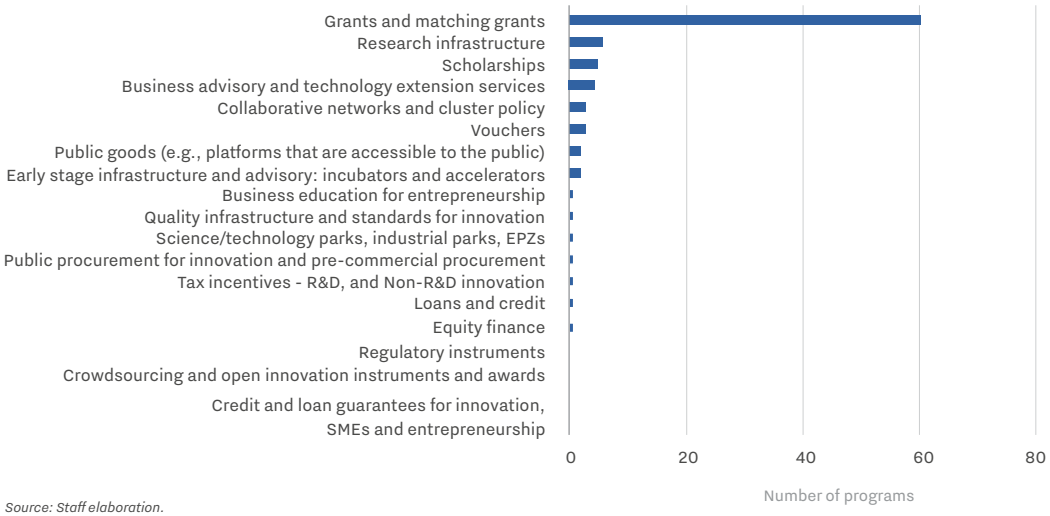
Grants and investments in research infrastructure are the prevailing mechanism of intervention, while financial instruments are less represented in the policy mix. Some 88 percent of programs (Figure 6.10) and over EUR 1 billion of the budget (Figure 6.11) are distributed in grant form, of which around a third is allocated to grants for research infrastructure. However, the *Needs Assessment* showed that a wide variety of instruments are necessary to support the changing needs of the innovation process (Section 1.5). For example, while smaller, younger firms and start-ups may require more grants and early stage infrastructure, scale-ups have a higher demand for more flexible financial instruments and soft support. Similarly, large firms have the capacity to take on debt, but they are being offered grants instead (see Section 6.1.5). Alternative forms of finance – such as loans, convertible loans, and equity – are missing from the policy mix, even though there is demand for them, as shown in the analysis presented in Appendix I. The large amount of financing available in grant form may be crowding out financial instruments, which could lead to distortions to incentives.

48 Introduction of systems of management and business processes and quality (ISO and similar norms).

49 STP II-financed Technology Transfer Offices program, which has already ended.

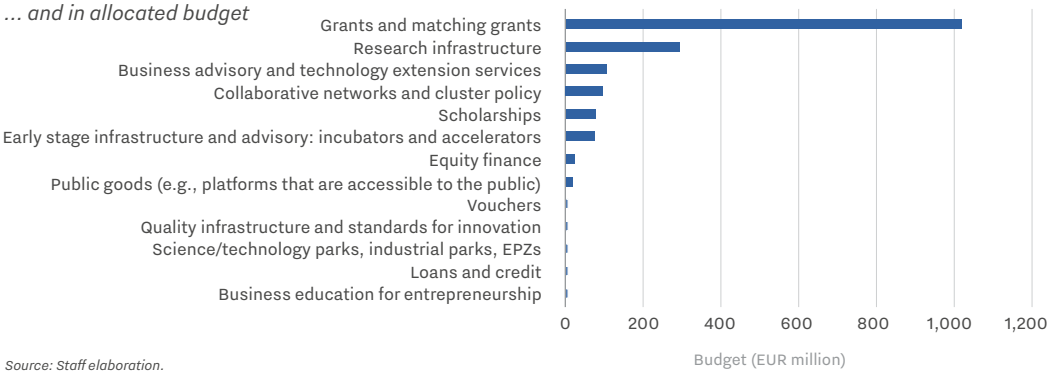
Vouchers are underutilized given the need to foster industry-science collaboration and R&D-based innovation. Of the four voucher schemes in the portfolio, two (Eureka and Interreg) are part of transnational schemes, one aims at supporting innovation in SMEs, and one aims at obtaining domestic quality certifications (i.e., non-R&D innovation). The take-up of the schemes has been very low so far, with 25 firms absorbing 2.4 percent of the budget for the SME innovation voucher, and 22 firms receiving 7 percent of the budget for quality labels.[50] The scheme supporting innovation in SMEs finances up to EUR 9,750 for product, service or process testing, studies, demonstration activities, and other expert and technical knowledge services.[51] However, service providers are limited to entities accredited as research organizations (mostly HEIs and PRIs, see section 2.1), which limits the pool of services that firms are able to obtain. The quality labels scheme is limited to national labels such as Croatian Quality, Original Croatian, Traditional Trades and Artistic Trades,[52] and may not be used for any other internationally recognized certificates. The poor absorption rate indicates that there are structural elements in the call that fail to adequately respond to the needs of businesses.

FIGURE 6.10 *Grants are the dominant instrument, both in number of programs...*



Source: Staff elaboration.

FIGURE 6.11 *... and in allocated budget*



Source: Staff elaboration.

50 Both schemes started contracting funds at end-2018.

51 The median awarded voucher as of May 2019 was around EUR 9,400.

52 *Hrvatska kvaliteta (Croatian Quality), Izvorno hrvatsko (Original Croatian), Tradicijski obrti (Traditional Trades) and Umjetnički obrti (Artistic Trades).*

The effects of the recently reintroduced R&D tax breaks are yet to be seen, though previous experience shows that it contributed to increasing business expenditures on R&D. The current R&D tax break scheme was introduced in July 2018, with the adoption of the Law on State Support for Research and Development Projects.[53] Since the scheme was implemented relatively recently, its outcomes are yet to be seen. The scheme allows for tax breaks equivalent to a percentage of eligible costs of projects for basic research (up to 100 percent), applied research (up to 50 percent) or experimental development (up to 25 percent) as well as feasibility studies (50 percent). In addition, for applied research, experimental development, and feasibility studies, the aid intensity may be increased if the R&D-performing entity is a small or medium enterprise (by 20 or 15 percentage points respectively). Collaboration or public dissemination of results may also increase aid intensity, but only for applied research and experimental development (15 percentage points). An evaluation of the tax incentive scheme that was in place until 2014 revealed that the tax incentives had a positive effect on business expenditures on R&D (Aralica and Botric, 2013).

The second indirect support instrument, public procurement for innovation, is yet to be widely used. This mechanism (*partnership for innovation*), was introduced as one of six procedures available in the Public Procurement Law adopted in 2016.[54] It may be used if the procurer has a need for innovative goods, services, or works that may not be satisfied with the goods, services or works already present in the market. The 2018 and 2017 statistical reports on implementation of public procurement[55] are silent on the implementation of this procedure, suggesting that it is not being used, despite the possibility provided for it in the law. In addition, Croatia participates in an Interreg Central Europe project (*PPI2Innovate*) that aims to stimulate the use of public procurement for innovation. Outputs of the project include a transnational guide for public procurement of innovative products and three separate guides for procurement in the ICT, energy and health sectors. It remains to be seen whether these efforts will increase the use of public procurement for innovation.

6.1.5 Lack of Coherence between Target Beneficiaries and Needs of the STI system

Most programs supporting researchers and research organizations are aimed at research excellence, but a significant portion of them are related to research infrastructure and other indirect means of achieving research excellence. At least 40 percent of programs support researchers or research organizations (Figure 6.12). Of these, 76 percent are related to research excellence, and 20 percent contribute to research excellence through research infrastructure. The results of this strong focus on researchers and research institutions are yet to be seen because their performance has been subpar, with only a few pockets of excellence (see Section 2.2).

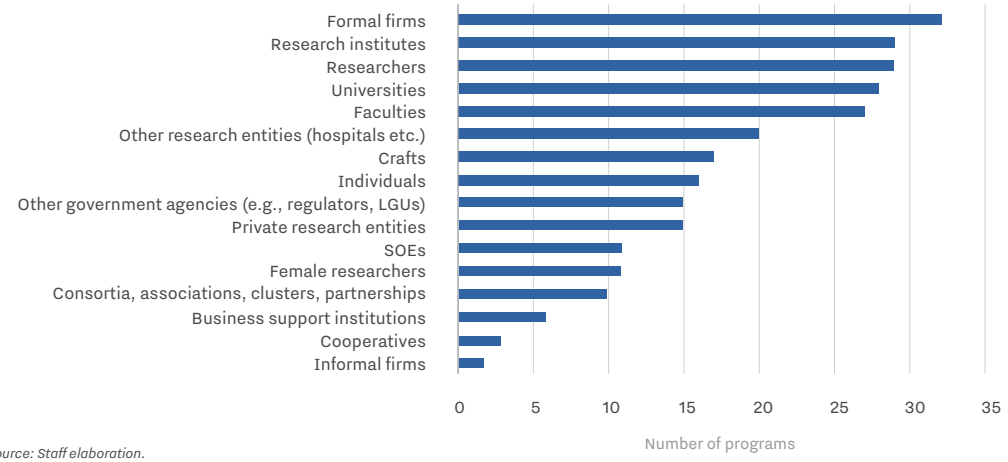
Depending on the focus of the program, different costs are covered, which is not always optimal. While it seems that all types of eligible expenditures are well covered (Figure 6.13), a deep dive into the different programs suggests that those that focus on firms primarily cover costs associated with placing a product on the market, while not many of them cover costs associated with core research. Conversely, programs aimed at the research community primarily cover costs associated with core research and do not necessarily finance costs associated with placing a product on the market.

53 OG 64/2018.

54 OG 120/2016.

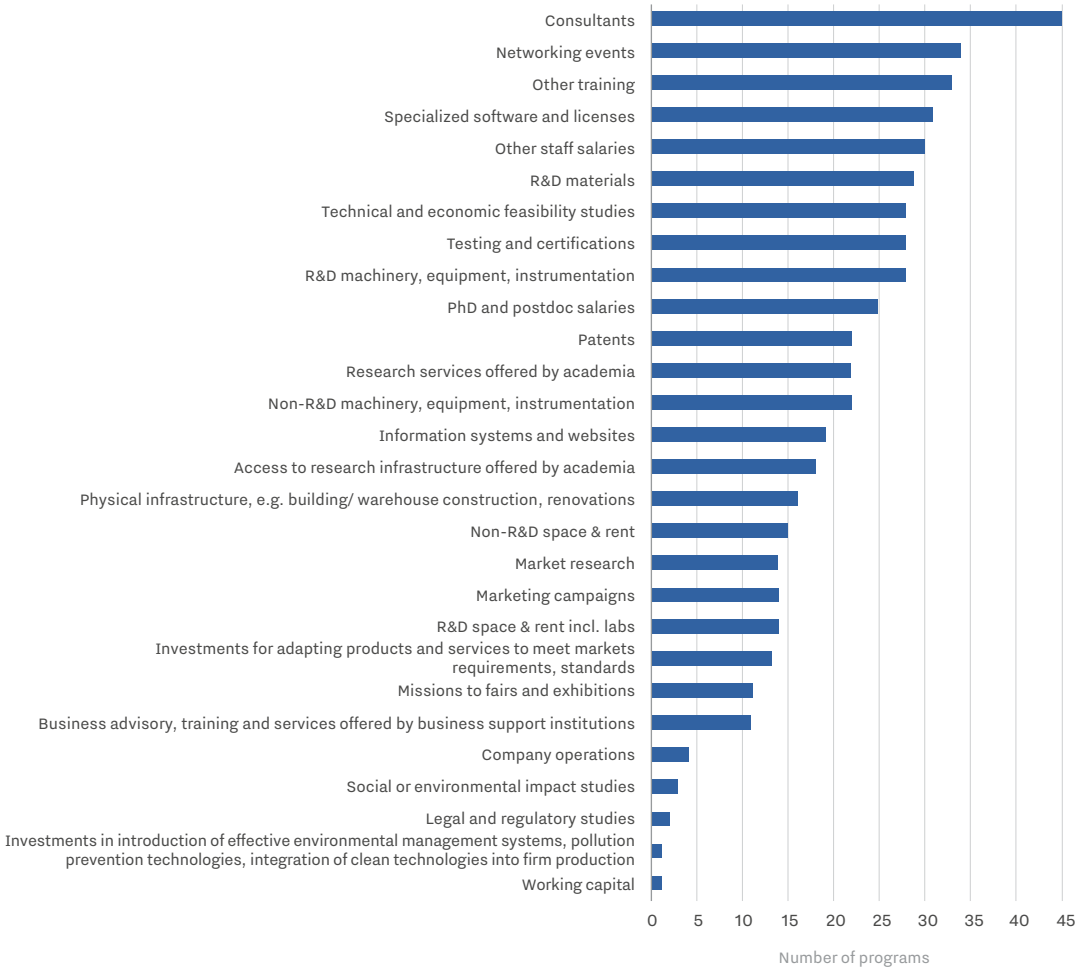
55 Ministry of Economy, Entrepreneurship and Crafts. Statistical Report on Public Procurement in the Republic of Croatia 2018 and 2017.

FIGURE 6.12 *Most programs target formal firms and research institutions*



Source: Staff elaboration.

FIGURE 6.13 *Many programs provide financing for consultant services, networking events, training, software, and salaries*

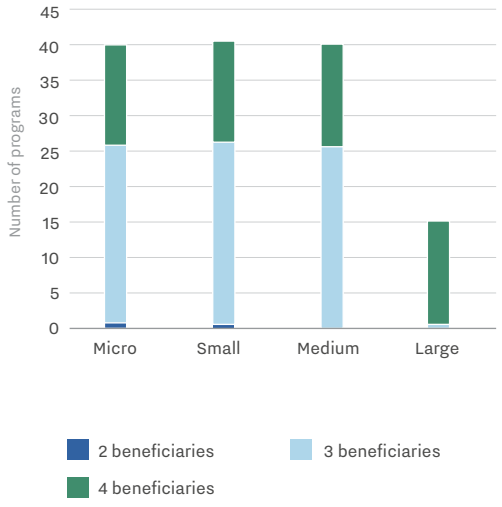


Source: Staff elaboration.

On the business innovation side, most programs are open to formal firms, specifically SMEs, though some programs bundle support to both SMEs and large firms, making program design more challenging. Over a third of programs (Figure 6.14) and around 40 percent of the budget available to firms (Figure 6.15) is dedicated to all size categories, while micro and small firms are targeted with only 6 percent of the budget. The capacities and needs of SMEs are substantially different from those of large firms, which means that striking the right balance in program design, administrative burden and monitoring in a single program is difficult. In addition, most of the programs that are open to both large firms and SMEs are grant instruments. Large firms have more resources to invest in the application process (including hiring consultants), giving them an advantage compared to smaller firms. The rationale behind using grants to support large firms is also not clear, given that they have better access to financial and debt markets than SMEs. An alternative strategy for supporting innovation in large firms would be to offer a loan program for projects that require substantial financing.

FIGURE 6.14

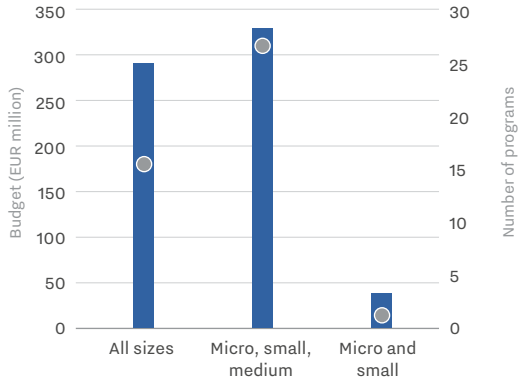
Some programs bundle support for SMEs and large firms



Source: Staff elaboration.

FIGURE 6.15

A large portion of the budget for firms is dedicated to firms of all sizes



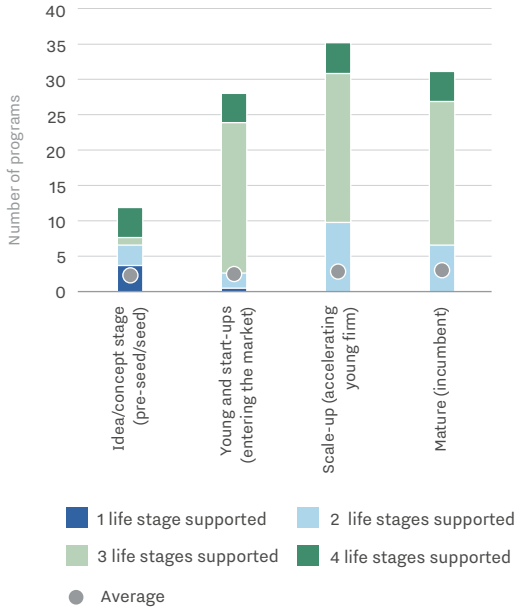
Source: Staff elaboration.

Support at the idea/pre-market stage is missing, financing for the start-up stage is heavily focused on commercialization, and most programs bundle support for all life cycle stages. Between 2014 and 2020, 12 programs supported firms at the idea stage (Figure 6.16 and Figure 6.18). However, four of them were implemented as direct support within the Second Science and Technology Project (STP II), two are transnational programs with low take-up in Croatia (Eureka and Eurostars), and two are related to early-stage infrastructure (i.e., business support institutions). STP II programs included interventions financing proof of concept (PoC) in both PROs and the private sector (the *PoC* program) and early stage financing for start-ups through convertible loans (the *RAZUM* program). The success of the PoC program has encouraged MEEC to finance its eighth edition through national funds, albeit only for the private sector. In the ESIF funding framework, there is only one program providing support to newly established firms.[56] Implemented in two phases, it provides financing for younger firms (firms with up to three years on the market) to adapt products

56 Innovations in newly established SMEs.

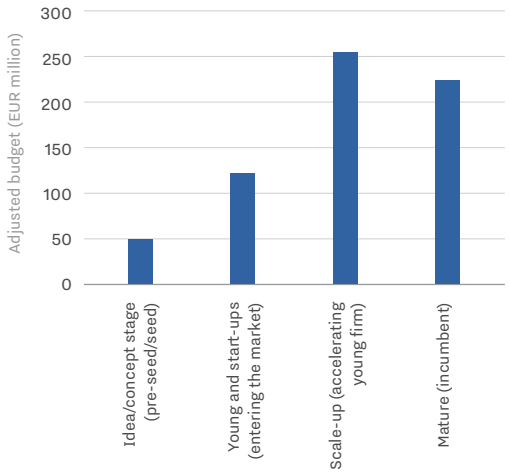
and services to the market and prepare for market launch. However, this program is heavily focused on commercialization; it does not feature any elements related to soft support or investment readiness. The recently launched program providing early-stage innovation financing through a VC fund fills this gap via an acceleration component, which is exactly the type of support that was missing.

FIGURE 6.16
There are few programs with support targeted at earlier stages of the firm life cycle



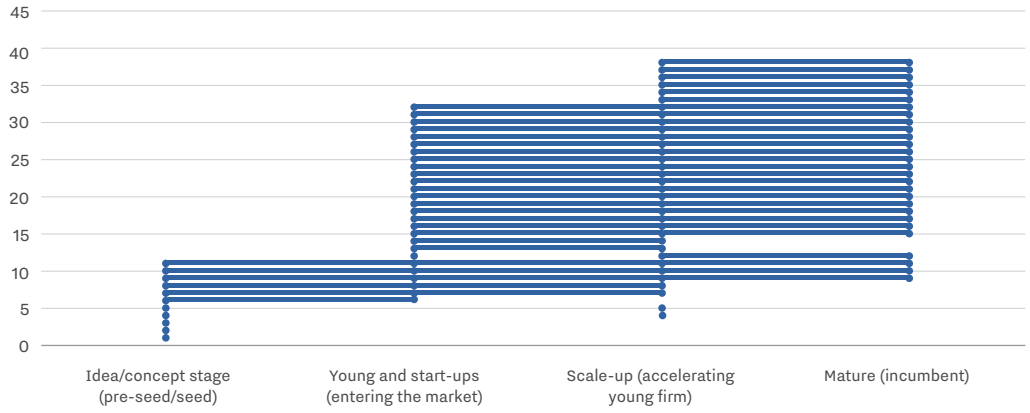
Source: Staff elaboration.

FIGURE 6.17
Not much funding is available for the idea stage



Source: Staff elaboration.
Note: For programs with multiple target groups, the budget is adjusted by dividing the program budget equally among different objectives.

FIGURE 6.18 *Programs often bundle together different life cycle stages, and most programs are suitable for mature firms*

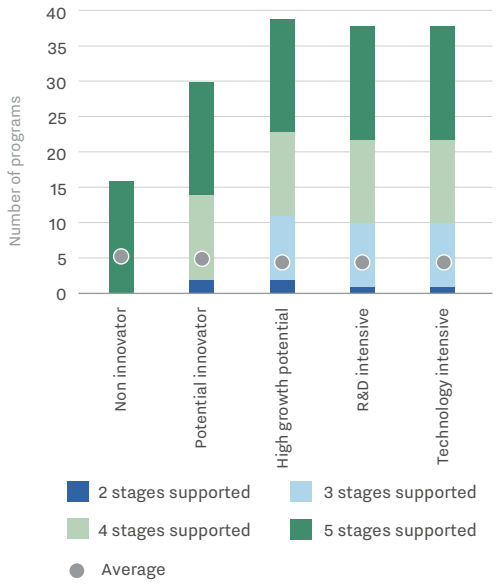


Source: Staff elaboration.
Note: The horizonal lines present programs that connect different life cycle stages.

Many programs do not take into account where companies are in the innovation cycle (Figure 6.19 and Figure 6.20). Programs are open to various types of companies, regardless of whether they are potential innovators or focused on technology adoption. This makes it difficult to provide the right support to different firms, because firms at different places in the innovation cycle have different needs. For instance, firms with high growth potential may need support on technology extension services, while technology-intensive firms may be focused on technology adoption. R&D-intensive firms have a whole different set of needs. It is very difficult to design a program that can respond to all the needs of firms in different stages of the innovation cycle. Finally, there is very little focus on non-innovators, which is suboptimal given the finding in the productivity analysis that firms that have not previously engaged in R&D experience large productivity gains when they start investing in R&D.

FIGURE 6.19

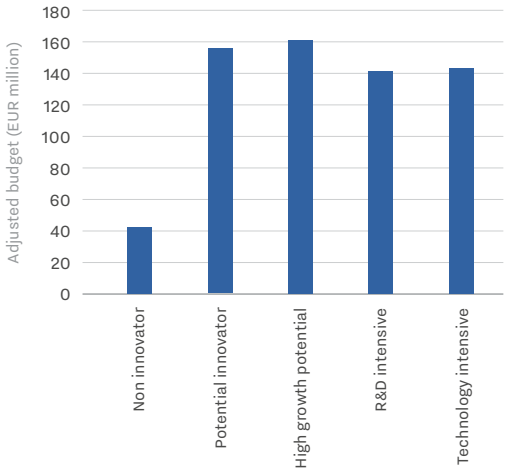
Most programs do not target specific stages of the innovation cycle



Source: Staff elaboration.

FIGURE 6.20

The lack of targeting is also reflected in the budget allocation for each stage of the innovation cycle

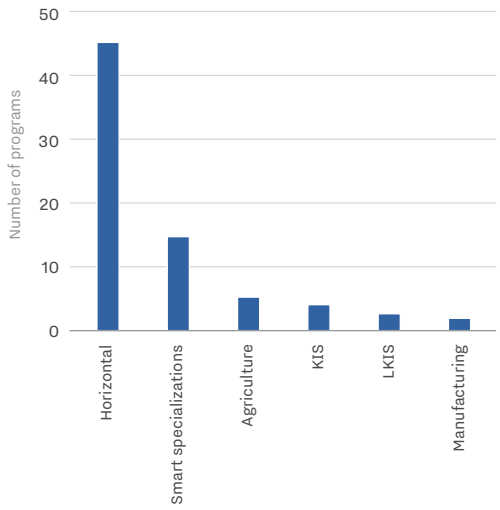


Source: Staff elaboration.
Note: For programs with multiple target groups, the budget is adjusted by dividing the program budget equally among different objectives.

There is a shortage of programs targeting knowledge-intensive services, especially considering Croatia's inability to grow knowledge-intensive services and exports. Almost two-thirds of programs support all sectors (i.e., they are horizontal), while the remainder are split evenly between smart specializations and vertical programs (Figure 6.21). The share of vertical programs is even lower in terms of budget (around 10 percent), with only 4 percent dedicated to knowledge-intensive services (Figure 6.22). However, all the programs targeting KIS are aimed at supporting research projects or financing infrastructure that enables KIS, while programs directly supporting the private sector are typically in smart specializations or horizontal.

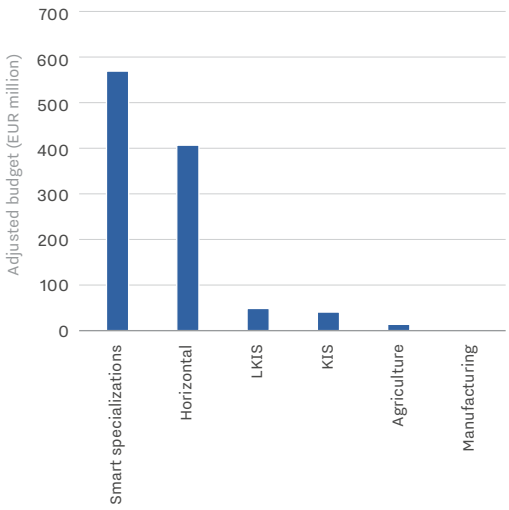
There are no programs targeting female researchers or female-owned firms, demonstrating a lack of attention to gender barriers in science and entrepreneurship. Section 2.2 confirmed that a gender gap persists in STEM fields, particularly engineering and medical sciences. Further, women are

FIGURE 6.21
Most programs have no sectoral preference



Source: Staff elaboration.

FIGURE 6.22
The most funding is allocated to smart specializations



Source: Staff elaboration.
Note: For programs with multiple target sectors, the budget is adjusted by dividing the program budget equally among different objectives.

underrepresented in entrepreneurial activities, and they face structural disadvantages that depress self-employment (World Bank Group 2019). Programs typically do not go beyond requiring applicants to comply with EU horizontal policies on gender equality and nondiscrimination. Some award points in the selection process for specific activities that contribute to gender equality. Still, closing the gender gap in STEM fields and women's entrepreneurship would require a more dedicated and focused set of activities and policies.

6.1.6 Supporting Ideas Through All R&D and TRL Phases

The policy mix is implicitly biased toward earlier stages of research and later stages of development. At first glance, there are no gaps in the policy mix with respect to R&D stage, but a deeper look indicates the existence of implicit biases toward earlier stages of research and later stages of development. These biases may be connected to the core agendas of MSE and MEEC as key institutions leading the innovation agenda. Every stage of research (basic, applied, experimental), and development (early development, pre-implementation, late development, post-implementation and starting production) (see Box 6.3) is supported by a number of programs (Figure 6.23). A similar conclusion can be drawn from the coverage of Technology Readiness Level (TRL) stages (Figure 6.24). However, a deeper analysis of programs suggests that there may be some gaps in the portfolio. In particular, three issues stand out:

— Programs designed by MEEC seem to have a bias toward commercialization. Commercialization is in the MEEC's core mandate, but very little focus remains on research and development projects that have a high risk of failure. The largest project financing program for the business sector (IRI) is a good example of this because, in theory, it covers everything from basic research to late

developmental stages. However, the program's selection criteria heavily favor projects that are closer to commercialization. They award more points to projects that are at the higher end of the TRL scale; projects that will result in a new product, service or patent; and projects that have higher estimates of revenues and profit from the newly developed product or service. Consequently, projects that are in research or earlier stages of development, when the commercial potential is less clear, are less likely to be selected.

— Programs designed by MSE and CSF seem to have a bias toward research, with little to no focus on carrying the research results to the private sector. There have been small proof of concept and technology transfer programs in the past, but not currently. Also, the research programs are heavily focused on the public sector. They are usually open only to organizations from the register of research organizations, which includes a very small number of private companies.
— Public RDI programs are more or less equally distributed between basic, applied and experimental research, whereas, drawing on the analysis in part 2.2, we know that countries with better performing innovation systems invest more in applied and experimental research.

BOX 6.2 Understanding R&D and TRL stages

Although the notion of the innovation value chain (Hansen and Birkinshaw 2008) is useful to model and think about the innovation process, it important to acknowledge that in practice this process is usually non-linear and often involves trial and error. Similarly, R&D activities do not typically progress in an orderly fashion from basic research all the way to commercialization. By definition, the R&D process entails a degree of uncertainty with respect to the time, cost, and even the ability to achieve the objectives of the R&D process.

Having this in mind, for the purpose of the portfolio mapping exercise, support for R&D was classified based on OECD definitions of R&D stages:

1. Basic research – interventions supporting experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundation of phenomena and observable facts, without any particular application or use in view;
2. Applied research – original investigation undertaken in order to acquire new knowledge, directed primarily toward a specific, practical aim or objective;
3. Experimental development – systematic work, drawing on knowledge gained from research and practical experience and producing additional knowledge, which is directed to producing new products or processes or to improving existing products or processes;
4. Early developmental stage – initial prototype preparation, demonstration/pilot implementation;
5. Pre-implementation activities – securing patent;
6. Late developmental stage and implementation – validation in real settings;
7. Post-implementation activities – preparing for commercialization, establishing product-market fit, promotion, looking for investors, licensing, feasibility studies, legal and regulatory studies, market research, etc.; and
8. Starting production – the innovative product is launched on the market.

BOX 6.2
(continued)

In addition, programs were classified based on their technology readiness level (TRL), on a scale from 1 to 9. Most programs do not define a TRL phase. In those cases, it was estimated using professional judgment. The TRL scale is as follows:

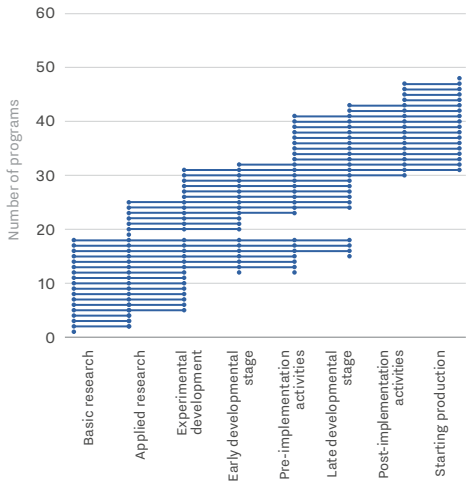
- TRL 1 Basic principles observed
- TRL 2 Technology concept formulated
- TRL 3 Experimental Proof of Concept
- TRL 4 Technology validation in lab
- TRL 5 Technology validation in relevant environment
- TRL 6 Demonstration in relevant environment
- TRL 7 Demonstration in operational environment
- TRL 8 System complete and qualified
- TRL 9 Successful mission operations

Although the TRL and OECD definitions should be consistent, so far there has been no universally accepted mapping of the two scales, and small deviations between them are possible.

Source: Staff elaboration based on OECD Frascati Manual.

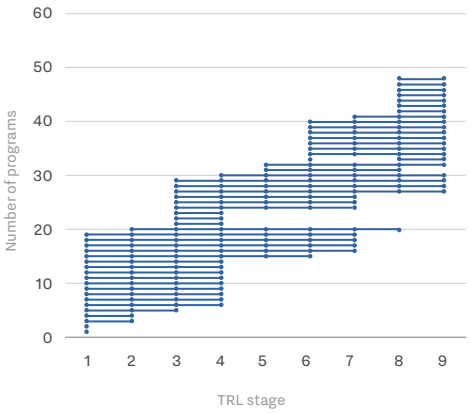
These biases emerge in part because of lack of targeting within programs, which creates challenges in tailoring program design to specific needs of different stages of R&D. Over half of the programs cover four or more R&D stages. This gives a false sense of flexibility and ability to help a project progress from one R&D stage to the next. In practice, by setting such a broad scope while implicitly favoring a narrower set of activities, programs are unable to adequately support all R&D stages. A similar conclusion may be drawn from coverage of TRL stages.

FIGURE 6.23
Many programs have a very broad coverage of R&D phases



Source: Staff elaboration.
Note: Excludes infrastructure projects.
The horizontal lines represent programs that cover different R&D phases.

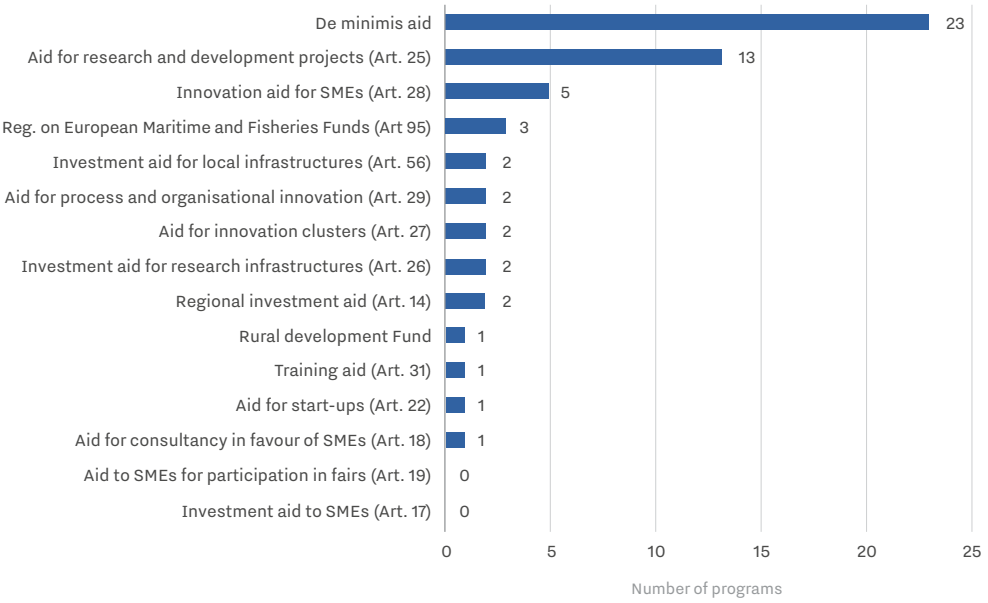
FIGURE 6.24
Lack of targeting is also evident in coverage of TRL stages



Source: Staff elaboration.
Note: Excludes infrastructure projects.
The horizontal lines represent programs that cover different TRL stages.

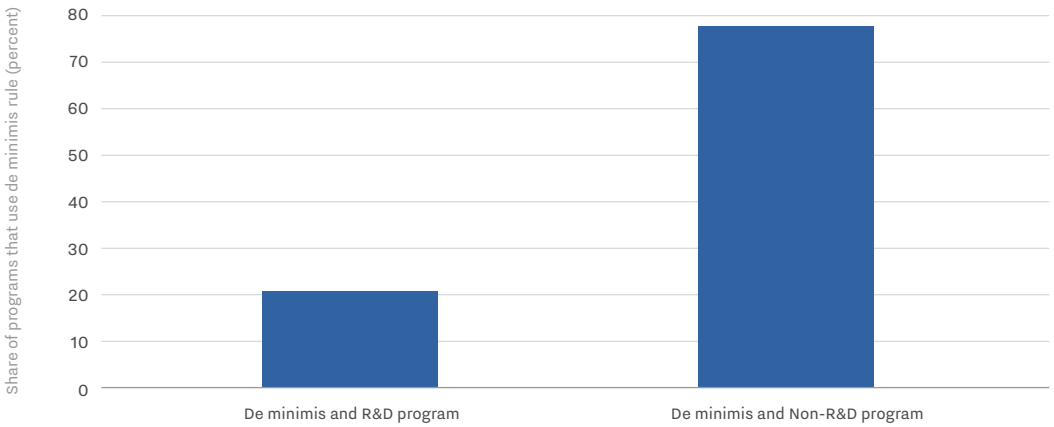
Reliance on *de minimis* aid may cause problems when attempting to advance one project through all R&D stages. Over 60 percent of programs use *de minimis* aid (Figure 6.25), and over one-fifth of those are programs that support R&D (Figure 6.26). The reliance on *de minimis* aid is problematic because it is, by definition, capped to EUR 200,000 over the course of three consecutive fiscal years. This means that there is an upper bound on providing progressively larger support as an idea advances from idea to commercialization through development and technology readiness. In addition, there is no centralized monitoring of the use of *de minimis* aid, and the selection process usually relies on a statement by the applicant that they have not exceeded the threshold.

FIGURE 6.25 *There is a heavy reliance on de minimis aid*



Source: Staff elaboration.

FIGURE 6.26 *A substantial share of de minimis programs support R&D*



Source: Staff elaboration.

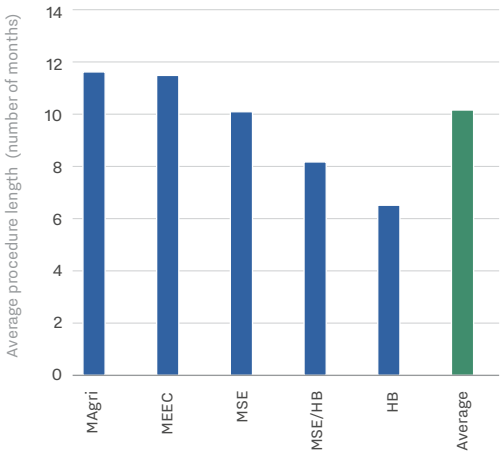
6.1.7 Administrative Burdens and Implementation Challenges

Administrative and bureaucratic requirements impose a burden on potential applicants, particularly smaller entities with less resources at their disposal. Some programs require submitting evidence that is already available to institutions performing project selection. For example, MSE requires applicants to submit a certificate demonstrating that they are registered with MSE's own register and evidence on the salaries of applicants from PROs, even though they are paid out by MSE. Programs that combine different types of state aid are also burdensome because the calculation of state aid falls on the applicants, who often do not have the knowledge and guidance required to perform this calculation.

Many programs, including some of the largest ones, have been experiencing implementation delays, often brought on by a flawed evaluation process. On average, it takes ten months for projects to complete the cycle from call announcement to contract signing, though the length of the process varies depending on the lead institution (Figure 6.27) and budget size (Figure 6.28). The data used in these figures includes calls published prior to 2019 that still have not finished the evaluation process, so in fact the delay is getting even longer. According to the Common National Rules, awarding funds should take no longer than 120 days from the date of closing of the call. Programs implemented by HAMAG-BICRO, smaller programs, and programs financed from the state budget are awarded more quickly than programs implemented by the Ministry of Agriculture and MEEC, large programs, and programs financed through bilateral agreements. The reason for the extended turnaround times are usually related to institutional complexity and difficulties in carrying out the evaluation of applications. More specifically, the governance structure of ESIF financed programs (Section 4) requires involving multiple institutions in the selection process (IB1 and IB2). This can lead to administrative sluggishness, because it requires circulating documents back and forth between institutions.

FIGURE 6.27

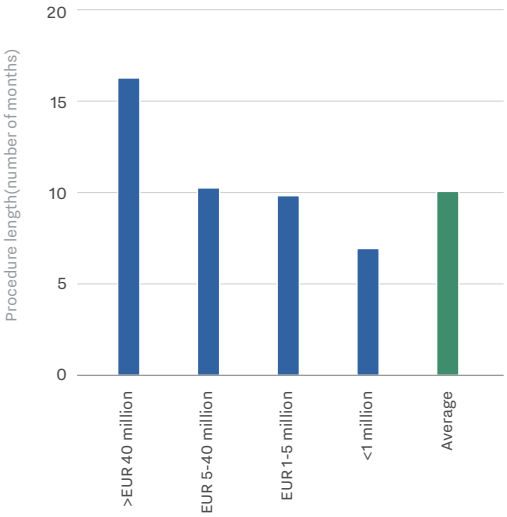
There is a notable variance in procedure times between different lead institutions



Source: Staff elaboration.
Note: Procedure length calculated as number of months between call start and contract signing.

FIGURE 6.28

There is also a notable variance in procedure times based on budget size



Source: Staff elaboration.

6.1.8 Program Clustering

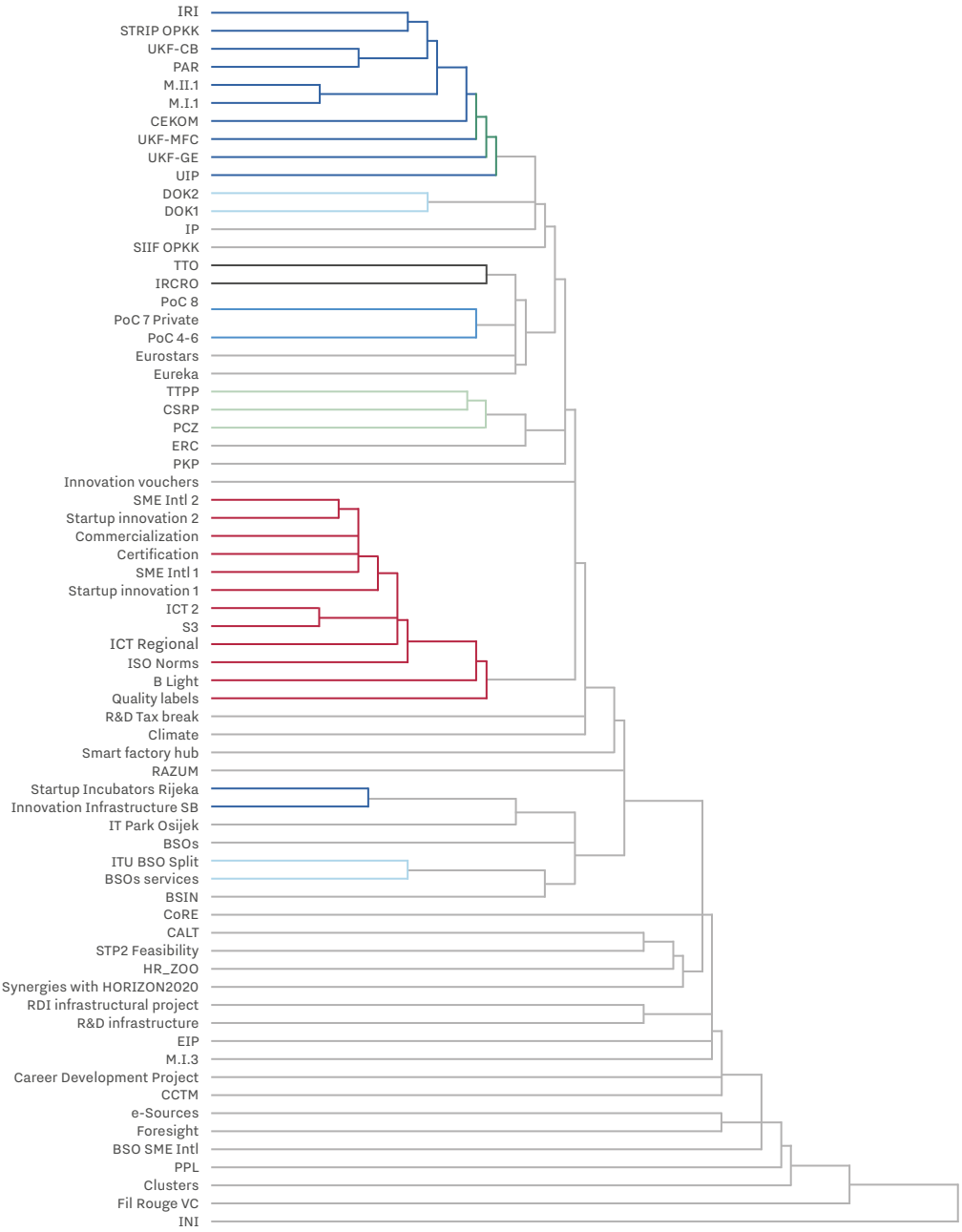
This section complements the analysis by clustering programs to identify those with similar characteristics. The programs were clustered by similar mechanisms of intervention, eligible beneficiaries, instrument objective, supported stage of firm life cycle, R&D phase, and firm size. Some of the programs (PoC, SME internationalization etc.) are identified as similar because they have been repeated throughout the period analyzed. As such, the results of the clustering should be interpreted cautiously, and quantitative program similarity should be underpinned by qualitative analysis. A high degree of similarity of programs within a cluster does not necessarily mean that they overlap, but it can indicate that program objectives are set too broadly. Such programs warrant a greater degree of coordination in program design to avoid overlap. The results of the cluster analysis are depicted in the dendrogram in Figure 6.29. Programs that are most similar to each other are directly linked by a vertical line connecting two horizontal lines (*a node*). For example, the IRI program is most similar to STRIP and thus they are directly connected through a node. The degree of similarity is represented by the distance of the node from the vertical axis. For example, we can infer that the programs M.I.1 and M.II.1 (Innovations in fisheries and Innovations in aquaculture) are more similar than STRIP and IRI because their node is closer to the vertical axis.

The clustering confirms that there is a heavy focus on programs supporting non-R&D innovation and programs that are closer to commercialization. Programs supporting non-R&D innovation provide support for several purposes, such as internationalization, certification, ISO norms, quality labels, and commercialization. However, some of these programs – like Certification, Commercialization and Start-up innovation – are similar, pointing to a significant investment in the commercialization phase while neglecting to foster the innovation pipeline.

There are several similar programs that support industry-science collaboration, which calls for better coordination and tailoring program design to the needs of target groups. For example, STRIP, IRI, PAR and CEKOM all envisage support for industry-science collaboration for a broad range of R&D stages. Incidentally, they are designed by three different institutions (MSE, MEEC, and CSF), which creates some challenges to efficient coordination. The most similar programs in this group are M.I.1 and M.II.1 from the OP Maritime and Fisheries, which support innovations in fisheries (M.I.1) and aquaculture (M.II.1). These two programs appear to have very similar characteristics except for the sectors they cater to.

Improving the coordination and targeting of programs would help avoid overlap and duplication and would free up resources to support underserved segments of the policy mix. Although clustering does not necessarily mean that there is overlap in programs, it does point to the areas of STI policy that are receiving the most support and the priorities of the current policy mix. This calls for (i) a greater effort to coordinate policies in areas where several institutions share a mandate, and (ii) a reconsideration of the priorities in the policy mix by reallocating resources to cover the gaps existing in the STI system. Underserved segments of the policy mix include technology transfer, early-stage development and early-stage financing.

FIGURE 6.29 *The most similarities are identified in programs supporting non-R&D innovation and industry-science collaboration*



Source: Staff elaboration.
Note: Clustering was based on the Jaccard similarity measure calculated among six variables: (1) Mechanism of Intervention, (2) Eligible Beneficiaries (3) Instrument Objective, (4) Life Cycle, (5) R&D Phases Supported, and (6) Firm Size, where the first three variables were assigned weights of 0.2222 and the latter three weights of 0.1111. The Jaccard similarity index compares the elements of two sets to see how many are shared and how many are distinct. It is defined as the ratio of the size of the intersection between two sets to the size of the union of the two sets: $J(A,B)= \frac{|A \cap B|}{(|A|+|B|-|A \cap B|)}$

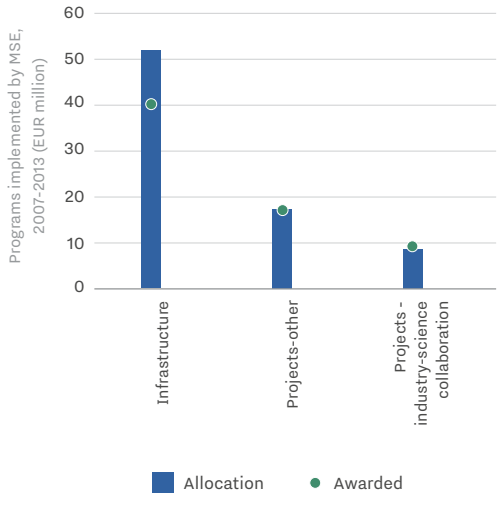
Programs are denoted by their short names. The list of short names and corresponding full names is provided in Appendix III.

6.1.9 MSE Support Programs from the 2007-2013 Period

Although not part of the current policy mix, the portfolio mapping includes ten MSE programs from the 2007–2013 period. These programs were financed through Instruments of Pre-Accession (IPA) and were part of OP *Regional Competitiveness* (OPRC) and OP *Human Resource Development* (OPHRD). The analysis in this section is not entirely reflective of the STI policy mix in this period because it does not include MEEC programs (however, during this period, MSE had the leading role with respect to innovation financing). Further, during this period, there was a lot less funding available, because Croatia joined the EU on July 1st, 2013. Nonetheless, this short analysis may serve as a comparison with the part of the current policy mix that MSE implements. It also provides analytical background and raises issues for further investigation in the *Functional and Governance Analysis* that follows the *Analysis of the Quality and Coherence of the Policy Mix* (as outlined in the Introduction).

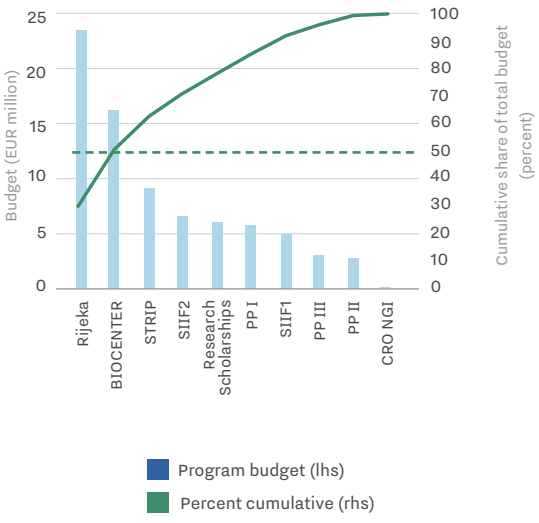
A significant portion of financing pertained to preparing and implementing infrastructure projects, while a slightly smaller portion of the budget was dedicated to R&D projects. Six of ten programs and two-thirds of the total budget were allocated to infrastructure spending, while the remainder pertained to R&D projects (Figure 6.30). The two largest projects were infrastructure projects (Rijeka University Campus and BIOCENTER), and they absorbed over 50 percent of the funding (Figure 6.31). Rijeka University Campus was a EUR 23.5 million project that aimed to improve R&D capacities through investments in new research centers, laboratories and equipment. BIOCENTER was more oriented toward industry-science collaboration and providing early stage infrastructure (laboratories and office spaces) to biotechnology firms. Other infrastructure financing included three programs (PP I, PP II, and PP III) that financed project documentation for 15 research infrastructure projects, for a total of EUR 3.6 million. As we found in the current policy mix, this approach to improving the research infrastructure has continued in the 2014–2020 period, partly by using World Bank financing to prepare technical documentation and using ESIF to finance the implementation of the projects.

FIGURE 6.30
A significant portion of financing implemented by MSE in 2007–2013 went to public R&D infrastructure



Source: Staff elaboration.

FIGURE 6.31
Over 50 percent of funding was absorbed by two of the largest projects

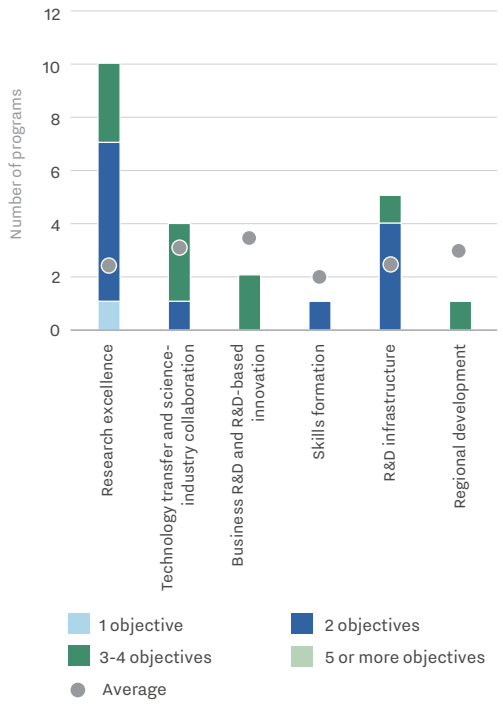


Source: Staff elaboration.

As expected, most programs aimed to enhance research excellence, with industry-science collaboration, technology transfer, business R&D and skills as secondary objectives. Research excellence was supported in all ten analyzed programs, and was always combined with other objectives, most notably R&D infrastructure and industry-science collaboration (Figure 6.32 and Figure 6.33). Industry-science collaboration was supported through a targeted program (STRIP), which provided financing for collaborative projects of research institutions (as the main beneficiaries) and the private sector (as partners). The program supported 19 collaborative research projects with a median grant value of almost EUR 500,000 and has been replicated in the 2014–2020 programming period. Two of the programs, Science and Innovation Investment Fund (SIIF) 1 and SIIF2 supported commercialization and technology transfer in HEIs and PRIs, but they were not sufficient to firmly establish technology transfer functions, as that would require a higher level of institutional commitment and support. The collaboration with the private sector was somewhat undermined, considering that the private sector could participate only as associates, without the possibility of receiving any funding.

FIGURE 6.32

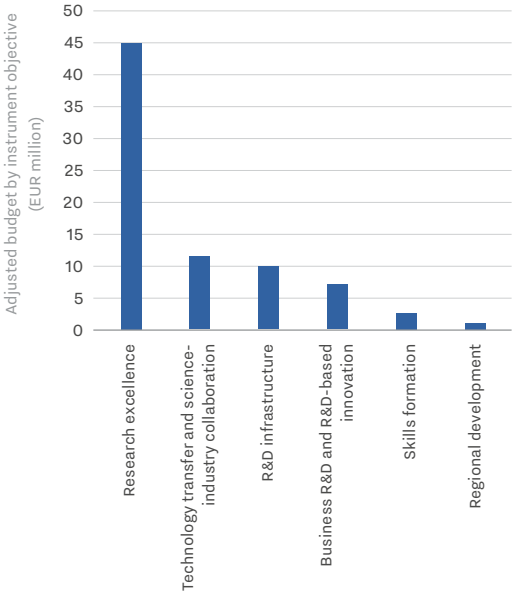
Most programs supported research excellence through R&D infrastructure



Source: Staff elaboration.

FIGURE 6.33

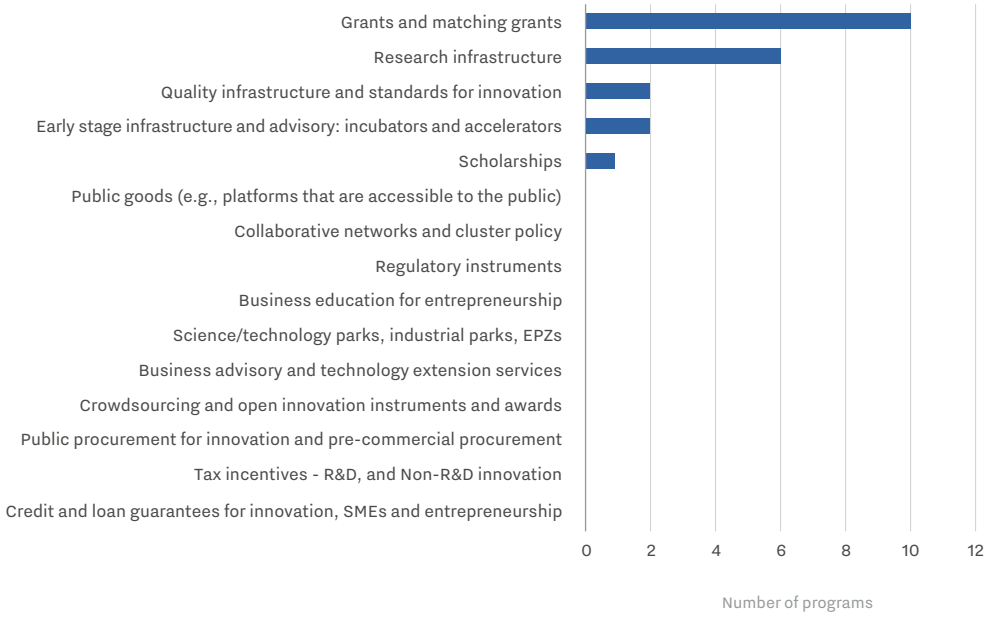
Most funding supported research excellence



Source: Staff elaboration.
Note: For programs with multiple target objectives, the budget is adjusted by dividing the program budget equally among different objectives.

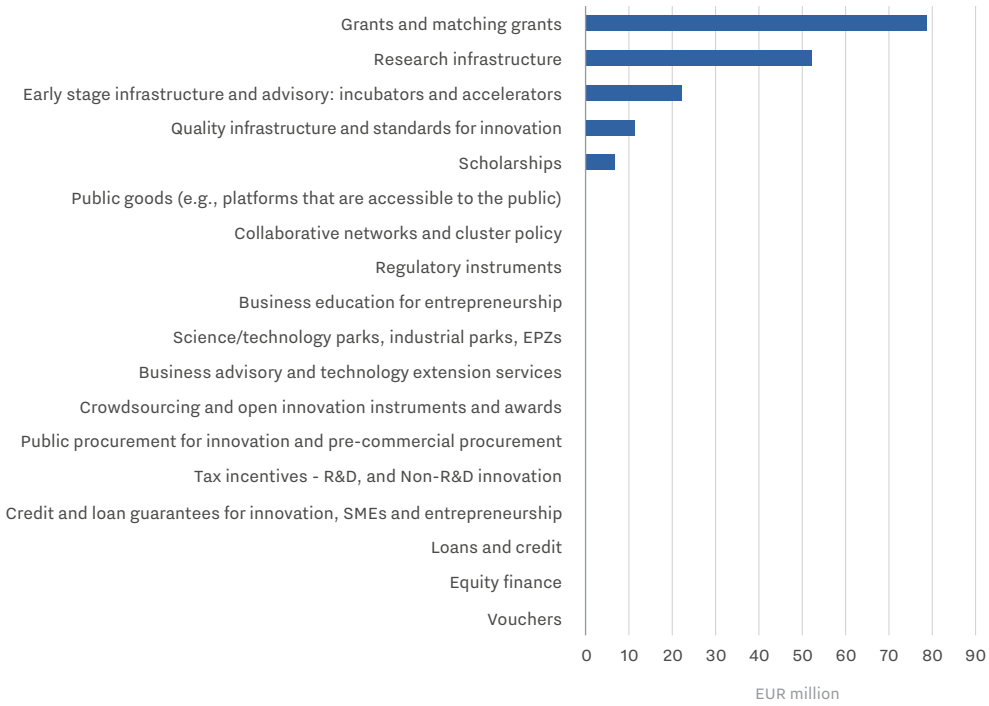
The prevailing mechanisms of intervention were grants and research infrastructure, and they mostly targeted researchers and research institutions. All programs were essentially grants, but six of them related to investments in infrastructure (Figure 6.34). A total of around EUR 79 million was disbursed as grants, of which around 52 million were invested in research infrastructure (Figure 6.35). The focus on grants and infrastructure is understandable, considering that these are programs designed by MSE for the benefit of research institutions (mostly HEIs and PRIs) (Figure 6.36).

FIGURE 6.34 *Grants and research infrastructure were the main mechanisms of intervention*



Source: Staff elaboration.

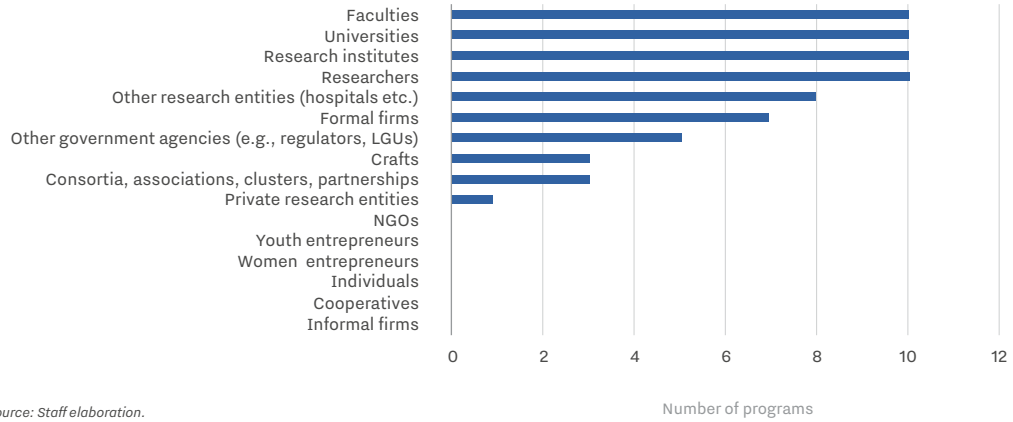
FIGURE 6.35 *Most of the funding was also allocated in the form of grants and infrastructure investments*



Source: Staff elaboration.

FIGURE 6.36

Programs targeted HEIs and PROs, with less support for the private sector

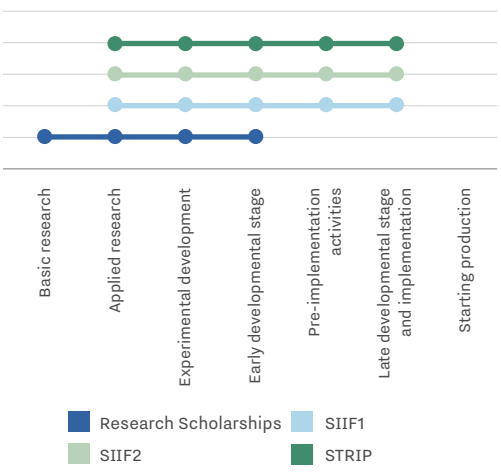


Source: Staff elaboration.

Compared to the current policy mix, the analyzed programs in the 2007–2013 period provided more support for applied research, as well as development, though lack of targeting in some programs was an issue. After excluding R&D infrastructure, only one program (Research scholarships) provided funding for basic research (among other types of R&D), while the remaining three programs spanned six or more R&D and TRL stages (Figure 6.37 and Figure 6.38). A close review of the programs suggests that, even though SIIF was open to financing several R&D stages, the program focus was centered on technology transfer. The focus of SIIF and STRIP was on applied research and experimental development (as opposed to basic research), which is closer to practices in countries with better innovation performance. STRIP was kept relatively open in terms of TRL coverage (same as SIIF), but it is more difficult to determine the core focus of the program and its respective success indicators.

FIGURE 6.37

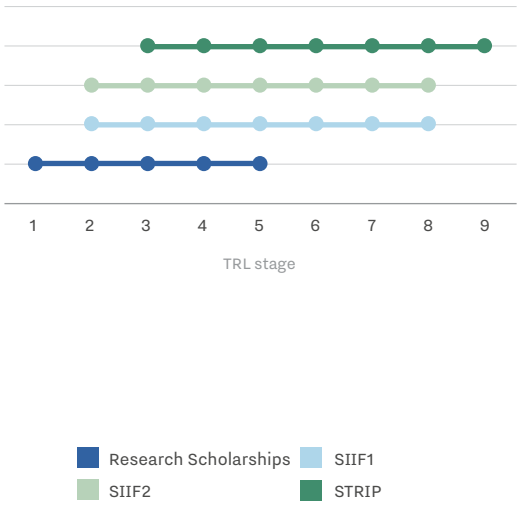
Programs included more support for applied research, as well as development, but there was not much targeting within programs



Source: Staff elaboration.

FIGURE 6.38

Programs also featured little targeting of TRL stages

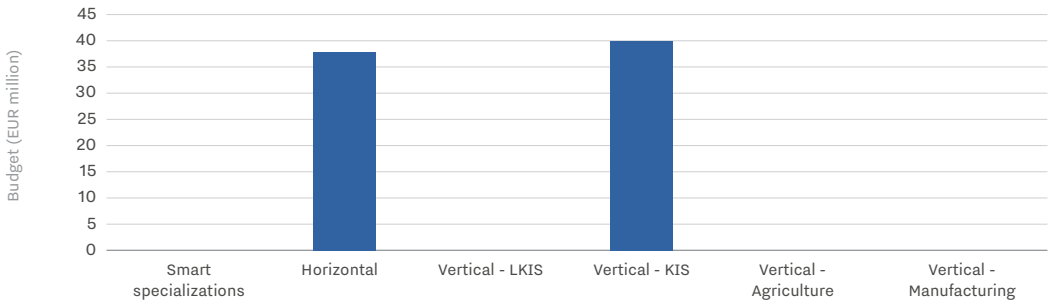


Source: Staff elaboration.

There is an almost equal allocation to horizontal programs and programs for KIS. The sectoral allocation of funding shows around EUR 40 million invested in horizontal programs and programs that support KIS (Figure 6.39). The support for KIS is somewhat indirect because it is delivered through investments in infrastructure that will enable the development of KIS. Most of the programs that support research projects are horizontal, because they allow for R&D that could lead to innovation in any sector.

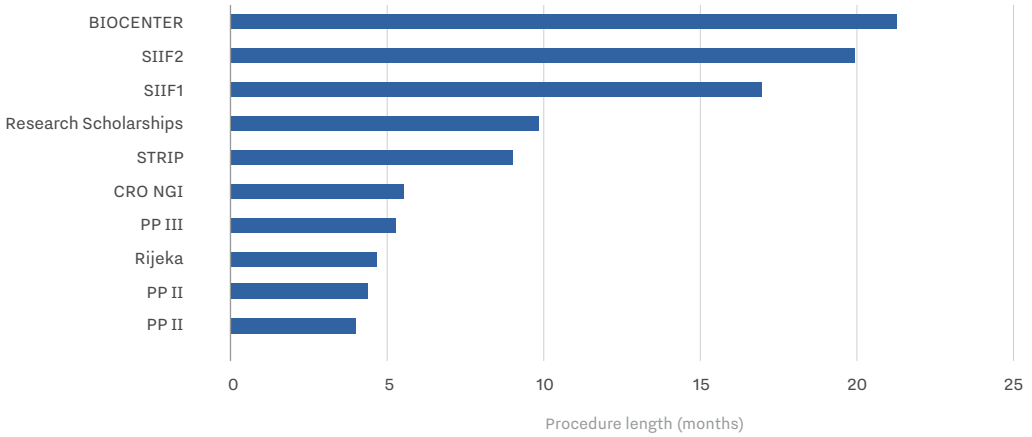
As in the current period, programs in the previous period also experienced extended delays in the selection process. Programs that supported infrastructure (except Biocenter) had the shortest turnaround (6 months or less) between call announcement and contract signing (Figure 6.40). In contrast, Biocenter, SIIF1 and SIIF2 experienced the longest delays (between 17 and 21 months). The reasons for such extended delays are connected to prolonged project evaluations. The SIIF project implemented in the current policy mix is experiencing even longer delays in selection (over 24 months). While the reasons are different, they are likely related to project evaluation.[57] This deterioration calls for more in-depth investigation that would allow for appropriate corrective actions.

FIGURE 6.39 *The budget is almost equally spread between horizontal programs and support for KIS*



Source: Staff elaboration.

FIGURE 6.40 *As in the current policy mix, some programs experienced significant delays in project selection*



Source: Staff elaboration.
Note: Procedure length calculated as number of months between call start and contract signing.

57 This is to be further investigated in the second stage of the project, Functional and Governance Analysis.

6.1.10 Selected Cross-Country Comparisons

This section presents a cross-country comparison of the policy mix in Croatia, Poland, and the Czech Republic, through the lens of issues most relevant to Croatia. The portfolio mapping exercise was conducted in Poland and the Czech Republic using the same methodology as in Croatia, which allows for cross-country comparison of the policy mix, with some caveats related to coverage. This is not an attempt to summarize the findings of the analysis of the policy mix in either Poland or the Czech Republic. Rather, this section presents only those elements of the policy mix that are most relevant to Croatia, where comparison is possible. The coverage of the portfolio mapping analysis was different in all three countries, both in terms of programs and in terms of monitored variables, which imposes some limitations on direct comparison. More specifically, the portfolio mapping in Poland does not include programs (i) for the small-scale piloting of new interventions, (ii) monitoring of national smart specializations, (iii) instruments for development of investment areas, and (iv) programs targeted toward the research sector; the Czech portfolio covers only SME support programs. In contrast, the Croatian portfolio mapping covers support to both public research and the private sector. Comparisons should also consider differences in the structure of the policy mix and amount of funding available. The budget covered in the portfolio mapping is largest in Poland (EUR 21 billion), followed by the Czech Republic (EUR 10 billion), while Croatia has less funding (EUR 1.1 billion). Similarly, Poland has the largest number of programs (182), while the Czech portfolio has 93 programs, and the Croatian portfolio covers 68 programs.

Compared to Croatia, the policy mix in the Czech Republic provides relatively more options to support new ventures, jobs and skills upgrades, and climate change. Support for productivity upgrades in existing firms, diversification and new ventures is roughly even (in around 45 percent of programs for each category). In Croatia, by contrast, there is more support for productivity upgrades in existing firms. The Czech policy mix also features a larger share of programs supporting investments in jobs, skills, and human capital (30 percent), as well as climate change (33 percent).

Grants are the dominant mechanism of intervention in all three countries, but Poland and the Czech Republic have a greater variety of support instruments than Croatia. In the Czech Republic, grants and matching grants account for 65 percent of funds and 60 percent of programs. In Poland, they account for over 75 percent of programs. In Croatia, they make up 88 percent of programs. Even considering that one-third of grants in Croatia are used for research infrastructure, Poland and the Czech Republic have a greater variety of instruments. In Poland, there are 14 voucher instruments (including vouchers for innovation, business advisory, R&D, and entrepreneurship) compared to four in Croatia and one in the Czech Republic. Poland and the Czech Republic have higher shares of programs providing equity finance, loans, loan guarantees and soft support. For example, Poland has 13 instruments providing equity finance, as well as loans for introducing new products and services. In the Czech Republic, education, training, business advisory, and extension services are present in a larger share of programs than in Croatia (16 and 13 percent respectively), though they account for a smaller portion of the budget.

The distribution of support based on firm size, life cycle and innovation cycle is similar in Poland, the Czech Republic and Croatia. In all three countries, most programs support SMEs and more mature firms, and beneficiary targeting within the same program could be improved. In Poland, support to micro, small and medium enterprises is roughly equally split, and a third of programs also provide support to large firms, mostly in the form of grants. As in Croatia, the policy mix in Poland and the Czech Republic features more support for mature and growing firms, with fewer funding opportunities at the idea and start-up stages. In the Czech Republic, 57 percent of programs provide support at the idea stage (albeit with only 13 percent of disbursed funds), compared to 16 percent of programs

in Poland and 18 percent in Croatia. In all three countries, support for all stages of the life cycle is often bundled together. In the Czech Republic, 88 percent of programs that supported start-ups and scale-ups included mature firms, while 68 percent also supported firms at the idea stage. In Poland, only three interventions featured targeted support for the idea and start-up stage, while 108 programs supported mature firms only. Similarly, over two-thirds of programs in the Czech Republic covered four or five segments of firms in the innovation cycle, with around half of the programs available to non-innovators. This is similar to Croatia, where around 40 percent of programs benefiting the private sector are open to non-innovators, and this support is usually bundled with other beneficiary types.

A significant number of instruments in Poland include support for business R&D, and the support spans from applied research to starting production. Around 40 percent of programs in Poland support business R&D, and one-third of those support five or more stages of R&D. More targeted programs (three stages or less) typically cover a combination of earlier developmental stages (experimental development, early developmental stages and pre-implementation activities) or closer-to-the-market development.

6.2 Analysis of Beneficiaries

- EUR 126 million was awarded for STI projects to over 620 companies in Croatia from ESIF funded programs. Some 71 percent of the allocation comes from a single program called *Increasing the development of new products and services that result from research and development activities (IRI).*
- Funding went predominantly to mature companies, especially those established before 2010. Medium-sized firms were most likely to obtain ESIF funding, and micro enterprises were least likely. Most of the firms that obtained funding are from the Zagreb region. Larger companies received larger grants on average.
- Most of the beneficiaries in R&D programs are firms that have previously invested in R&D, confirming that funding is largely supporting within-firm productivity growth. Most of the beneficiaries of R&D programs are from the knowledge-intensive services sector.
- Beneficiaries are significantly more export-oriented than non-beneficiaries and are over 12 times more likely to be high growth firms.
- Firms that received ESIF funding performed better than the non-beneficiary population in the year before receiving support.
- ESIF beneficiaries have better financial results than World Bank beneficiaries, reflecting the focus of ESIF programs on more mature firms. Participation in the World Bank programs was often followed by participation in the ESIF programs, indicating that World Bank support is an investment in the pipeline that increases readiness for ESIF financing.

6.2.1 Scope of the Analysis

European funds should support projects that have high potential for growth but are not able to get financing on the market (for example, due to riskiness). One of the main justifications for government intervention is market failure. EU-funded innovation support programs attempt to overcome the market failure in financing innovation by providing funding for companies that would otherwise be unable to secure funding for RDI projects on the financial market because returns on investment (and risks) for such interventions are assumed to be the highest. However, identifying market failures and selecting companies that should be supported is difficult. For example, program managers may have incentives to select the companies that are most likely to succeed (minimizing the risk of failure), rather than more risky ones with the highest expected returns on investment.

The aim of this analysis is to shed light on the kinds of companies that have been supported to date. The analysis looks at the differences between supported and non-supported companies taking into account productivity, financial measures (e.g., profitability, assets) and company characteristics (which are also used as controls). The analysis introduces a synthetic firm's financial performance (FFP) index. The focus is on MEEC-led programs because they are primarily focused on firms.

The beneficiaries (companies) of nine ESIF funded programs were analyzed to extract certain profile characteristics. The World Bank prepared a firm-level dataset matching data on beneficiaries of nine ESIF-funded RDI programs with their financial statements. As of May 31, 2019, a total of 686 grants had been awarded under the analyzed programs. Of these, 649 ESIF grants that were awarded to 591 beneficiaries were matched by company name with firm-level data. A total of 37 companies were excluded from the analysis, either because they were established recently (firm-level data is still not available) or because there was only old data available. The comparison group consists of 119,693 non-beneficiary companies. Additionally, Box 6.5 presents the results of the analysis for three World Bank programs (PoC, IRCRO, and RAZUM) with a total of 119 projects.

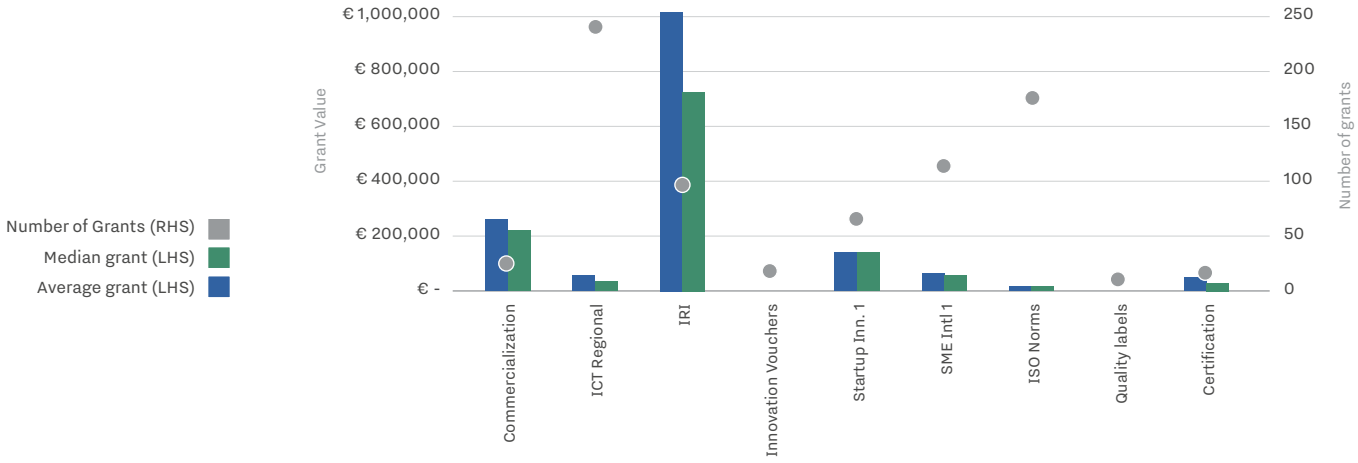
6.2.2 Characteristics of the Analyzed EU-Funded Programs

The total funding awarded to firms amounted to EUR 126 million, and the median grant value received by enterprises was EUR 44,000. All programs (except for the *Innovation Vouchers* and *Quality Labels* programs) disbursed funding in the form of grants.[58] The smallest grant amounted to EUR 2,000, and the largest was worth EUR 6.8 million. As a result, the mean grant value of EUR 182,000 was markedly higher than the median (Figure 6.41).

Two programs stand out in terms of the number of firms supported and funding allocated: *IRI* and *ICT Regional*. *IRI* had the highest budget of all programs, with EUR 97 million to be distributed on supporting R&D activities in enterprises (Figure 6.42). It also had, by far, the highest median grant value, EUR 727,000. The ICT *Regional* program, with the second largest budget, distributed the most grants (207 projects). Its grants are for fostering entrepreneurship development among start-ups and more mature firms.

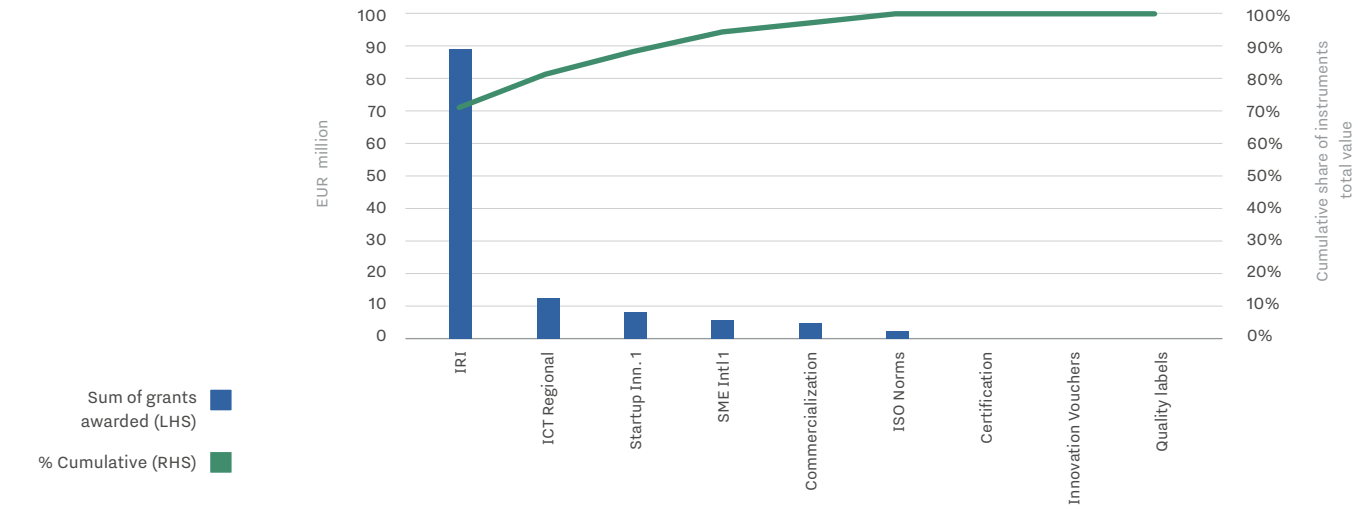
58 Vouchers are referred to as grants later in the text for a lack of a better term for both grants and vouchers.

FIGURE 6.41 *The largest grants are distributed through IRI*



Source: Staff elaboration based on the list of beneficiaries of ESIF financed programs

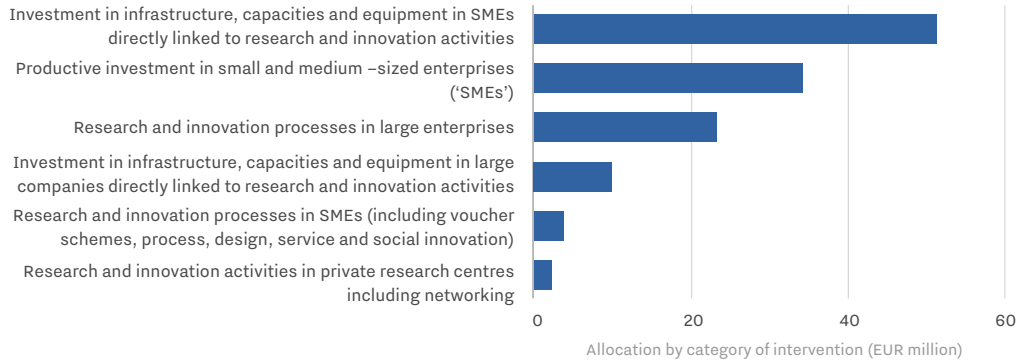
FIGURE 6.42 *IRI constitutes 71 percent of the whole ESIF allocation*



Source: Staff elaboration.

The nine programs analyzed can be classified into six categories of intervention as per the division in the Operational Programme for Competitiveness and Cohesion. The largest category, with 41 percent of funds (EUR 52 million), was Investment in infrastructure, capacities and equipment in SMEs directly linked to research and innovation activities (Figure 6.43). The second most supported category was Productive investment in SMEs, where 27 percent of all funds (EUR 35 million) were allocated. Large firms were rarely targeted, but due to the *IRI* program, this category of firms received EUR 24 million, and was the third largest category in this classification.

FIGURE 6.43 *Some 41 percent of funding was spent on investment in infrastructure, capacities and equipment in SMEs*

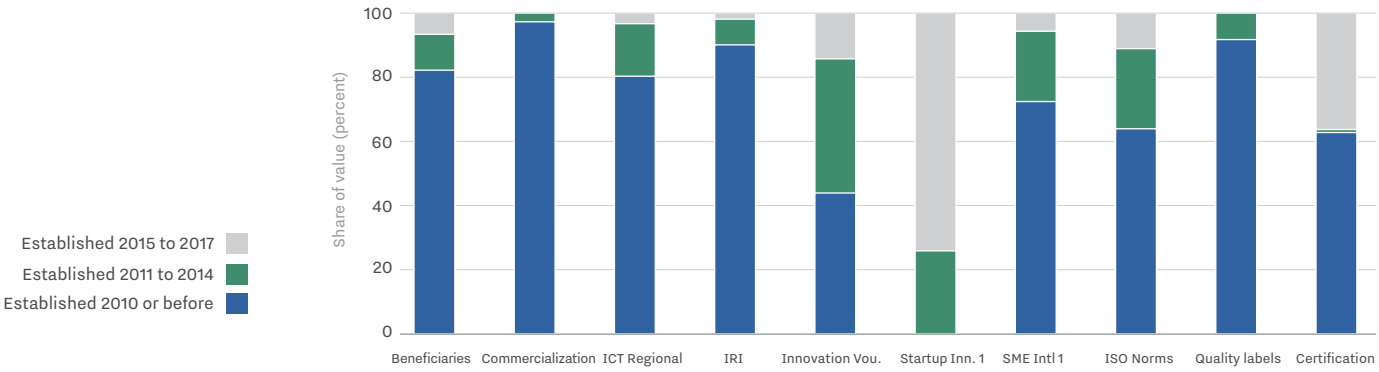


Source: Staff elaboration based on the list of beneficiaries of ESIF financed programs.

6.2.3 Characteristics of the Analyzed Beneficiaries

Beneficiaries are predominantly mature companies. Two-thirds of beneficiaries were established in 2010 or before, and they received 82 percent of the ESIF funding.[59] Moreover, a small share (12 percent) of beneficiaries can be classified as young companies, that is, firms established in 2015 or later (Figure 6.44). At the same time, almost a third of all companies in FINA are young, meaning that young companies are underrepresented among beneficiaries. Only in *Startup Innovation 1* was the share of young companies (two-thirds of its participants) larger than in the population. This was the only program that did not target scale-up and mature life stage; only seed and start-up companies were in its focus. *ICT Regional*, *IRI, Quality Labels* and *Certification* did not target young companies, and the majority of their participants were incorporated in 2010 or earlier. *Commercialization* had the oldest population – 94 percent of companies were incorporated in 2010 or before – in spite of the fact that it was also open to new entrants.

FIGURE 6.44 *Mature companies (established in 2010 or before) received 82 percent of the ESIF funding*

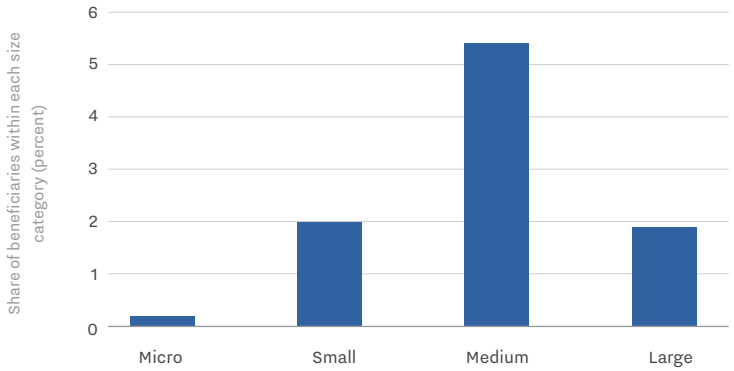


Source: Staff elaboration based on FINA.

59 Because the earliest available FINA database is from 2010, it is unknown in which years older companies were incorporated.

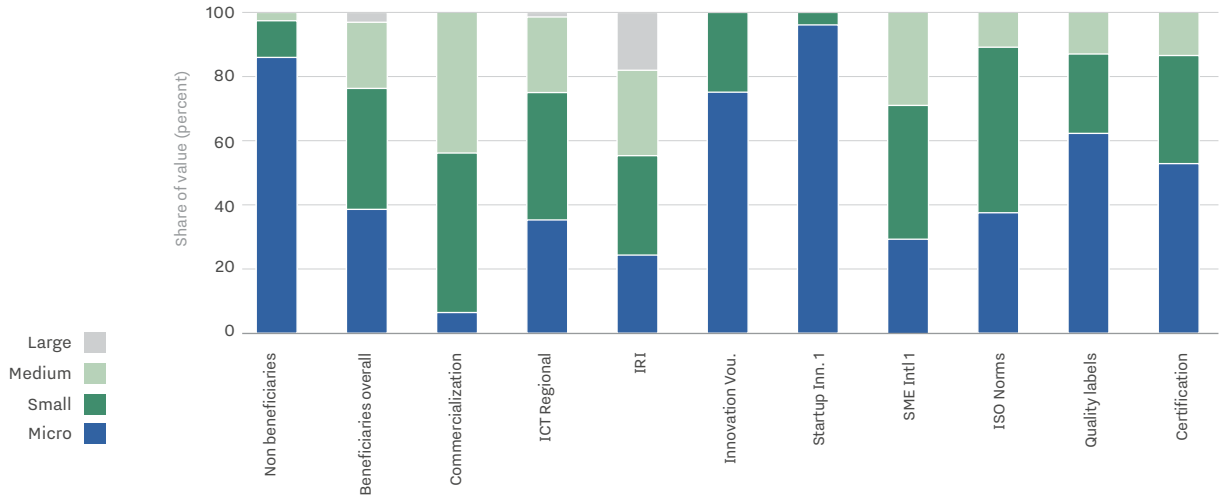
Medium-sized firms were most likely to obtain ESIF funding (Figure 6.45) and micro enterprises were least likely.[60] In Croatia, 86 percent of companies are micro enterprises, 11 percent are small, 2 percent are medium and less than 1 percent are large. In the population of beneficiaries, micro and small companies accounted for the largest share, 39 percent and 38 percent respectively (see Figure 6.46). Medium companies constituted 20 percent of beneficiaries' population and large ones only 3 percent. Large companies were eligible for the *IRI* and *ICT Regional* programs only, and they accounted for 19 percent and 1 percent respectively.

FIGURE 6.45 *Medium firms are most likely to obtain ESIF grants*



Source: Staff elaboration based on FINA.

FIGURE 6.46 *Medium and large companies accounted for larger share of the beneficiaries, compared to their representation in the whole population*



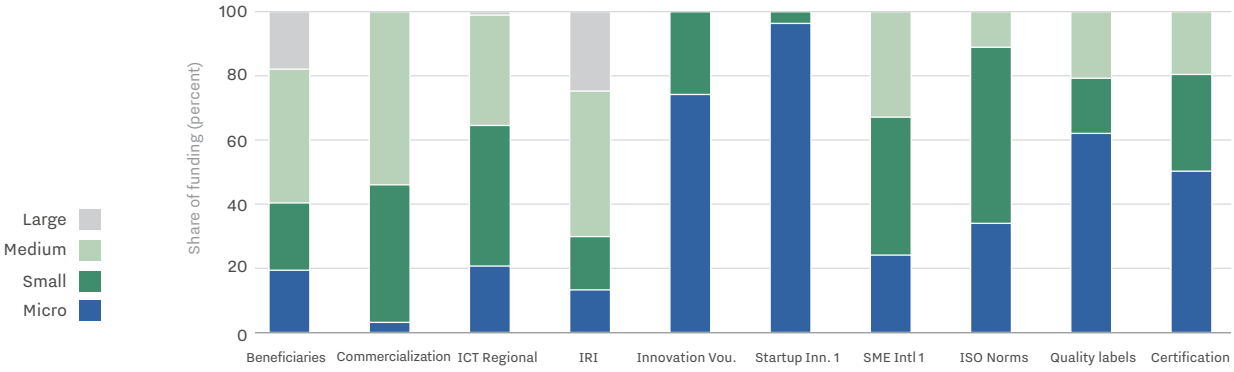
Source: Staff elaboration based on FINA.

60 This report uses the Eurostat definition of enterprise size, classifying firms as: micro enterprises (with less than 10 persons employed), small enterprises (with 10-49 persons employed), medium-sized enterprises (with 50-249 persons employed) and large enterprises (with 250 or more persons employed).

Because larger companies applied for larger grants, the share of medium and large companies in the total monetary value of grants is substantially higher than in the number of beneficiaries. Large enterprises (which account for 3 percent of all beneficiaries) received 18 percent of the funding, and medium-sized firms (20 percent) got 41 percent (Figure 6.47). Larger firms also received higher median grants. Small companies received 21 percent and micro firms the remaining 20 percent.

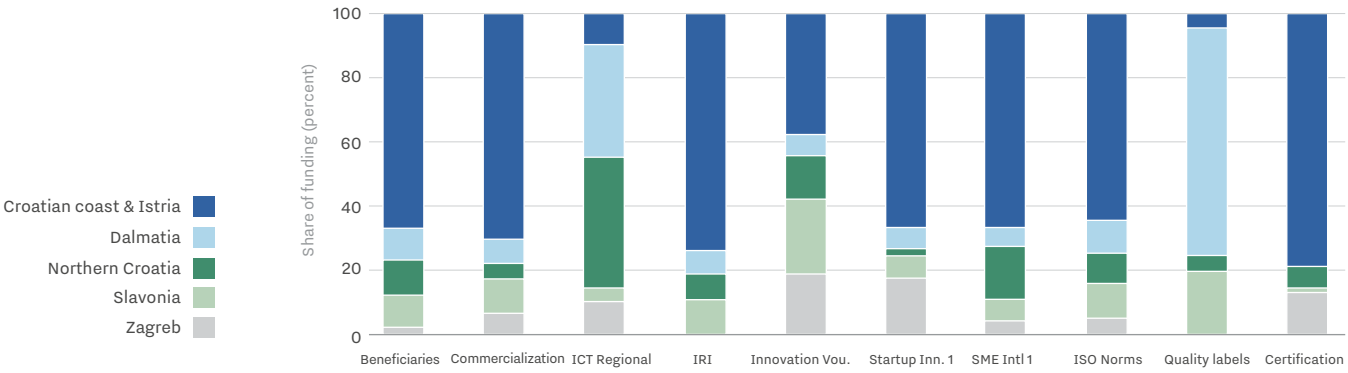
Companies from the Zagreb region received two-thirds of funding, compared to one-third for firms from the remaining four regions. Firms from Northern Croatia, Dalmatia and Slavonia each obtained 10 percent of the monetary value of all grants. The Croatian coastline & Istria only received 3 percent (see Figure 6.48). The discrepancy between Zagreb and the other regions can be explained by two factors. First, the number of companies and beneficiaries in the Zagreb region is higher than in any other region. Second, the share of medium and large firms among beneficiaries from Zagreb is higher than in other regions, and as discussed earlier, larger firms apply for larger grants.

FIGURE 6.47 *Medium-sized and large firms obtained 59 percent of the ESIF funding*



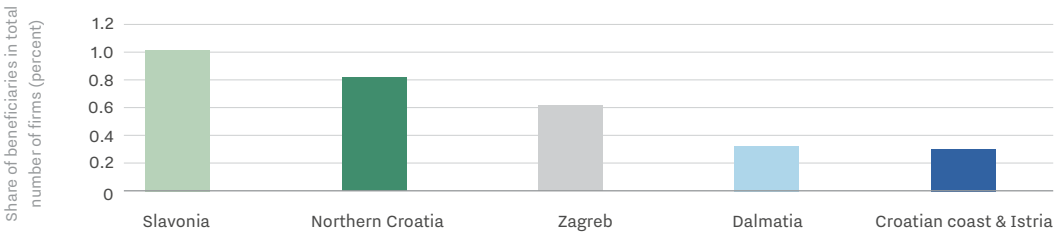
Source: Staff elaboration based on FINA.

FIGURE 6.48 *Most of the ESIF funding went to firms based in Zagreb*



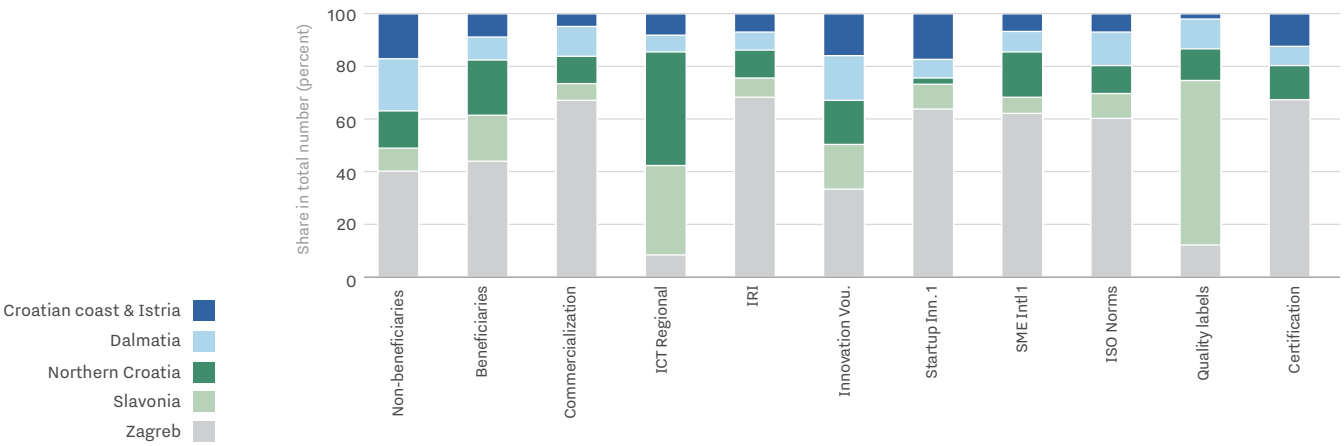
Source: Staff elaboration based on FINA.

FIGURE 6.49 *Slavonian firms were most likely to obtain ESIF funds*



Source: Staff elaboration based on FINA.

FIGURE 6.50 *Almost half of all beneficiaries are Zagreb based companies*



Source: Staff elaboration based on FINA.

Although many Slavonian firms were awarded with funding, it is unclear whether this is due to favoring applicants from lagging regions. On the one hand, firms from Slavonia (a catching-up region) were more likely to receive EU funds (Figure 6.49). On the other hand, among the four programs that awarded additional points for provenance (i.e., *ICT Regional, Certification, SME Intl 1* and *ISO Norms*), only ICT Regional can be considered strongly geographically diversified (Figure 6.50). In addition, Quality Labels did very well in Slavonia even though additional points for regional development purposes were not awarded.

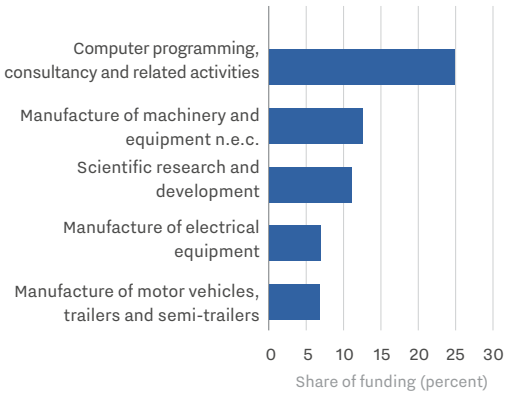
Computer programming, consultancy and related activities were the most supported area of economic activity (Figure 6.51).[61] Figure 6.52 shows that, in general, firms that provide knowledge-intensive services (KIS) were four times more likely to obtain ESIF funds than firms that provide less-knowledge intensive services (LKIS).[62] However, only 0.2 percent of all LKIS companies and 0.8 percent of KIS companies obtained funding. Among all beneficiaries, 38 percent can be classified as KIS providers (Figure 6.53) and they obtained 43 percent of all the funding. LKIS providers account for 14 percent of beneficiaries and obtained only 5 percent of the available funding. *ICT Regional* was oriented specifically at LKIS and had the highest share of this type of firms among all programs. Many of the beneficiaries of the *Certification* and *Quality Labels* programs were from the low technology sector.

61 Areas of economic activity are defined by NACE 2-digit codes for the purposes of this analysis.

62 According to Eurostat, KIS have the following NACE codes: 50, 58, 60, 61, 62, 63, 64, 66, 69, 70, 71, 72, 73, and 74, whereas LKIS are defined by NACE codes: 45, 46, 47, 49, 52, 55, 56, 68, and 79.

FIGURE 6.51

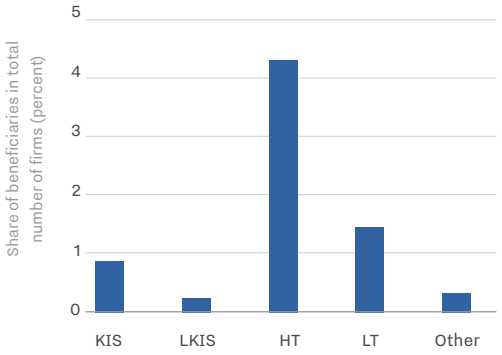
Computer programming, consultancy and related activities was the most supported area by the ESIF programs



Source: Staff elaboration based on FINA.

FIGURE 6.52

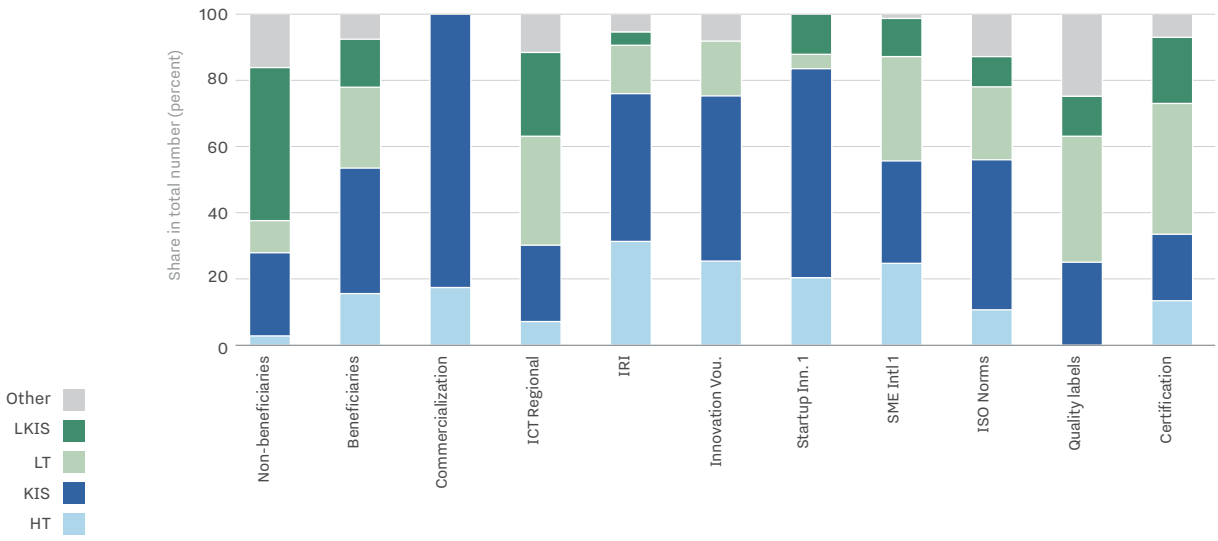
High technology (HT) and low technology (LT) firms were most likely to obtain funds



Source: Staff elaboration based on FINA.

FIGURE 6.53

Over half of all beneficiaries are HT and KIS firms



Source: Staff elaboration based on FINA.
Note: 'Other' are all firms that are not HT, LT, KIS or LKIS. Examples are agricultural and construction companies.

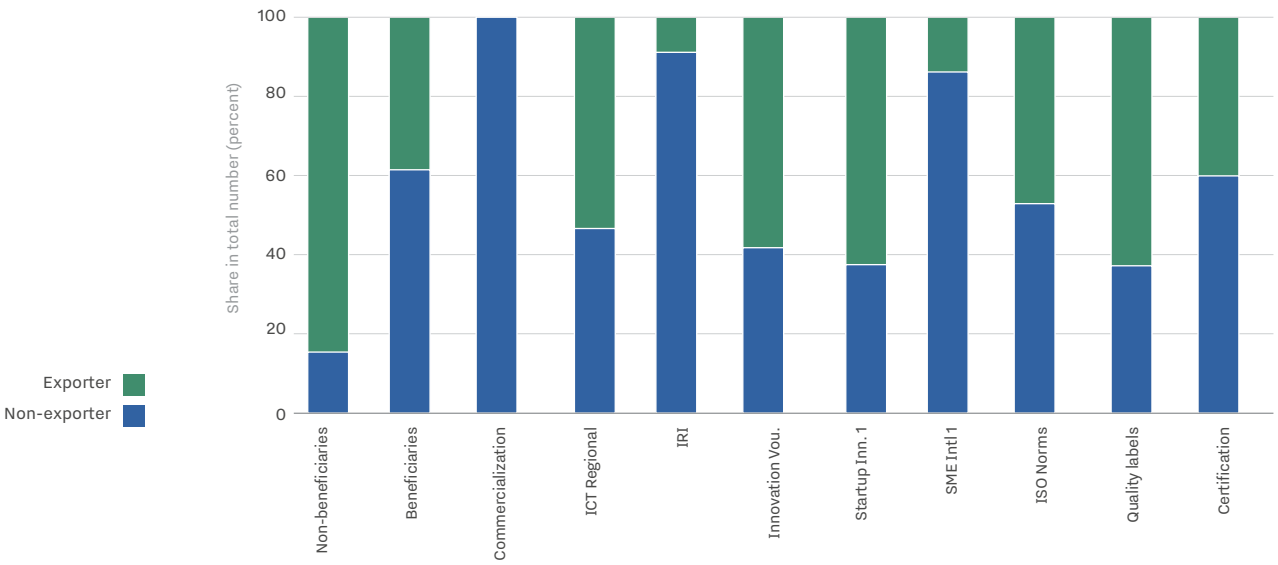
High technology (HT) manufacturing firms were three times more likely to receive grants than low technology (LT) manufacturing firms.[63] Furthermore, HT firms received larger grants and obtained a third of all ESIF funding, whereas LT firms obtained 16 percent of the total. *Commercialization* had, as one of its objectives, technology adoption or diffusion as an instrument. However, none of its participants is classified as an LKIS or LT firm. However, two other programs with the same focus – *ICT Regional* and *Certification* – have high shares of LT and LKIS.

63 According to Eurostat, HT firms have the NACE codes 20, 21, 26, 27, 28, 29, and 30, whereas LT firms are defined by NACE codes 10, 11, 13, 14, 16, 17, 18, 22, 23, 25, 31, 32, and 33.

Industrial companies are almost three times more likely to receive ESIF funding than service companies. Although industrial and service companies account for 23 percent and 74 percent of all companies, each sector accounts for almost half of all beneficiaries. The remaining 1 percent of beneficiaries comes from the agricultural sector.[64] Agricultural companies[65] participated only in the *Quality Labels* and *ICT Regional* programs where their share in the number of participants amounted to 25 percent and 1 percent respectively. The only program that stated an orientation toward a specific sector was *ICT Regional*, which favored non-knowledge intensive services.

Beneficiaries are substantially more export-oriented than non-beneficiaries. Exporters[66] received 89 percent of the total value of funding and non-exporters only 11 percent (see Figure 6.54). In general, a quarter of all income from beneficiaries' sales comes from abroad, compared to only 6 percent for non-beneficiaries. The highest share of exporters was in *Commercialization*, *IRI* and *SME Intl 1* (respectively 100 percent, 92 percent and 87 percent). While only the last program has internationalization as its main objective, most programs (except for *ICT Regional, IRI* and I*nnovation Vouchers*) have export promotion as an objective. Nonetheless mean and median values of share of foreign sales in total sales are equal regardless of whether a program has export support as an objective or not. The smallest percentage of exporters was in *Quality Labels* and *Startup Innovation 1*.

FIGURE 6.54 *Beneficiaries are more export-oriented than non-beneficiaries*



Source: Staff elaboration based on FINA.

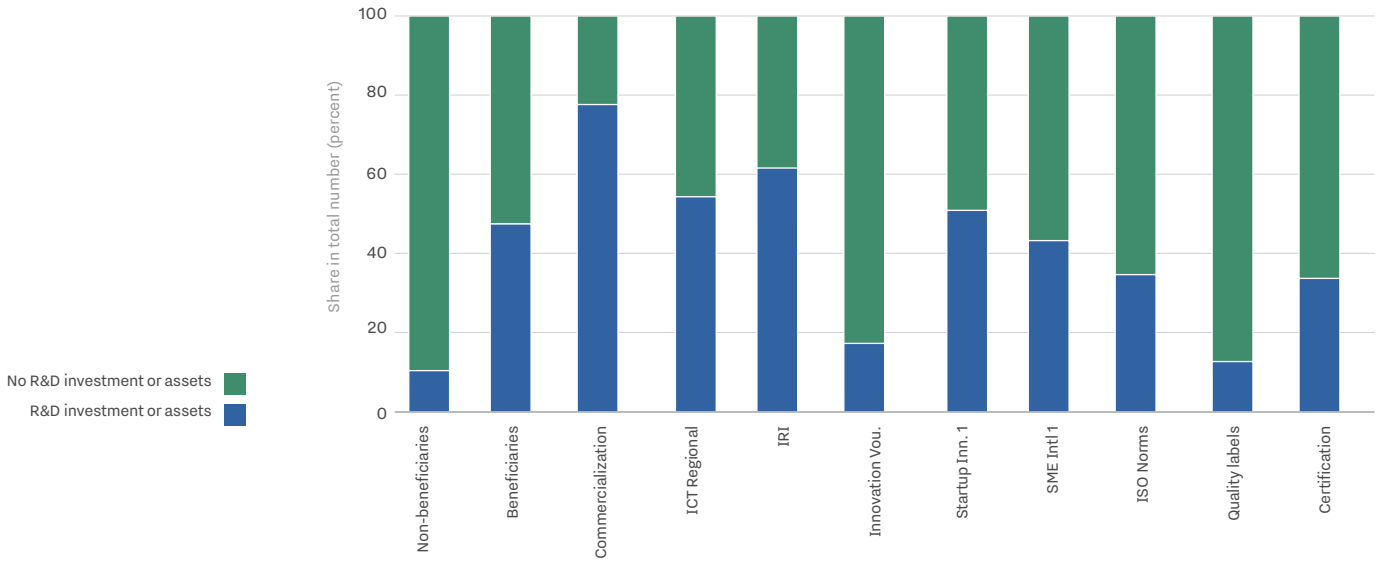
64 Agriculture is defined by all NACE codes smaller than 10, industrial companies are all those that deal with manufacturing, construction and similar types of activities (secondary sector, NACE codes from 10 to 43) and services are all NACE codes higher than 43.

65 Agriculture companies are well represented in the Rural Development Program, so their low participation in the Operational Program for Competitiveness and Cohesion should not be misinterpreted as underrepresentation in all EU programs.

66 Exporters are firms that have any revenue from sales abroad.

Firms that have previously invested in R&D obtain three-quarters of the ESIF funding, revealing a focus on increasing the R&D intensive margin as opposed to the extensive margin.[67] Some 42 percent of beneficiaries invested in R&D in 2017, compared to 6.5 percent of non-beneficiaries. R&D investment accounts for a larger share of total investment among beneficiaries than among non-beneficiaries: beneficiaries spent 18 percent of total investment on R&D, whereas non-beneficiaries spent 3 percent. Moreover, beneficiaries have more R&D-related assets on their balance sheets than a typical firm in Croatia. Among beneficiaries, 66 percent have R&D-related assets, over 5 times more than in the case of non-beneficiaries. R&D-related assets also constitute a higher share of total assets when it comes to beneficiaries (7 percent of total assets versus only 1 percent for nonbeneficiaries). *Startup Innovation 1* had the highest share of participants with any R&D-related assets. *Commercialization, IRI* and *Innovation Vouchers* share the objective of supporting business R&D and R&D-based innovation, and they have higher shares of firms with R&D-related assets than do programs without such an objective. However, around 50 percent of beneficiaries neither invest in R&D nor have any R&D-related assets (see Figure 6.55). This is a significantly smaller percentage than in the overall population, where 90 percent of companies neither invest in R&D nor have any assets of this type. All in all, there is a clear pattern of behavior among firms – those that have previously invested in R&D dominate in the R&D programs, whereas those that have not previously invested in R&D dominate in non-R&D programs. This approach could be reconsidered in light of the findings of the productivity analysis, which shows that higher productivity gains are associated with increasing the number of firms engaging in R&D (i.e., the extensive margin).

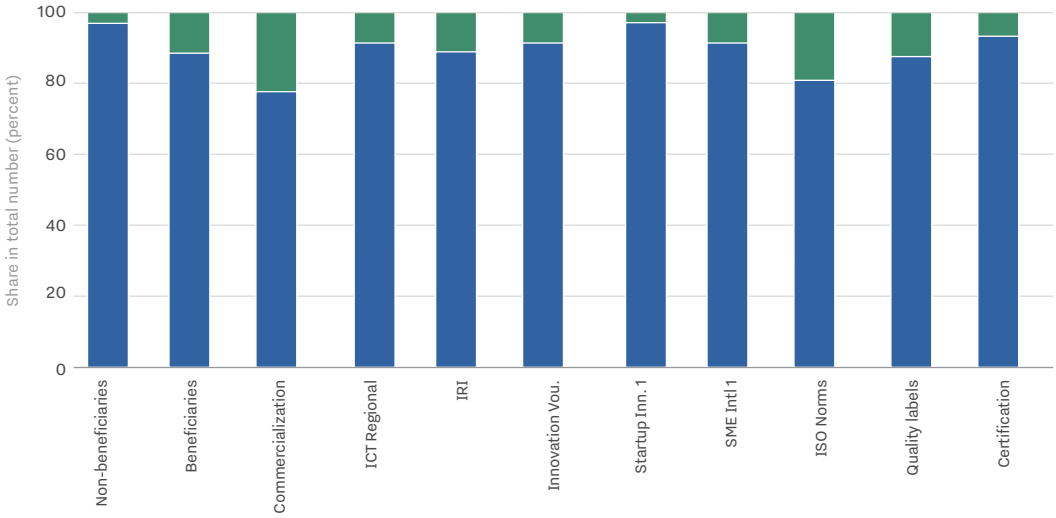
FIGURE 6.55 *In many R&D programs, most beneficiaries have invested in R&D previously*



Source: Staff elaboration based on FINA.

67 *Investment in R&D* is proxied by a variable labeled AOP282 in FINA. It captures gross investment in other tangible assets and intangible assets (biological assets, investments in research and development, software, databases and other intangible assets). R&D related assets are the following: sum of accumulated stock of R&D investment (AOP004 in FINA), concessions, patents, licenses, trademarks, software and other rights (AOP005) and intangible assets in progress (AOP008).

FIGURE 6.56 *Compared to the population, a good portion of the beneficiaries are high growth firms*



Source: Staff elaboration based on FINA.

Around 1 percent of firms in the overall population are high growth firms (HGFs) compared to 11 percent in the population of beneficiaries. HGFs were identified employing the OECD and Birch methodologies (see Grover, Medvedev and Olafsen 2019, for more details).[68] *Commercialization* and *ISO Norms* have the highest share of HGFs (22 percent and 19 percent respectively) based on the OECD definition (see Figure 6.56). Based on the Birch definition, 31 percent of beneficiaries of IRI and 22 percent of the beneficiaries of *Commercialization* can be considered high growth firms. The three areas of economic activity (by NACE classification) with the highest share of HGFs are *gambling and betting activities* (23 percent), *mining support service activities* (14 percent) and *remediation and other waste management services* (13 percent).

6.2.4 Firm's Financial Performance Index

The FFP index is a synthetic measure that allows comparisons of financial performance between firms. There is no single optimal measure of firm performance that can be applied universally; each measure has its limitations. To mitigate these limitations, we created an index of firm performance consisting of four variables typically used in the literature. The variables are return on equity (ROE), return on assets (ROA), employee productivity and EBITDA margin (see Box 6.4 for the approach). Other potential measures, like debt-to-assets or debt-to-equity ratios, were excluded because it is difficult to determine their optimal level.

68 The OECD definition is "firms that employ more than 10 workers and whose employment grows at an average annual rate of 20 percent or more over a period of three consecutive years." The Birch definition is "HGFs are firms that employ more than 10 workers (including owners but excluding unpaid workers) and whose employment growth places them above the 90th percentile of the Birch index of all firms in the economy, with the index defined over a period of three consecutive years." Both methods yield similar results, and correlation between them is 0.7

BOX 6.4 Firm's financial performance index

The FFP index consists of four variables of equal weight: return on equity (ROE), return on assets (ROA), employee productivity and EBITDA margin. The index was calculated based on the appropriate variables from the FINA dataset. Due to a large number of outliers in the FINA data, each component of the index was capped at the bottom and at the top. That is, observations below the 1st decile and above the 9th decile were truncated by assigning them the values of these deciles. All variables were standardized to ensure comparability. Because of standardization, the expected value of the index equals 0.

The formula for the index is as follows:
FFP Index =0.25 x (ROE + ROA + EBITDA margin + Employee Productivity)
where variables in the parenthesis are standardized.

A higher value on each of the components means that a company has a better financial standing. Therefore, the higher the index is, the better the company performs financially.

The four components of the FFP index are:

1) **EBITDA** is a measure of earnings before interest, taxes, depreciation and amortization. Thus, **EBITDA margin** can be calculated as:

$$\textit{EBIITDA margin} = \frac{\text{EBITDA}}{\text{Total Revenue}}$$

EBITDA focuses on operating profitability and cash flow. Scaling it with total revenue allows comparisons of profitability of two or more companies of different sizes. Negative EBITDA means that earnings are negative (costs are greater than revenues) which was a case for around one-fourth of all Croatian companies in 2017.

2) **Return on equity (ROE)** is an indicator of financial performance calculated by dividing net income by shareholder's equity. Because shareholders' equity is equal to a company's assets minus its debt, ROE could be interpreted as the return on net assets. ROE is thought of as a measure of how well management is using company's assets to create profits. It is calculated as:

$$\textit{ROE} = \frac{\text{Net Income}}{\text{Equality}}$$

Net income is defined as total income minus expenses. Equity is equal to total assets minus liabilities. Hence, ROE can be negative if expenses exceed total revenue from sales.

3) **Return on assets (ROA)** is a measure of how profitable a company is relative to its total assets. It gives an idea of how efficiently management is using its assets to generate earnings. ROA takes into consideration a company's debt, which distinguishes it from other metrics such as ROE. It can be calculated as follows:

$$\textit{ROA} = \frac{\text{Net Income}}{\text{Total Assets}}$$

4) **Employee productivity** is a measure of how much each worker contributes to the income of a company. It is calculated as follows:

$$\textit{Employee productivity} = \frac{\text{Net Income}}{\text{Average full time Employment equivalent}}$$

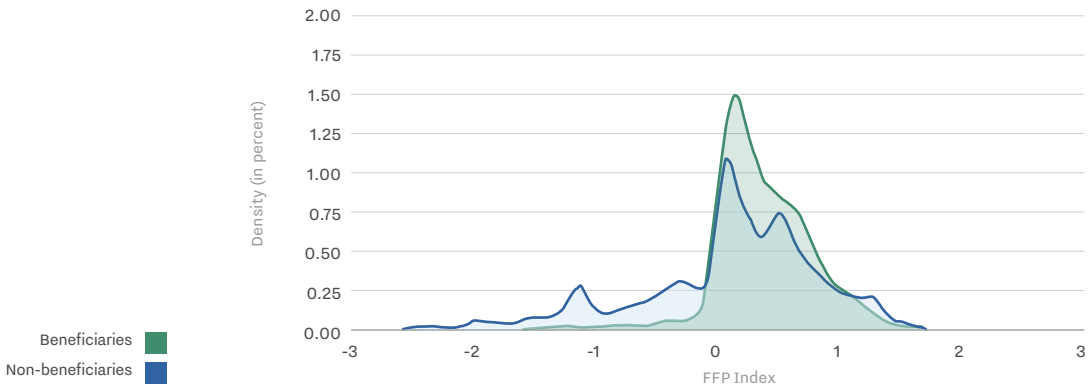
The FFP index divides beneficiaries into three groups: weak performers, average performers and top performers. They are defined as follows:

- **Weak performers** are companies with an FFP index lower than 1st quartile in the population of all firms;
- **Average performers** are companies with an FFP index between 1st and 3rd quartile; and
- **Top performers** are companies with an FFP index above 3rd quartile.

The desired outcome for a funding program is that there should be few weak performers and few top performers among the beneficiaries; most of the beneficiaries should be average performers with potential to grow. Such targeting allows for correcting market failures.[69] One consideration is that weak performers might not guarantee a sufficient return on investment. Another is that top performers are usually capable of obtaining funds from other sources, so providing them with extra funds is a form of deadweight loss and may crowd out market financing. Additionally, supporting weak firms often artificially delays their exit from the market, which blocks their capital and human resources from being used more efficiently in more productive firms. Hence, supporting average performers is most likely to lead to effective use of public funds.

A median and average company that received ESIF funding performed better than a non-beneficiary in the year before receiving support.[70] The FFP index allows ordering companies in terms of their financial standing. For the set of companies in the database, the index takes a value of -2.43 to 1.36. Figure 6.57 shows the distribution of beneficiaries and non-beneficiaries, that is, the share of companies that have a given value of the index. An average beneficiary has a value of the index equal to 0.25, and a median beneficiary has a value equal to 0.18, as compared to 0.00 for an average non-beneficiary and 0.06 for a median non-beneficiary. This means that beneficiaries have better financial standing than non-beneficiaries. The thin left tail of the distribution of beneficiaries in Figure 6.57 indicates that there is a lack of poorly performing companies in the population of beneficiaries. This may mean that the application process is successful at eliminating the worst performers or simply that these companies are not applying for ESIF funding.

FIGURE 6.57 *Beneficiaries perform better than non-beneficiaries*



Source: Staff elaboration based on FINA.

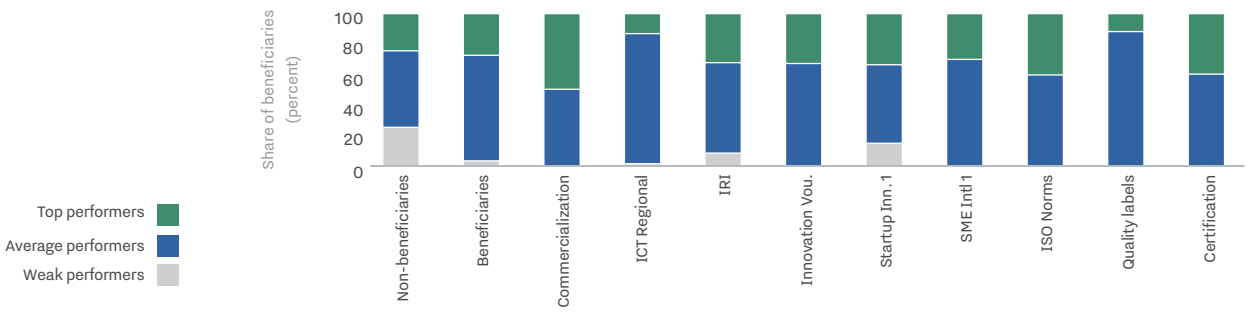
69 Ideally, only companies that are experiencing a market failure would be targeted. However, in practice, it is difficult to identify companies suffering from a market failure. Hence, proxies are used.

70 To ensure robustness of the results, company size and area of economic activity were controlled for because these two factors differentiate firms' performance the most. Nonetheless, the results of the exercise do not change the main findings of the analysis, which points to its robustness.

Top performers account for a good portion of the beneficiaries. Figure 6.58 shows that the programs with the highest share of top performers are *Commercialization, Certification* and *ISO Norms*. However, because the first two programs have small numbers of beneficiaries (18 and 15 respectively), this result may be biased. Programs with the largest share of average performers are Quality Labels (88 percent), *ICT Regional* (86 percent), *SME Intl 1* (70 percent) and *Innovation Vouchers* (67 percent). Weak performers account for only 3 percent of all participants, and six programs did not have any. *Startup Innovation 1* had the highest share of weak performers, but it was still less than 15 percent. As far as value is concerned, one third of the funding went to top performers, 56 percent to average performers and 12 percent to weak performers.

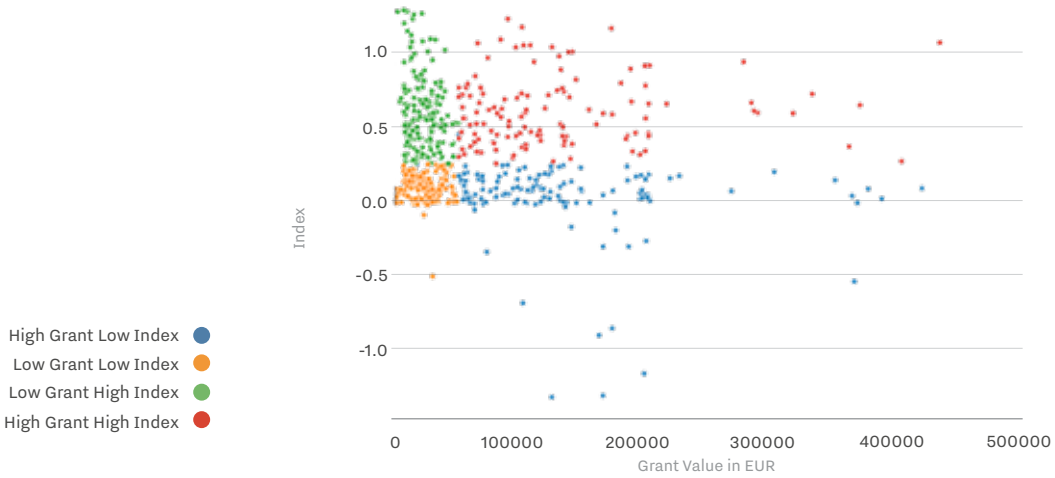
Better performing companies are not obtaining larger grants. There is no strong relation between value of a grant received and index. Figure 6.59 is divided into 4 color-coded quadrants. Cut-off points were median grant value (EUR 44,000) for the low/high grant division and median FFP index (0.18) for the low/high FFP index division. Each of the quadrants had around 25 percent of the beneficiaries. The dots are scattered in all four quadrants. For example, there are many high performing firms that receive large grants, but there are also many high performing firms that receive small grants. Consequently, no far-reaching inferences can be made about the relationship between grant value and the FFP index. The relationship is also weak in each of the programs with more than 20 beneficiaries.

FIGURE 6.58 *Top performers are well represented in all programs*



Source: Staff elaboration based on FINA.

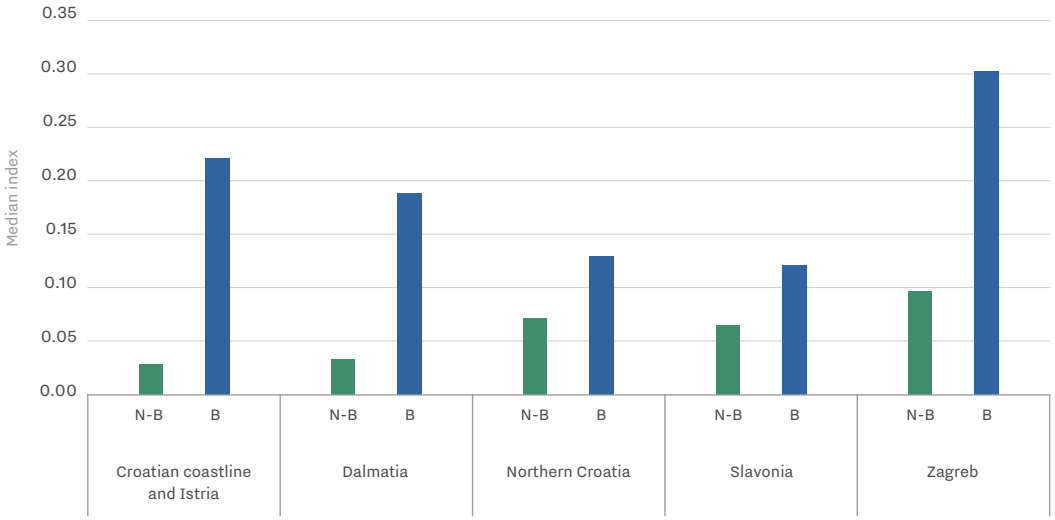
FIGURE 6.59 *There is no strong relationship between index and grant value*



Source: Staff elaboration based on FINA and beneficiary list.

The firms with the best financial performance are from the Zagreb region, and those with the worst financial performance are from the Croatian coastline & Istria and Dalmatia. Hence, the Zagreb region has the highest share of top performers among beneficiaries (Figure 6.60). Generally, beneficiaries perform better than non-beneficiaries in each region, but the discrepancy varies from region to region. The difference is negligible in Northern Croatia and substantial in Zagreb and the Croatian coastline & Istria. Some 84 percent of beneficiaries in Northern Croatia and 80 percent in Slavonia are average performers, whereas in Zagreb only 55 percent are average performers. The share of average performers in Dalmatia and the Croatian coastline & Istria is 71 percent and 75 percent correspondingly. Among beneficiaries in each region, fewer than 5 percent are weak performers.

FIGURE 6.60 *The best performing companies are from Zagreb and the Croatian coastline & Istria*



Source: Staff elaboration based on FINA.
Note: N-B = Non-Beneficiaries, B = Beneficiaries.

Programs with small budgets support better-performing companies more often than programs with large and medium-sized budgets. Programs were grouped by budget size with the goal of determining whether they support different kinds of companies. The large programs group contains only IRI, which at EUR 130 million has by far the largest budget. The medium programs group, which includes programs that have budget sizes from EUR 5 to 15 million, contains Commercialization, ICT Regional, Innovation Vouchers, Startup Innovation, and SME Intl 1. The small programs group, which includes programs with budgets smaller than EUR 5 million, contains ISO Norms, Quality labels, and Certification. The median FFP index value of small program beneficiaries is the highest (0.29), followed by large programs (0.18) and medium programs (0.16). Small-budget programs also have the highest share of high growth firms among their beneficiaries (16 percent). Medium-sized programs support low tech and LKIS companies more than small and large budget size programs. LT/LKIS companies usually perform worse than HT/KIS companies, which may explain why beneficiaries of medium-sized programs have the lowest index. Medium-sized programs have the highest share of young firms (i.e., firms established in 2015 or later). Small programs support micro and small companies almost exclusively. So do medium programs, but with a small share of medium enterprises. Large programs support every firm size, but predominantly small and medium enterprises.

BOX 6.5 Beneficiaries of World Bank programs

Participants in the World Bank programs were analyzed using the same methodology as the beneficiaries of the ESIF programs. The World Bank beneficiaries from the private sector were part of three programs: *Proof of Concept (PoC)*, *IRCRO* and *RAZUM*. Programs that targeted academic institutions are not analyzed here. The funding was distributed between 2012 and 2018. PoC financed 105 projects, *IRCRO* 18, and *RAZUM 6*.

World Bank programs mostly targeted start-ups, young companies and micro enterprises, so it is expected that World Bank beneficiaries would have lower FFP indices than ESIF beneficiaries. Beneficiaries of the ESIF programs are usually mature companies that can afford to undergo a demanding application process. The World Bank support schemes focus more on start-ups, that is, companies that are young and cannot cope well with burdensome application processes. These companies require a lot of handholding, and a program needs to be very flexible to reach them. For instance, the PoC program does not even require a company to be registered at the time of application.

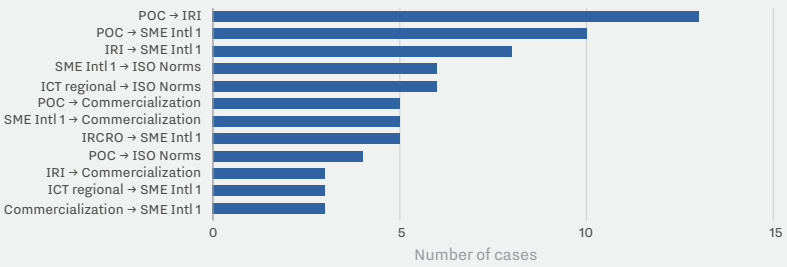
The ESIF programs (intentionally or unintentionally) target firms with better financial performance than the World Bank programs do. The 2017 firm-level data for most of the World Bank beneficiaries reflects the state of the firm a year *after* the funding was obtained and used. By contrast, for the ESIF beneficiaries it reflects the state of the firm *during* the first year when the grant was received. The World Bank beneficiaries have lower FFP indices than the ESIF beneficiaries despite receiving financial support. Therefore, the ESIF programs target financially stronger companies. As Table 6.2 shows, mean and median FFP indices for the ESIF beneficiaries are markedly higher. Interestingly, the dispersion of FFP index scores (as measured by standard deviation) is higher among the World Bank beneficiaries. Higher dispersion in FFP indices can be expected when firms in younger stages are supported (as is the case for the World Bank programs). PoC participants had the highest median FFP index, at 0.12, followed by participants of *RAZUM* (0.10) and *IRCRO* (0.08) which shows that the differences between World Bank programs in terms of beneficiaries' performance are negligible.

TABLE 6.2 *Descriptive statistics for the FFP index among WB and EU beneficiaries and non-beneficiaries*

	count	1Q	median	3Q	max	mean	min	std
N-B	118,381	-0.30	0.07	0.44	1.36	0.00	-2.43	0.68
WB	119	-0.01	0.11	0.51	1.09	0.15	-2.27	0.51
EU	649	0.01	0.18	0.48	1.18	0.25	-1.35	0.34

Source: Staff elaboration.
Note: 1Q means 1st quartile, 3Q means 3rd quartile. N-B are non-beneficiaries. WB are beneficiaries of World Bank programs. EU are beneficiaries of ESIF.

FIGURE 6.61 *There is no strong relationship between index and grant value*



Note: Only progressions more frequent than 2 were included.

BOX 6.5
(continued)

The World Bank programs have contributed to the pipeline of innovation projects. Participation in World Bank programs often led to participation in ESIF programs. A total of 33 companies participated in ESIF programs after receiving grants from *PoC*, which is one third of all the *PoC* beneficiaries analyzed. The most popular type of progression across programs was starting with *Proof of Concept* and advancing to *IRI* which happened with 13 companies (see Figure 6.61).[71] Eight companies (45 percent of all IRCRO beneficiaries) progressed from *IRCRO* to ESIF programs. Furthermore, three of six *RAZUM* beneficiaries subsequently participated in ESIF programs. Counting only the ESIF programs, the most frequent progression was from *IRI* to *SME Intl 1* (eight instances).

71 Progression is defined as participating in one program and later participating in a different one. If company X participated in programs A, B and C (in this order in time) than it is counted that the company did 3 progressions (A to B, B to C, A to C).

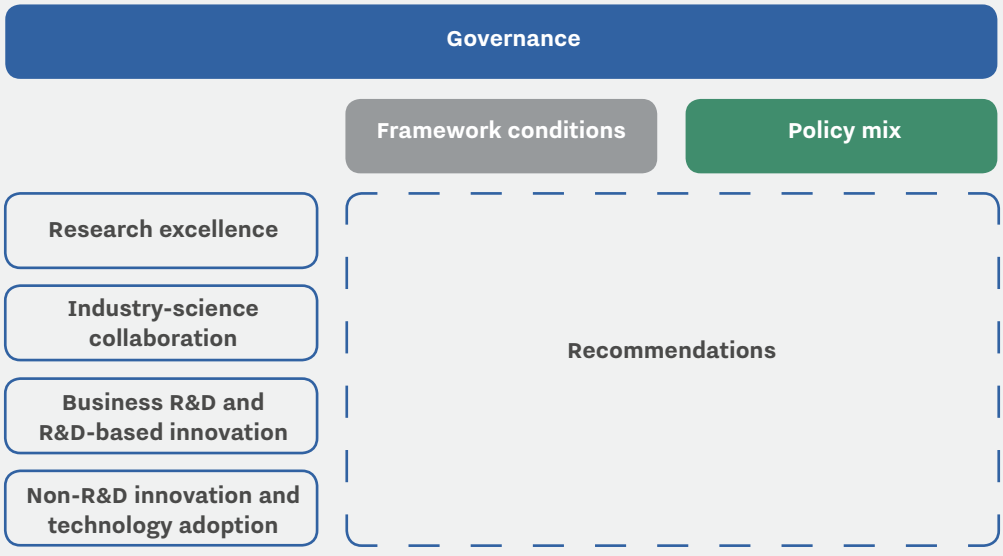
PART THREE
RECOMMENDATIONS

7 RECOMMENDATIONS

The recommendations in this section are guided by the analytical framework documented in previous World Bank reports. The *Guidance Note on Public Expenditure Review in Science, Technology and Innovation* (Correa, 2014) provides the overall framework for assessing the public spending in STI. It discusses four intermediary outcomes: (i) research excellence, (ii) science-industry collaboration transfer, (iii) business R&D and knowledge-based start-ups, and (iv) non-R&D business innovation and technology adoption. In the context of this first report under the Croatia PER in STI, these outcomes are analyzed through three perspectives: (i) governance, (ii) policy mix, and (iii) framework conditions (Figure 7.1). *The Innovation Paradox* (Cirera and Maloney, 2017) takes a deep dive into some of these elements and complements the thinking about the policy mix by providing the so-called *Capabilities Escalator* (Figure 7.2). Based on the findings of the *Needs Assessment* and the *Policy Mix*, Croatia is moving to stage 2, and the question is how Croatia can improve its policy mix to address the needs of a maturing National Innovation System (NIS). Lastly, the recommendations are aligned with the recent work conducted under the Croatia National Development Strategy Policy Note 2030: Growth, Competitiveness and Innovation (Correa, Milchevski, et al. 2019).

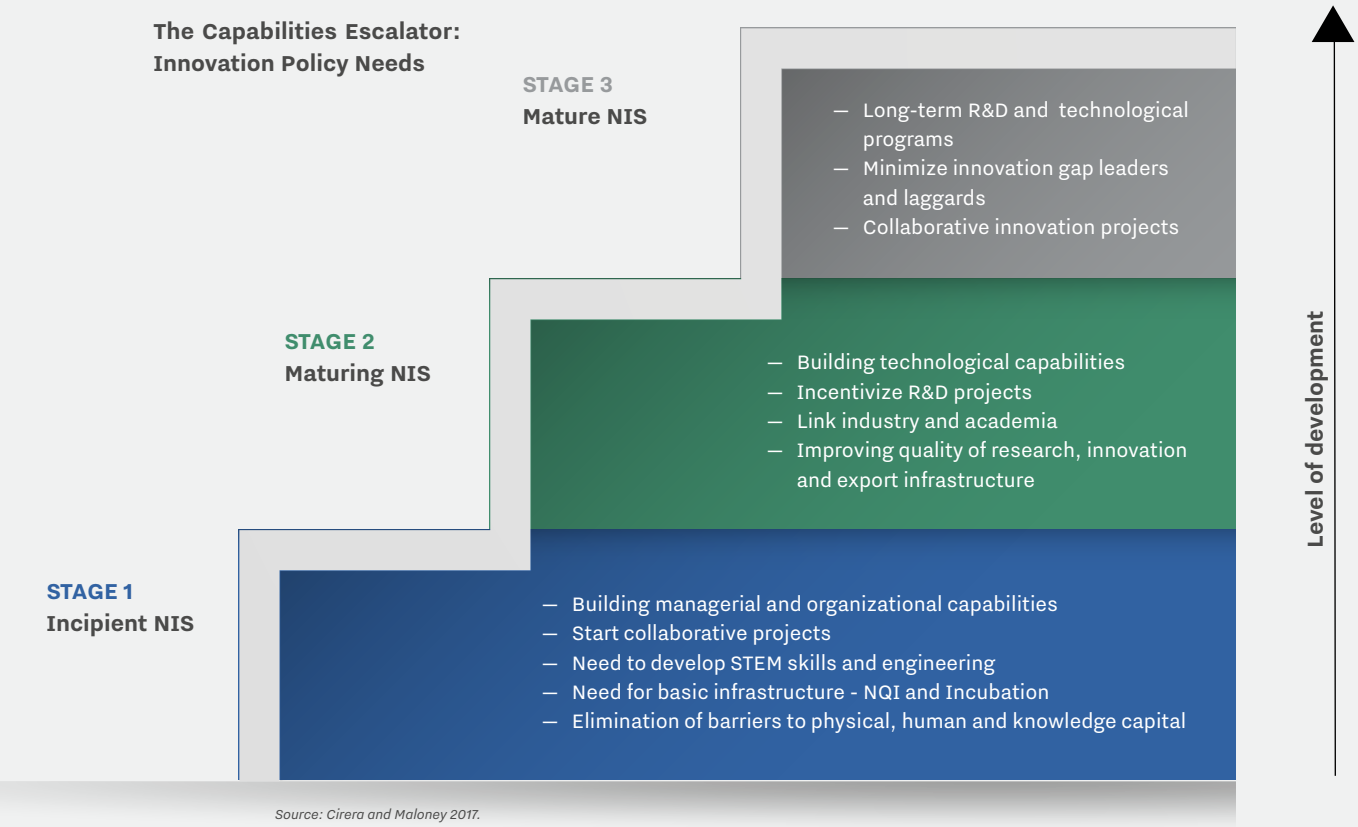
The recommendations are kept short to highlight the main points. Before each recommendation, there is a brief explanation of the problem. One should refer to the respective parts of the analyses in the *Needs Assessment* and the *Policy Mix* for further details. Such granularity is not provided in this section to avoid repetition and ensure the focus remains on the main points.

FIGURE 7.1 *Framework for recommendations*



Source: Staff elaboration.

FIGURE 7.2 *Framework for assessing innovation policy needs*



Source: Cirera and Maloney 2017.
Note: NQI stands for National Quality Infrastructure.

7.1 STI Policy Governance

Advancing the development of the NIS requires high-level reforms to STI policy governance

Framework Conditions

PROBLEM

STI policymaking and financing are not sufficiently coordinated. Many institutions are involved in the process, which makes it challenging to have a complete view of the system and coordinate actions.

Recommendation 1
Priority: Short term
Use the existing interministerial National Innovation Council (NIC) as a platform for different line ministries to consult with MSE and MEEC (as lead institutions for STI policy) on any sectoral STI financing initiatives. The NIC should provide an avenue for regular, structured discussions and coordination between different line ministries on long-term and short-term plans for STI support and financing.

PROBLEM

The current division of the STI agenda does not maximize the expertise of institutions in different stages of the RDI cycle. The division of the STI agenda by beneficiaries (public vs. private), rather than core functions and natural competences (research vs. commercialization) has led to gaps in the policy mix. This primarily refers to places where the private and public sector agendas should converge.

Recommendation 2
Priority: Short term
Divide the responsibility for the STI agenda along RDI lifecycle stages rather than by final beneficiary. This division can make the most of the knowledge accumulated in the MSE to support earlier stages of R&D and in the MEEC to support activities that are closer to the market.

PROBLEM

The governance of ESIF programs is burdensome, involving three institutions (in some cases even more) to design and implement a program. The roles are not divided in the same way for all programs. The extent to which different entities participate in the design and evaluation of certain programs varies. This creates problems in the feedback mechanism for conveying experiences from the field, the time it takes to conduct evaluations, the quality and efficiency of programs from the implementation perspective, and other aspects of program management.

Recommendation 3
Priority: Short term
Streamline the process of program design and implementation to minimize administrative burdens and delays. There are a number of procedures that make evaluation, public procurement, and so on very difficult (fees for evaluators, use of international evaluators, etc.). They need to be reviewed. The more institutions that are involved, the greater the need for coordination. If the number of institutions that participate in the process cannot be reduced, Croatia at least needs to ensure that the capacities of the various institutions are at the appropriate level. (See Recommendation 4 for a new innovation agency).

PROBLEM

The STI system is overly fragmented. Besides having multiple agencies at different levels, the bulk of innovation financing is implemented mainly by MSE and MEEC, on the ministerial level, and through two implementing agencies (HAMAG-BICRO and CFCA). There is no institution below the level of ministries specialized for innovation where the two agendas meet.

Recommendation 4
Priority: Medium term
Establish a dedicated innovation agency as a vehicle for MSE and MEEC to implement STI policy. The agency needs to have a clear mission to support policy coordination, design, monitoring and evaluation. MSE and MEEC have different mandates, and having a single innovation agency serving the ministries, alongside measures to improve interinstitutional coordination, would contribute to coordination of the policy mix. With its innovation expertise and focused mandate, the agency could contribute to improving the design and implementation of support programs and reduce transaction costs for beneficiaries.[72] In addition, the innovation agency could take the responsibility for smaller, targeted, programs where certain ideas to support innovation can be tested. Part of it may even serve as the IB2 body for some of the ESIF funding. Although this is a purely administrative task, having specialists in innovation do it would ensure that it is done well and help avoid unnecessary burdens on beneficiaries during implementation.

72 World Bank Group (2019) suggests seven building blocks to position innovation agencies for success: (i) a clear and adaptable mission; (ii) capable staff; (iii) effective governance and management structures; (iv) diagnostic-based interventions; (v) robust monitoring and evaluation (M&E); (vi) sustainable funding; and (vii) strategic partnerships and networks.

7.2 Enhancing Research Capabilities and Directing Them toward the Needs of the Economy

The research sector in Croatia should make more progress toward research excellence by fostering the quality of research outputs

Framework Conditions

PROBLEM

The research sector is highly fragmented, which leads to difficulties in coordination and limits the ability to design incentives for research excellence, collaboration and internationalization. The outdated public research and funding model has resulted in inefficient resource management with limited accountability.

Recommendation 5
Priority: Medium term
Improve the governance of public research organizations by integrating public universities and reinforcing accountability policies. Streamline the institutional landscape by consolidating public research institutes. Some institutes have very few scientists and operate in overlapping fields. The consolidation of institutes should be based on rigorous analysis by international experts complemented by the results of funding through funding agreements for institutes.

PROBLEM

The current structure of performance-based financing provides limited financial incentives for institutions to foster excellent science. Performance-based financing is a very small share of funding in PROs compared to funding for salaries and operating costs.

Recommendation 6
Priority: Medium term
Increase the performance-based component for research activities and create a bonus framework for researchers who produce high-quality outputs. The performance-based portion of funding should be used to incentivize the work of top researchers.

PROBLEM

Career advancement criteria and remuneration of researchers do not sufficiently reward excellent science. Criteria for career advancement favor quantity over quality of research, and there are no bonuses for outstanding research performance.

Recommendation 7
Priority: Medium term
Revise the career advancement framework to reflect the greater importance of publication quality over quantity and provide incentives for inter-institutional and international collaboration. Introduce bonuses for researchers that produce high-quality research.

Policy Mix

PROBLEM

The research sector produces the most uncited publications per researcher in Europe, but publications that are products of collaboration, especially international collaboration, tend to get cited more. At the same time, participation in Horizon 2020, an important avenue for international collaboration, has declined.

Recommendation 8
Priority: Short term
Increase grant support for international collaboration and researcher mobility (both outward and inward). Continue funding for successful international collaboration programs under the UKF. Introduce programs to foster the pipeline of Horizon 2020 applications.

PROBLEM National funding for R&D projects has halved, having been replaced with EU funds. However, these funds are not equivalent in terms of flexibility and administrative burden.

Recommendation 9
Priority: Medium term
The trend of declining national funding for R&D projects should be reversed. The funding may be used to finance projects that require a greater degree of flexibility (e.g., proof of concept). National funds could also be used to complement ESIF funded programs, such as building up the pipeline of applications for ESIF funding, or facilitate procedures within ESIF-funded programs (e.g., by funding experts for substantive project evaluation).

PROBLEM The significant investments in public research infrastructure cannot be standalone activities and require complementary actions.

Recommendation 10
Priority: Medium term
Enact a clear policy and guidance for wider use of the publicly funded research infrastructure. Conduct activities to prepare research institutions for contract research.

PROBLEM In the current academic system, new research positions at PROs are permanent. There is no rigorous screening process for the development of the researcher or accountability for the quality of work.

Recommendation 11
Priority: Medium term
Introduce a tenure-track program with a probationary period to pursue high quality research.

The link between the research sector and the industry should be strengthened

Framework Conditions

PROBLEM The public research sector rarely brings its research to commercialization and rarely transforms new knowledge into intellectual property. The legal framework for commercializing research in PROs and its intellectual property implications are unclear, discouraging researchers from pursuing projects with market potential.

Recommendation 12
Priority: Short term
Clarify the framework for commercialization and use of intellectual property developed within PROs.

PROBLEM Public research organizations do not have an established culture of technology transfer and transforming knowledge into intellectual property. Such culture is not reflected in the strategic direction and leadership of HEIs. In addition, the career advancement framework provides no incentive for researchers to pursue research that would promote innovation, collaborate with the private sector, or engage in technology transfer.

Recommendation 13
Priority: Medium term
The orientation toward market needs should be championed by the top management of HEIs, formalized through statutory and strategic documents, and reflected in the career advancement framework and financial incentives for researchers. Spin offs should be encouraged by various means (allowing researchers to take time off to pursue commercialization, providing financial support to pursue commercialization, etc.).

Policy Mix

PROBLEM

There is a gap in financing technology transfer and prototyping activities in public research organizations. Resources in TTOs, both human and financial, are too limited to cover the costs of patent filing. Lack of incentives for researchers are also an issue.

Recommendation 14
Priority: Short term
Introduce a mechanism of institutional financing of technology transfer offices in public research organizations that will allow for sustainable and long-term funding for regular staff and IPR management. This would bring additional value to technology transfer offices in HEIs, while any additional activities could be complemented by support programs (such as SIIF) on a project basis.

PROBLEM

The current policy mix provides roughly equal financing for basic, applied and experimental research, while countries with better innovation performance finance predominantly applied research and experimental development. In Croatia, the balance is likely tipped even more in favor of basic research by institutional funding in HEIs, which are not oriented toward commercialization of research results (as reflected in a low level of patents compared to the number of scientific publications). As such, current investments in applied research and experimental development are insufficient for technology transfer to occur.

Recommendation 15
Priority: Medium term
Allocate more funding toward applied research and experimental development and improve the targeting of support programs that cover all three stages.

The private sector should invest more in R&D to reach Croatia's growth, productivity and development targets

Framework conditions

PROBLEM

Most support programs for R&D are restricted to entities registered in the Registry of Research Organizations, which excludes many private firms that perform R&D but do not meet accreditation requirements for access to the registry. The accreditation process imposes high barriers for R&D-performing firms to access the registry, which includes a strategic research program, infrastructure requirements, and at least three research staff with PhD degrees. This prevents R&D-performing firms from accessing R&D funding.

Recommendation 16
Priority: Short term
Streamline the requirements for accreditation to the Registry of Research Organizations to allow R&D-performing firms to participate in programs funding R&D.

Policy Mix

PROBLEM

Support for business R&D is going to larger and more mature companies, while productivity gains from R&D investments are highest in smaller and younger firms. In the largest program providing support for business R&D, 82 percent of funding went to firms established in 2010 or earlier. Programs that support R&D in large firms also support smaller firms, which makes targeting and tailoring more difficult.

Recommendation 17
Priority: Short term
Provide more targeted funding to smaller and younger firms in knowledge-intensive sectors. Ensure that the application process is extremely simple and does not require a lot of resources. At the same time, design soft support programs and interventions to motivate smaller and younger firms to invest in R&D.

PROBLEM

Programs for R&D-based innovation are implicitly biased toward projects that are close to commercialization, while the innovation pipeline is underserved. This is mainly due to the lack of targeting in some programs that finance R&D innovation. As a result, the selection process ends up being biased toward the commercialization phase. R&D by definition has a high risk and requires acceptance of failure, which is difficult in a program that requests commercialization as a result.

Recommendation 18
Priority: Short term
Provide tailored and targeted funding for R&D stages between research and commercialization. More focused, more targeted programs would help to tailor the program elements in accordance to the program objective.

PROBLEM

The voucher mechanism to support business R&D and R&D-based innovation is ineffectual, as evidenced by low take-up. At the same time, the voucher program imposes restrictions on eligible R&D service providers, which must be entities from the Registry of Scientific Organizations (see Recommendation 16). Firms are therefore restricted in the partner they may use and may not be able to find partners with the appropriate expertise in the Registry.

Recommendation 19
Priority: Short term
Vouchers that support business R&D should allow collaboration with entities outside the Registry of Scientific Organizations, provided that they have the appropriate knowledge and competences. As this is a support of low financial value, it should be more flexible and accessible.

PROBLEM

There is an overreliance on *de minimis* aid in RDI support programs. This type of support has a relatively low cumulative cap (EUR 200,000), limiting the ability of support programs to follow an idea through to all its research and development stages.

Recommendation 20
Priority: Short term
The policy mix should feature sufficient funding to bring an idea through all stages of research, development, and commercialization. When planning the mix of programs, keep in mind the funding limitation of *de minimis* aid, and avoid using it if another type of state aid is available for a particular activity.

PROBLEM There is very little focus on skills in innovation financing because the ESF portion to innovation financing is very small.

Recommendation 21
Priority: Medium term
Increase innovation financing through ESF, with a focus on increasing human capital for research and innovation. This may be in the form of various support programs to researchers or training activities for business innovation.

7.3 Fostering Innovation

Increase the ability of innovative firms to enter the market and gain market share by improving conditions for market entry and exit and reducing the restrictiveness of product and service market regulations

Framework conditions

PROBLEM Burdensome procedures to start and operate a business discourage entrepreneurs from entering the market. Croatia still ranks poorly on starting a business compared to other countries, with longer and more costly procedures than the CESEE and OECD averages.

Recommendation 22
Priority: Short term
Implement business registration reform to streamline starting a business by introducing interoperability among different institutions involved in the registration process. In parallel, streamline licensing requirements to operate in specific sectors.

PROBLEM Overly regulated product and service markets drag on the resources of newly established businesses. Starting a business requires dealing with lawyers, notaries and so on, which are highly regulated and hence costly. This increases the cost of starting a business and reduces either the enthusiasm to become an entrepreneur or the level of investment the entrepreneur can put into the core business.

Recommendation 23
Priority: Short term
Reduce regulatory burdens in regulated professions relevant for business operations. Because there are over 300 regulated professions in Croatia, their review and deregulation should be done in batches spread out over time, and prioritized based on relevance for the economy, restrictiveness of requirements, and reform momentum.

PROBLEM Firm exit and re-entry is hampered by an extended and costly insolvency procedure. Croatia has a relatively inefficient insolvency framework, with worsening performance. This impairs the efficient reallocation of resources in the economy and makes entrepreneurs more risk averse because market re-entry after a failed business idea is slow and costly.

Recommendation 24
Priority: Medium term
Measures to reduce the time necessary for processing insolvency cases should be aimed at strengthening the quality of insolvency practitioners. Over the long term, it is necessary to revisit the insolvency framework to address structural deficiencies in the legislation, as well as facilitate voluntary liquidation.

Increase the variety of innovation support instruments, including early-stage financing and lending

Framework conditions

PROBLEM

The legal framework for the establishment and operation of venture capital funds is overly burdensome. The legal framework discourages the establishment of investment vehicles for early-stage financing in Croatia due to adverse tax implications and burdensome corporate governance requirements. Existing funds are more on the private equity end of the spectrum, investing mainly in mature, medium-sized firms rather than start-ups.

Recommendation 25
Priority: Short term
Amend the legislation regarding establishment of alternative investment funds to reduce tax and operational burdens for venture capital funds. In particular, it is necessary to improve the alignment of the legal framework with the EU Directive on Alternative Investment Fund Managers with respect to reducing regulatory burdens imposed on smaller funds and fund managers and relaxing corporate governance requirements. At the same time, it is necessary to strengthen licensing requirements in line with international best practices (fit and proper requirements).

Policy Mix

PROBLEM

The policy mix relies heavily on grants as a form of support, regardless of the purpose of the intervention or the targeted beneficiaries. Grant support is available to SMEs and large firms alike, sometimes within the same program. Consequently, grant support could be crowding out other forms of financing. At the same time, access to finance is lacking in Croatia, entailing high costs, especially for SMEs and younger firms that have little to no access to collateral. There is a lack of appropriate financing mechanisms dedicated to innovation that would improve access to finance (such as equity, convertible loans and loan guarantees).

Recommendation 26
Priority: Short term
Improve the link between innovation market failures and appropriate policy instruments. Provide more lending and loan guarantees for innovation, tailoring financing mechanisms to different stages of the innovation cycle and beneficiary type.

PROBLEM

There is very little support in the form of investment readiness programs. The investment readiness of start-ups could be improved as entrepreneurs might be reluctant to surrender partial ownership in the firm, and might have internal deficiencies that prevent them from attracting high-profile investors.

Recommendation 27
Priority: Short term
Introducing programs to provide soft support for investment readiness in start-ups would facilitate business angel and venture capital equity investments. The programs may include skills building courses in financial planning, marketing and pitching.

Financial support for non-R&D innovation should be more targeted; business support infrastructure should be complemented by soft support

Policy Mix

PROBLEM

There are significant investments in business support infrastructure (business incubators and similar facilities) that do not always incorporate soft support. Support for services by BSOs came quite late (in July 2019), as a follow-up to an earlier program launched in 2016 that financed only infrastructure. Focus has been much more on infrastructure than on the services that should be provided by the BSOs. Management of these organizations lack the skills needed to run the infrastructure effectively and make the most of it.

Recommendation 28
Priority: Short term
Programs should tie investments in business support infrastructure with appropriate business support and development services. This would help business infrastructure achieve its mission more effectively. It is important to ensure that the management has sufficient capacity to provide the knowledge support necessary to assist new entrepreneurs.

PROBLEM

There is a need to improve management practices in Croatian SMEs, especially when it comes to performance monitoring. A significant portion of SMEs are family-managed firms whose management practices lag behind those of professionally run firms. Firms with better management practices are more likely to innovate. At the same time, the policy mix features a significant number of programs supporting non-R&D innovation and technology adoption, but there is no targeted support for improving managerial practices.

Recommendation 29
Priority: Short term
Provide financing to improve the managerial practices of firms. Such a program should take into account that managers often overestimate their capabilities and may not be able to make objective assessments of the necessary improvements. Therefore, any program to support managerial practices should incorporate an external diagnostic exercise to identify priorities for intervention. The program should also be structured to provide incentives for participants to commit the time and effort to follow through with the necessary changes.

7.4 Summary of Policy Recommendations

Theme	Objective	Area of intervention	Recommendation	Priority
STI Policy Governance	Advancing the development of the NIS requires high-level reforms to STI policy governance	Framework conditions	**Recommendation 1** Use the existing interministerial National Innovation Council (NIC) as a platform for different line ministries to consult with MSE and MEEC (as lead institutions for STI policy) on any sectoral STI financing initiatives. The NIC should provide an avenue for regular, structured discussions and coordination between different line ministries on long-term and short-term plans for STI support and financing.	**Short term**
			Recommendation 2 Divide the responsibility for the STI agenda along RDI lifecycle stages rather than by final beneficiary. This division can make the most of the knowledge accumulated in the MSE to support earlier stages of R&D and in the MEEC to support activities that are closer to the market.	**Short term**
			Recommendation 3 Streamline the process of program design and implementation to minimize administrative burdens and delays. There are a number of procedures that make evaluation, public procurement, and so on very difficult (fees for evaluators, use of international evaluators, etc.). They need to be reviewed. The more institutions that are involved, the greater the need for coordination. If the number of institutions that participate in the process cannot be reduced, Croatia at least needs to ensure that the capacities of the various institutions are at the appropriate level. (See Recommendation 4 for a new innovation agency).	**Short term**
			Recommendation 4 Establish a dedicated innovation agency as a vehicle for MSE and MEEC to implement STI policy. The agency needs to have a clear mission to support policy coordination, design, monitoring and evaluation. MSE and MEEC have different mandates, and having a single innovation agency serving the ministries, alongside measures to improve interinstitutional coordination, would contribute to coordination of the policy mix. With its innovation expertise and focused mandate, the agency could contribute to improving the design and implementation of support programs and reduce transaction costs for beneficiaries. In addition, the innovation agency could take the responsibility for smaller, targeted, programs where certain ideas to support innovation can be tested. Part of it may even serve as the IB2 body for some of the ESIF funding.	**Medium term**

Theme	Objective	Area of intervention	Recommendation	Priority
			Although this is a purely administrative task, having specialists in innovation do it would ensure that it is done well and help avoid unnecessary burdens on beneficiaries during implementation.	
Enhancing Research Capabilities and Directing Them toward the Needs of the Economy	The research sector in Croatia should make more progress toward research excellence by fostering the quality of research outputs	Framework conditions	**Recommendation 5** Improve the governance of public research organizations by integrating public universities and reinforcing accountability policies. Streamline the institutional landscape by consolidating public research institutes. Some institutes have very few scientists and operate in overlapping fields. The consolidation of institutes should be based on rigorous analysis by international experts complemented by the results of funding through funding agreements for institutes.	**Medium term**
			Recommendation 6 Increase the performance-based component for research activities and create a bonus framework for researchers who produce high-quality outputs. The performance-based portion of funding should be used to incentivize the work of top researchers.	**Medium term**
			Recommendation 7 Revise the career advancement framework to reflect the greater importance of publication quality over quantity and provide incentives for inter-institutional and international collaboration. Introduce bonuses for researchers that produce high-quality research.	**Medium term**
		Policy Mix	**Recommendation 8** Increase grant support for international collaboration and researcher mobility (both outward and inward). Continue funding for successful international collaboration programs under the UKF. Introduce programs to foster the pipeline of Horizon 2020 applications.	**Short term**
			Recommendation 9 The trend of declining national funding for R&D projects should be reversed. The funding may be used to finance projects that require a greater degree of flexibility (e.g., proof of concept). National funds could also be used to complement ESIF funded programs, such as building up the pipeline of applications for ESIF funding, or facilitate procedures within ESIF- funded programs (e.g., by funding experts for substantive project evaluation).	**Medium term**
			Recommendation 10 Enact a clear policy and guidance for wider use of the publicly funded research infrastructure. Conduct activities to prepare research institutions for contract research.	**Medium term**

Theme	Objective	Area of intervention	Recommendation	Priority
			Recommendation 11 Introduce a tenure-track program with a probationary period to pursue high quality research.	**Medium term**
Enhancing Research Capabilities and Directing Them toward the Needs of the Economy (continued)	The link between the research sector and the industry should be strengthened	Framework conditions	**Recommendation 12** Clarify the framework for commercialization and use of intellectual property developed within PROs.	**Short term**
			Recommendation 13 The orientation toward market needs should be championed by the top management of HEIs, formalized through statutory and strategic documents, and reflected in the career advancement framework and financial incentives for researchers. Spin offs should be encouraged by various means (allowing researchers to take time off to pursue commercialization, providing financial support to pursue commercialization, etc.).	**Medium term**
		Policy Mix	**Recommendation 14** Introduce a mechanism of institutional financing of technology transfer offices in public research organizations that will allow for sustainable and long-term funding for regular staff and IPR management. This would bring additional value to technology transfer offices in HEIs, while any additional activities could be complemented by support programs (such as SIIF) on a project basis.	**Short term**
			Recommendation 15 Allocate more funding toward applied research and experimental development and improve the targeting of support programs that cover all three stages.	**Medium term**
Enhancing Research Capabilities and Directing Them toward the Needs of the Economy (continued)	The private sector should invest more in R&D to reach Croatia's growth, productivity and development targets	Framework Conditions	**Recommendation 16** Streamline the requirements for accreditation to the Registry of Research Organizations to allow R&D-performing firms to participate in programs funding R&D.	**Short term**
		Policy Mix	**Recommendation 17** Provide more targeted funding to smaller and younger firms in knowledge-intensive sectors. Ensure that the application process is extremely simple and does not require a lot of resources. At the same time, design soft support programs and interventions to motivate smaller and younger firms to invest in R&D.	**Short term**
			Recommendation 18 Provide tailored and targeted funding for R&D stages between research and commercialization. More focused, more targeted programs would help to tailor the program elements in accordance to the program objective.	**Short term**

Theme	Objective	Area of intervention	Recommendation	Priority
			Recommendation 19 Vouchers that support business R&D should allow collaboration with entities outside the Registry of Scientific Organizations, provided that they have the appropriate knowledge and competences. As this is a support of low financial value, it should be more flexible and accessible.	**Short term**
			Recommendation 20 The policy mix should feature sufficient funding to bring an idea through all stages of research, development, and commercialization. When planning the mix of programs, keep in mind the funding limitation of de minimis aid, and avoid using it if another type of state aid is available for a particular activity.	**Short term**
			Recommendation 21 Increase innovation financing through ESF, with a focus on increasing human capital for research and innovation. This may be in the form of various support programs to researchers or training activities for business innovation.	**Medium term**
Fostering Innovation	Increase the ability of innovative firms to enter the market and gain market share by improving conditions for market entry and exit and reducing the restrictiveness of product and service market regulations	Framework Conditions	**Recommendation 22** Implement business registration reform to streamline starting a business by introducing interoperability among different institutions involved in the registration process. In parallel, streamline licensing requirements to operate in specific sectors.	**Short term**
			Recommendation 23 Reduce regulatory burdens in regulated professions relevant for business operations. Because there are over 300 regulated professions in Croatia, their review and deregulation should be done in batches spread out over time, and prioritized based on relevance for the economy, restrictiveness of requirements, and reform momentum.	**Short term**
			Recommendation 24 Measures to reduce the time necessary for processing insolvency cases should be aimed at strengthening the quality of insolvency practitioners. Over the long term, it is necessary to revisit the insolvency framework to address structural deficiencies in the legislation, as well as facilitate voluntary liquidation.	**Medium term**

Theme	Objective	Area of intervention	Recommendation	Priority
Fostering Innovation (continued)	Increase the variety of innovation support instruments, including early-stage financing and lending	Framework conditions	**Recommendation 25** Amend the legislation regarding establishment of alternative investment funds to reduce tax and operational burdens for venture capital funds. In particular, it is necessary to improve the alignment of the legal framework with the EU Directive on Alternative Investment Fund Managers with respect to reducing regulatory burdens imposed on smaller funds and fund managers and relaxing corporate governance requirements. At the same time, it is necessary to strengthen licensing requirements in line with international best practices (fit and proper requirements).	**Short term**
		Policy Mix	**Recommendation 26** Improve the link between innovation market failures (lack of access to finance) and appropriate policy instruments. Provide more lending and loan guarantees for innovation, tailoring financing mechanisms to different stages of the innovation cycle and beneficiary type.	**Short term**
			Recommendation 27 Introducing programs to provide soft support for investment readiness in start-ups would facilitate business angel and venture capital equity investments. The programs may include skills building courses in financial planning, marketing and pitching.	**Short term**
	Financial support for non-R&D innovation should be more targeted; business support infrastructure should be complemented by soft support	Policy Mix	**Recommendation 28** Programs should tie investments in business support infrastructure with appropriate business support and development services. This would help business infrastructure achieve its mission more effectively. It is important to ensure that the management has sufficient capacity to provide the knowledge support necessary to assist new entrepreneurs.	**Short term**
			Recommendation 29 Provide financing to improve the managerial practices of firms. Such a program should take into account that managers often overestimate their capabilities and may not be able to make objective assessments of the necessary improvements. Therefore, any program to support managerial practices should incorporate an external diagnostic exercise to identify priorities for intervention. The program should also be structured to provide incentives for participants to commit the time and effort to follow through with the necessary changes.	**Short term**

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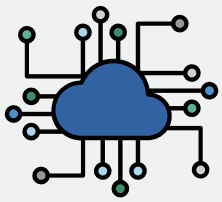
APPENDICES

APPENDICES

I. Survey on Firm-level Productivity



- To understand better the low productivity and performance of Croatian firms, the World Bank surveyed firm capabilities and collected data from 727 companies in five regions and four sectors of economy.
- High technology companies, exporters, companies that introduced any innovation and firms that invested in technical R&D tended to be more productive. These companies also registered more marks, patents and industrial designs, spent more on R&D and innovation projects and were more innovative.
- As the main obstacles to company growth, firms reported high taxes, excess government procedures, lack of credit, and the qualifications, availability and costs of the workforce.

To understand better the low productivity and performance of Croatian firms, the World Bank surveyed firm capabilities. Data collected from companies offers insights into managerial practices, technology adoption, innovation, human resource management, global value chains and access to finance. Between January and June 2019, 727 SMEs in manufacturing and services sectors were interviewed. The sample of interviewed companies is representative for five regions of Croatia and for four sectors of economy: knowledge-intensive services (KIS), less-knowledge-intensive services (LKIS), high technology manufacturing (high-tech), and low technology manufacturing (low-tech) Table I.1 provides details of the firms' regional and sectoral distribution. Box I.1 provides details on the method of sample selection and the interview process.

TABLE I.1 The sample of the survey is representative for five regions and four sectors

Number of firms	Croatian coast & Istria	Dalmatia	Northern	Slavonia	Zagreb	Total
KIS	37	32	57	41	39	**206**
LKIS	38	44	51	38	36	**207**
High technology manufacturing	17	4	32	17	31	**101**
Low technology manufacturing	37	43	43	49	41	**213**
TOTAL	**129**	**123**	**183**	**145**	**147**	**727**

Note: Medium-high technology companies are classified as high technology and medium-low technology as low technology.

BOX I.1 Methodology of sample selection and interview process

The Financial Agency (FINA)[73] database provides the sample frame for a random selection of a representative group of companies in five regions and four sectors. The study focused mostly on small- and medium-size companies, that is, those employing 10 to 249 employees in manufacturing and 6 to 249 employees in services (so micro service companies of 6 to 9 employees are also included).[74] Of 122,111 companies in the FINA database in 2017, 13,905 were included in the sample frame.

Following OECD and Eurostat definitions, companies were classified based on NACE codes into:
(i) **High-tech manufacturing** (high-tech), which includes also medium-high manufacturing (NACE codes: 20, 21, 26, 27, 28, 29, 30);
(ii) **Low-tech manufacturing** (low-tech), which includes also medium-low manufacturing (NACE codes: 10, 11, 13, 14, 16, 17, 18, 22, 23, 25, 31, 32, 33);
(iii) **Knowledge-intensive services** (KIS, NACE codes: 50, 58, 60, 61, 62, 63, 64, 66, 69, 70, 71, 72, 73, 74);
(iv) **Less-knowledge-intensive services** (LKIS, NACE codes: 45, 46, 47, 49, 52, 55, 56, 68, 79).

Counties in Croatia were mapped into five broad regions in the following way:
(i) **Zagreb:** Zagreb and city of Zagreb;
(ii) **Northern Croatia:** Krapina-Zagorje, Varaždin, Koprivnica-Križevci, Bjelovar-Bilogora, Međimurje, Sisak-Moslavina, Karlovac;
(iii) **Slavonia:** Virovitica-Podravina, Požega-Slavonia, Slavonski Brod-Posavina, Osijek-Baranja and Vukovar-Sirmium;
(iv) **Croatian coastline and Istria:** Lika-Senj, Primorje-Gorski kotar, Istria;
(v) **Dalmatia:** Zadar, Šibenik-Knin, Split-Dalmatia, Dubrovnik-Neretva.

A total of 4,807 firms were contacted, and 17 percent of contacted firms agreed to participate in the survey, which is a typical response rate for this type of survey. The average firm in the sample of 727 companies is similar in terms of employment and age to an average firm in the sample frame. However, it is highly likely that on average respondents' companies are better performing. Usually, better performing companies are more open to participation in surveys and easier to contact. Therefore, the results of this analysis are likely biased upwards. Where possible, we comment on the bias, comparing the survey sample to the population of companies of the same size in the FINA dataset.

The interviews were conducted in person, and an owner, CEO, director, or high-level manager was the respondent. The interviews usually lasted 45-60 minutes, and 60 questions were asked.

Source: Staff elaboration.

73 Financial Agency (FINA) is the leading Croatian provider of financial data services. The database comprises all tax registered firms in Croatia.

74 Gathering information on management practices of Croatian firms was one of the main purposes of the survey. This objective determined the lower and upper bounds for the number of employees because (i) structured management practices are usually not used in micro companies, (ii) large companies (of over 249 employees) tend to have multiple facilities, frequently with different management approaches. Grover et al (2019) provide detailed descriptions of management practices among Croatian firms and their consequences for firm performance.

Manufacturing companies in the sample employ more workers than service companies. Table I.2 presents the distribution of company size among four sectors of the economy. This distribution, to a large extent, reflects the distribution of a population of Croatian firms of the same size in the FINA dataset. Half of service companies in the sample employ 6 to 9 employees (micro companies) and less than 5 percent employ 50 to 250 (medium companies). Among manufacturing companies, 18 percent are medium-sized. The size distribution across sectors is important because larger companies are usually more innovative and productive. Hence, simple comparison of sectors will favor those with larger shares of medium-sized companies (such as high technology manufacturing). Young companies (that is, companies established in 2015–2017), account for 6 percent of the sample and are evenly distributed across sectors and regions. Some 90 percent of firms were established after 1989.

TABLE I.2 Distribution of companies by size and sector

Number of firms	KIS	LKIS	HIGH TECHNOLOGY	LOW TECHNOLOGY	TOTAL
Micro	112	94	-	-	**206**
Small	82	107	78	178	**445**
Medium	12	6	23	35	**76**
TOTAL	**206**	**207**	**101**	**213**	**727**

Source: Staff elaboration based on survey data.
Note: Companies are classified as micro when they employ 6-9 employees, small employ 10 to 49, and medium 50 to 249.

This section follows the structure of the *Needs Assessment* and complements it by providing a detailed picture of a set of SMEs in the manufacturing and service sectors using a unique dataset of 727 companies. First, we assess the performance of companies in the sample, that is, their productivity, innovativeness, exports and participation in global value chains. Second, we discuss gaps in the Croatian business environment as perceived by survey respondents. Third, we assess outputs and outcomes against firm-level inputs (investments and firm capabilities).

Some results and messages from the survey would differ from comprehensive analytics that took the entire system into account. This chapter presents findings only based on the survey and should be interpreted as such. The 727 firms that participated do not behave exactly the same as the whole population of firms would, due to these reasons: (i) only some micro firms were considered, those from the service sector and with over 6 employees; (ii) the results in this analysis are likely biased upwards; and (iii) not all NACE codes fall under the sectors in the survey, meaning there is a set of firms from the population that have not been considered.

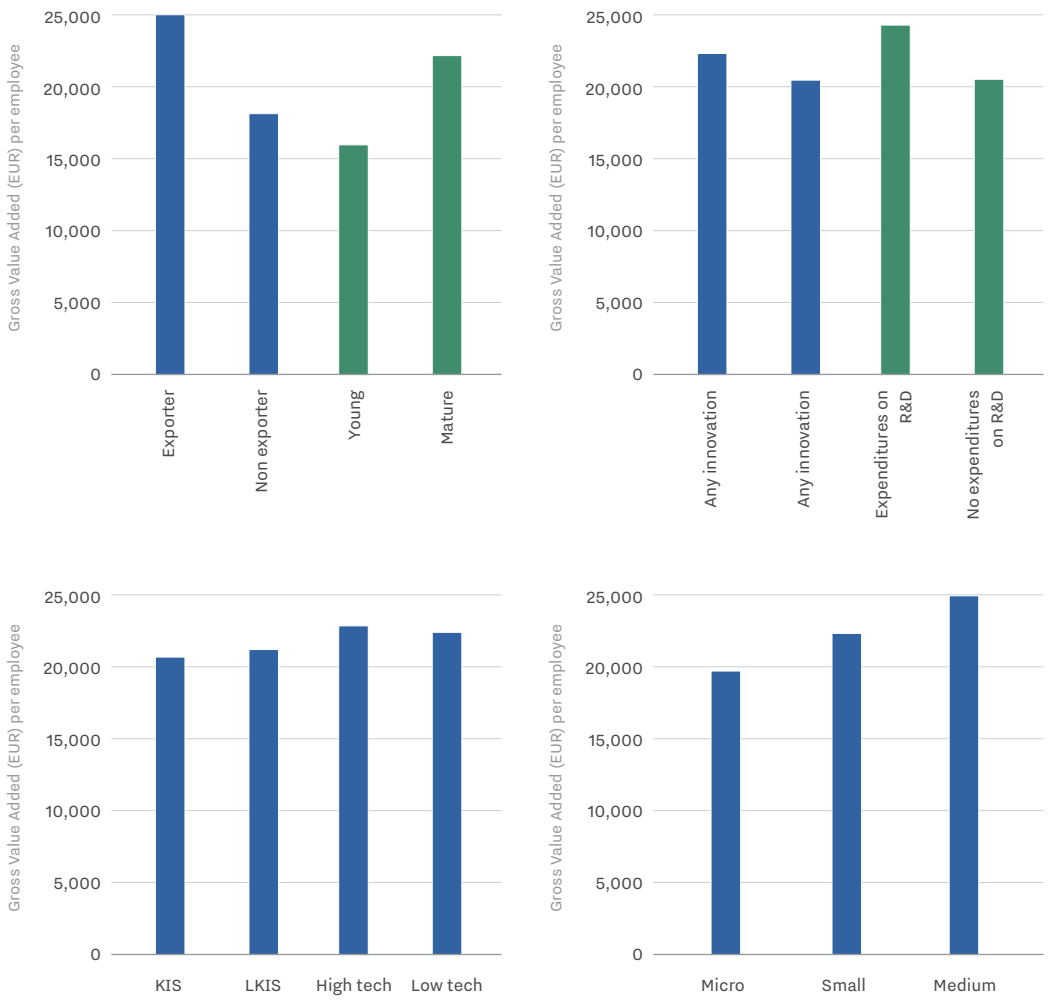
I.1 Observed Performance

Exporters, mature firms, companies that innovate[75] and firms that invest in technical R&D are more productive. Productivity is an important determinant of growth. From 2015 to 2017, productivity gains accounted for over half the growth in the Croatian economy. Among survey respondents (and contrary to the productivity analysis in the first part in this assessment), larger companies, exporters and companies that innovate tend to be more productive (Figure I.1). Additionally, in 2017, companies

75 That is, companies that introduced any innovation. Companies were asked to report product, process, organizational and marketing innovations that were introduced at the company level.

that introduced at least one innovation and firms that invested in R&D were more productive than those that did not. Surprisingly, there is no (statistically significant) difference in productivity between firms in the four sectors of the economy. Moreover, the larger the company, the more productive it is. This finding, while consistent with the global literature, conflicts with the results of a study that analyzed all companies in the FINA dataset and found an inverse pattern: large companies were less productive than medium-sized companies, and medium-sized firms were less productive than small and micro firms (Correa, Milchevski, et al. 2019). There are two plausible explanations. First, the sample of companies in the survey differs from the population. Second, different productivity measures were used – this study uses value added per employee, whereas the aforementioned study used TFP.

FIGURE I.1 *Mature firms, medium-sized firms and exporters are more productive than young companies, small and micro firms and non-exporters*

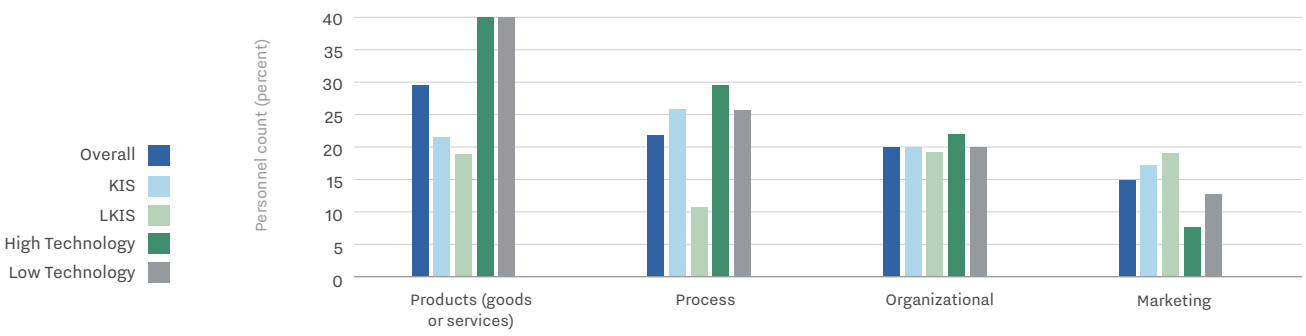


Source: Staff elaboration based on survey data and FINA.
Note: Productivity is measured as gross value added, that is, the difference between total income from sales and material costs, per employee (full-time equivalent). Firms with productivity levels above HRK 1 mln (EUR 130 000) per employee are considered outliers and were removed from the dataset.

Manufacturing firms are twice as likely as service firms to introduce product innovations and (except for LKIS firms) equally likely to introduce process innovations and organizational innovations. All surveyed companies were asked about products (goods or services), processes (including methods), organizational changes or approaches to marketing that were new or significantly improved in their company in 2017. As such, innovativeness in the survey is defined broadly and goes beyond invention (that is, creating new products or processes). It captures foremost innovation at the level of the company, and not at the level of the region or the economy. Manufacturing companies were twice as likely to introduce product innovation in 2017 as service companies (Figure I.2). LKIS firms were the least likely to improve existing processes or methods. Half of companies introduced no innovation, and the least likely to introduce innovation were LKIS and small companies. As expected, the bigger the company, the more likely it was to introduce innovation: 52 percent of small companies and 63 percent of medium companies did in 2017. Exporters were marginally more likely to adopt innovation as compared to non-exporters, but there was no difference between young and mature companies. As expected, companies that invested in R&D were substantially more likely to introduce innovation compared to companies that did not invest in R&D (71 percent vs 41 percent respectively), particularly for product and process innovations.

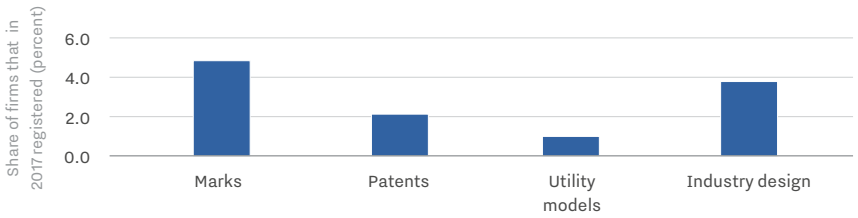
High technology companies, medium-sized companies and exporters more frequently registered marks, patents and industrial designs. Utility models were least frequently registered, and marks most frequently in 2017 (Figure I.3). High technology companies were the most likely to register marks and patents, and LKIS firms the least likely. As expected, manufacturing companies were responsible for more industry designs than service companies. Medium-sized companies and exporters were more likely to register a mark, patent, utility model (except for exporters) or industrial design compared to small and medium companies and to non-exporters, respectively. There was no difference between young and mature companies.

FIGURE I.2 *LKIS companies are the least innovative and high technology the most innovative firms in 3 out of 4 categories*



Source: Staff elaboration based on survey data.
Note: Bars show the share of companies of a given type that introduced this type of innovation at the company level in 2017.

FIGURE I.3 *Marks and industry designs were most frequently registered*

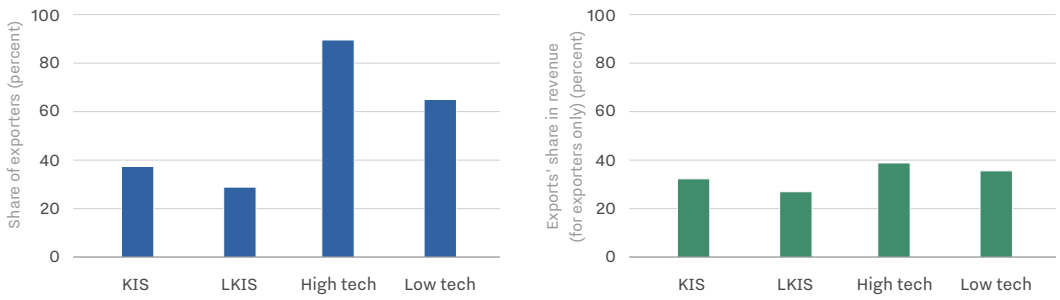


Source: Staff elaboration based on survey.

Most high technology companies export to foreign markets. High technology firms were more likely to export their goods than low technology companies and, especially, firms in the service sector (Figure I.4). Moreover, high technology companies that exported generated the highest share of their revenues from exports.[76] Mature companies were marginally more likely to export than young companies.

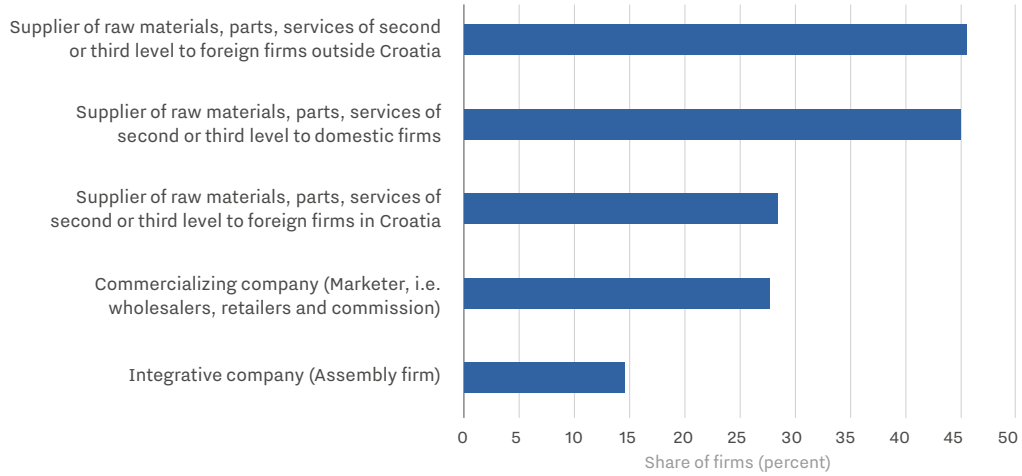
One in four companies participated in global value chains (GVCs), and access to market and greater stability of demand and prices were considered the main benefits of GVC participation. Firms in Croatia tended to participate in production chains as tier 2 and tier 3 suppliers, mostly collaborating with foreign firms outside of Croatia and domestic firms, as illustrated by Figure I.5. There was less collaboration as tier 2 and tier 3 suppliers with foreign firms in Croatia, which may be an area of interest to support linkages. Croatian firms were infrequently included in final production. That is, they are not collaborating much with assembly firms.

FIGURE I.4 *Mature firms, medium-sized firms and exporters are more productive than young companies, small and micro firms and non-exporters*



Source: Staff elaboration based on survey.

FIGURE I.5 *Croatian firms supply most frequently to foreign firms outside Croatia or domestic firms*



Source: Staff elaboration based on survey data.
Note: Only firms participating in production chains are included. Firms were asked to indicate their location in the link of the productive chain.

76 The share of exporters is slightly lower for the same types of companies in FINA data. 74 percent of high technology, 59 percent of low technology, 34 percent of KIS and 29 percent of LKIS are exporters. Shares of exports for those exporting are also similar: 39 percent, 39 percent, 36 percent, 26 percent.

BOX I.2 The curious case of family-managed companies in Croatia

Recent research indicates that family-managed companies are less productive than professionally managed ones. Although empirical research on firm value and performance is inconclusive (Astrachan and Zellweger 2008), recent studies suggest that family management is correlated with weaker performance. Lemos and Scur (2018) argue that dynastic CEO succession results in worse managerial practices, leading to productivity decreases of 5 to 10 percent. Iacovone, Maloney and Tsivanidis (2019) show (based on a sample of 11 countries, 134 regions and over 119,000 firms) that family-managed firms are on average 24.8 percent less productive than professionally managed firms.

Family-owned and family-managed firms in the Croatia sample appear to have similar outcomes and characteristics as professionally managed companies. Of 727 companies in the sample, 64 percent are managed by the founder or the founder's family, and the reminder by a manager or general manager. The large sample of family-led and professionally managed companies in Croatia allows testing differences in characteristics and outcomes between these groups of companies. Contrary to the two recent studies quoted above, there are no differences in productivity between family-led and professionally led companies in the Croatian sample, despite the fact that family-owned firms have worse managerial practices. (See Box I.3 for a discussion on managerial practices of Croatian firms.) Family-led and professionally led firms in Croatia are also equally likely to innovate, register a mark, utility model or patent, export, have similar shares of exports in revenue, and participate in GVCs.

Source: Staff elaboration based on survey data.

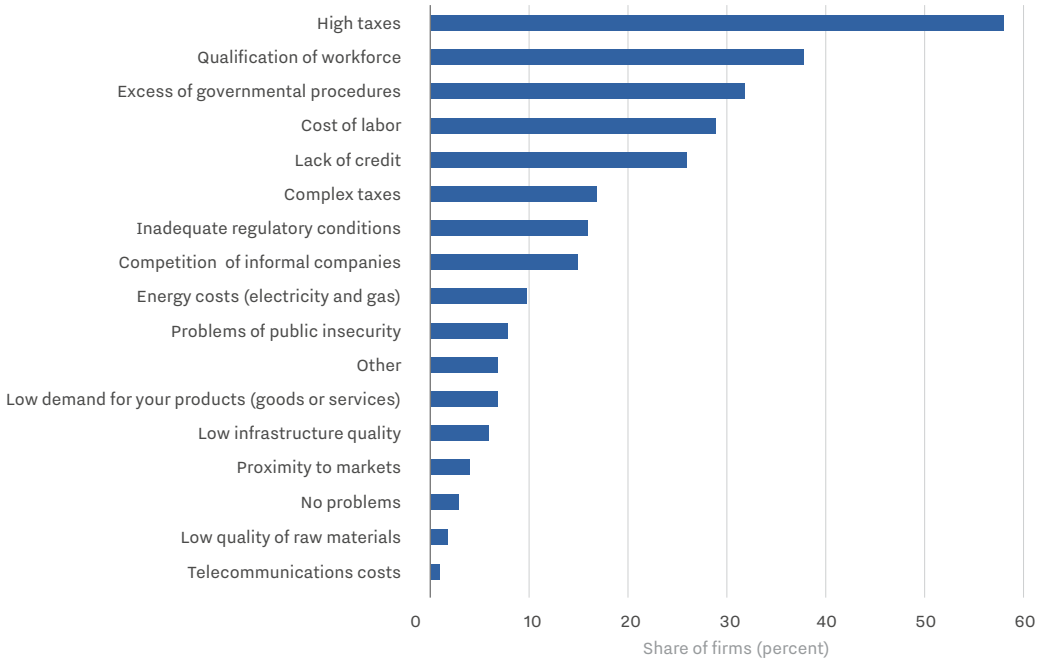
As discussed in the *Needs Assessment*, productivity results from several processes. These processes include innovation and improvements of firm capacities, improvements in factor allocations and productive entry and exit. The following two sections shed more light on these processes. First, we discuss the main obstacles in the business environment as perceived by survey respondents. Second, we look closely at firms' investments in their capabilities: expenditures on R&D, innovation, salaries, training and quality certificates.

I.2 Gaps in the Croatian Business Environment: Inputs that Influence Firm Performance

Companies report high taxes, the qualifications and costs of the workforce, excess government procedures and lack of credit as the main obstacles to their growth. Some 58 percent of companies listed high taxes among main three obstacles to company growth (Figure I.6). In the World Bank's *Doing Business 2019*, Croatia ranks 89th on the indicator *Paying Taxes*, ahead of only Bulgaria and Italy, with particularly low rankings for the number of payments required per year and the time it takes to file taxes.[77] One-third of companies indicated there is an excess of government procedures in Croatia. Most important, two types of regulations were mentioned: i) regulations regarding registration for taxes, which especially affect micro and small companies, and ii) regulations related to construction licenses, environmental income statements and concessions for water use, which are

77 https://www.doingbusiness.org/en/rankings for DB ranking 2019.

FIGURE I.6 *High taxes are listed as by far the biggest problem for the growth of the company*



Source: Staff elaboration based on survey.
Note: Respondents were asked to provide three main problems they face for the growth of the company.

more problematic for medium companies. Companies were also asked to indicate the main procedure on which the company dedicates the most time and resources and consider the main obstacle to its growth. The three main procedures mentioned were: i) registration for income tax, wage tax, withholding taxes, VAT or the payroll tax, which is especially problematic for micro and small companies; ii) construction licenses, environmental income statements or concessions for water use, which are especially problematic for medium companies; and iii) procedures related to obtaining credit instruments or opening accounts at financial institutions.

The quality of institutions remains a problem for firm growth in Croatia. Some 56 percent of companies rated flexibility of regulations and standards, as well as labor, customs and trade regulations as high or very high restrictions on the adoption of more efficient production or management processes. Half of companies listed corruption as a high or very high obstacle.[78] Companies complain also about the lack of technical support, either from government or the private sector. High technology companies and larger companies seem to find a way around these obstacles, as they report problems with the quality of institutions less frequently than other companies.

Labor shortages, especially for qualified labor, affect the majority of companies. Firms listed problem solving, taking initiative, as the most severe skills shortages, followed by education quality and discipline. Two-thirds of companies had workforce shortages in the last year. Companies in all regions and at varied

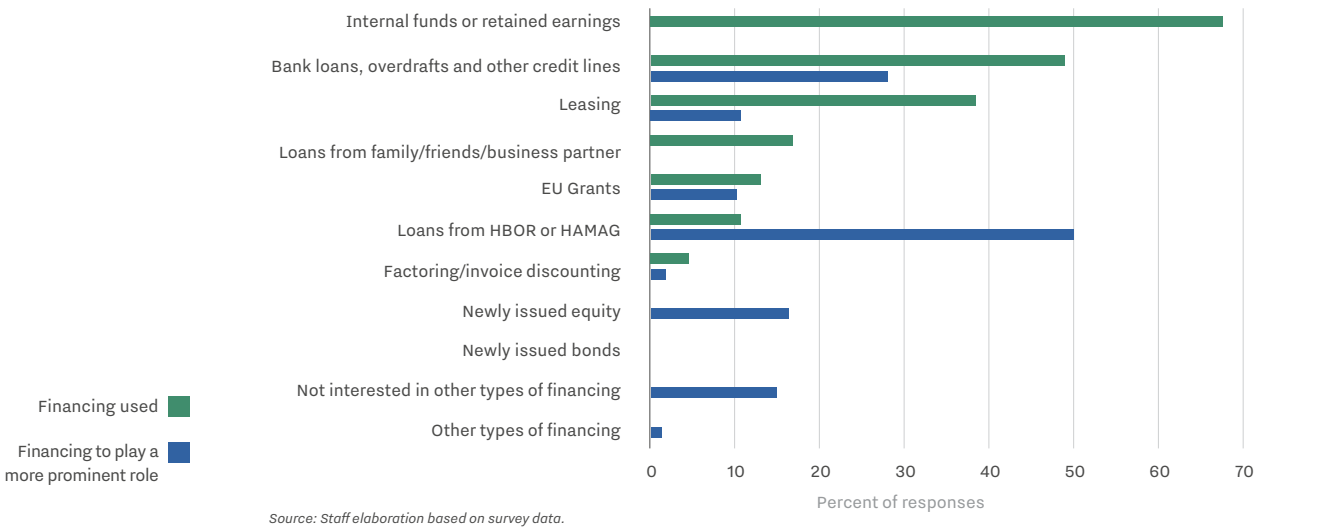
78 The survey question asked companies to rate the importance of obstacles to the adoption of more efficient production or management processes on a scale from 1 to 5, 1 being least restrictive and 5 being most restrictive.

stages of maturity reported similar challenges. Some 90 percent of companies experience a shortage of qualified labor when trying to recruit. As a result, companies indicated that recruitment takes more time, requirements for experience are lowered and higher salaries need to be offered. The shortages in the labor market and their consequences affect manufacturing companies more, especially low technology firms. Shortage of skilled labor is very or most restrictive on the adoption of more efficient production or management processes for most firms, especially for low-tech manufacturers.

Companies would like HBOR's and HAMAG's loans to play a more prominent role in their financing. Bank loans, credits and overdrafts, and leasing are the most frequently used sources of external financing for firms' activities. Internal funds and retained earnings remain the main source of financing for business activities (Figure I.7). Bank loans, credits and overdrafts, and leasing are the main sources of external financing. Manufacturing companies are using these two types of external financing more frequently than service companies. One in 10 companies used loans from HBOR or HAMAG, but half wish that loans and guarantees from these institutions would play a more prominent role in their financing. Surprisingly, beneficiaries of EU-financing in the sample are five times more common than among similar firms in the population.[79]

Companies are dissatisfied with the costs of financing and, especially, collateral requirements. Half of companies indicated satisfaction with the amount of financing obtained, the length of maturity and the type of financing obtained (Figure I.8). High technology companies are usually the most satisfied with external financing and its conditions, whereas low technology companies indicate the lowest satisfaction. Firms list the availability of capital and the costs of financing as major obstacles to the adoption of more efficient production or management processes. Limited capital availability affects basic service companies and low technology companies two to three times more often than it affects KIS and high technology companies. Moreover, LKIS and low-tech firms are also more often affected by high capital costs.

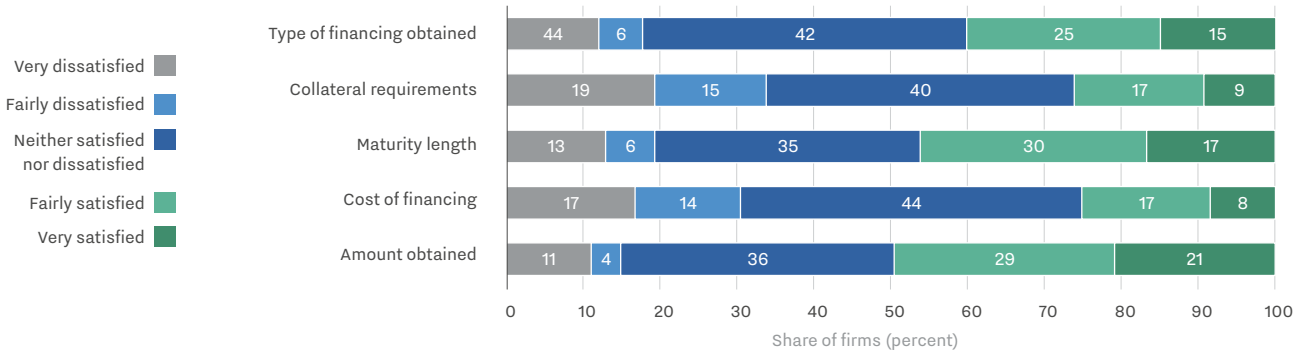
FIGURE I.7 *The most popular form of financing for firms are internal funds or retained earnings*



Source: Staff elaboration based on survey data.
Note: Firms were asked to indicate: "Type of financing used in the last year for business activities and financing that should play a more prominent role in the financing mix of a company in the next one or two years." Multiple answers were possible. Answers „Loan from family/friends/business partner" and „Internal funds or retained earnings" were not available when respondents were asked about financing playing a more prominent role. Similarly, „Other types of financing" and „Not interested in other types of financing" were not available for financing used.

79 For the same types of companies in the FINA dataset, 2.3 percent of firms are beneficiaries of EU funds. One potential explanation would be response bias: 17 percent of companies agreed to be interviewed and, among those, the share of EU funds beneficiaries was over five times higher. However, a more likely explanation is that respondents treated other forms of financing as EU grants.

FIGURE I.8 *Firms are most dissatisfied with collateral requirements for external financing obtained*



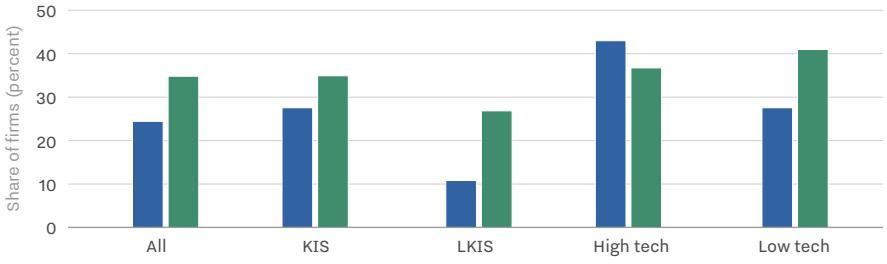
Source: Staff elaboration based on survey data.
Note: Firms were asked the question: "Thinking about all of the external finance you obtained, how satisfied or dissatisfied were you with it in terms of …?"

I.3 Firm-level Investment and Capabilities

Three-quarters of surveyed companies did not invest in technological R&D projects in 2017. R&D includes three types of activities: basic research, applied research and technological development. It encompasses experimental or theoretical works to develop new materials, products or devices, to implement new processes and systems, or to substantially improve existing ones. As expected, high technology companies are most likely to invest in R&D projects (Figure I.9). Similarly, mature companies are four times more likely to report expenditures on R&D compared to young companies. Moreover, larger companies invest more frequently.[80] Companies (except for LKIS firms) are over three times more likely to use internal staff for R&D activities than outsource it to an external party.

Two-thirds (66 percent) of companies did not report expenditures on innovation projects in 2017. Innovation projects were defined as projects that lead to improvements in products, processes, organization or marketing in the company. Manufacturing companies were more likely to invest in innovation projects than service companies were (Figure I.9).

FIGURE I.9 *Manufacturing companies more frequently invest in R&D and innovation projects*



Source: Staff elaboration based on survey data.

80 38 percent of medium-sized companies and 25 percent of small companies reported expenditures on R&D. This is roughly twice as much as in the Eurostat data presented in the *Needs Assessment*, indicating the results in the sample may be biased upwards. However, the results in the survey confirm the *Needs Assessment* finding that size, age and sector are important characteristics determining spending on R&D.

TABLE I.3 *High-tech companies have the highest total spending on R&D and innovation*

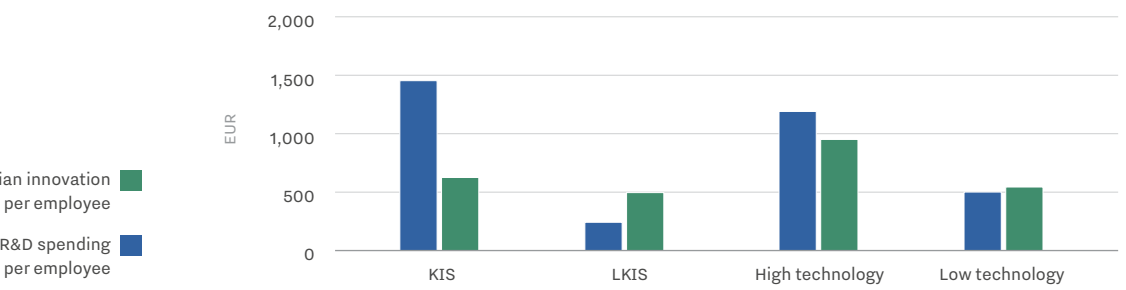
	KIS	LKIS	HIGH TECHNOLOGY	LOW TECHNOLOGY	ALL
Expenditures on R&D among 182 companies that reported investing in R&D (25 percent of companies)					
P25	2,600	1,300	13,000	5,850	**3,640**
P50 (MEDIAN)	13,000	2,600	32,500	13,000	**13,000**
P75	52,000	19,500	143,000	39,000	**60,450**
Expenditures on innovation among 253 companies that reported expenditures on innovation projects 34 percent of companies)					
P25	2,600	1,300	13,000	1,300	**3,250**
P50 (MEDIAN)	6,500	5,850	26,000	13,000	**11,700**
P75	26,000	16,055	97,500	65,000	**39,000**

Source: Staff elaboration based on survey data.
Note: Only companies that reported expenditures on R&D or innovation are included. Of the surveyed companies, 81 could not estimate expenditures on innovation in 2017 – they were excluded from these calculations. There are 24 companies that introduced innovation but had no expenditures on the innovation projects. P25, P50, P75 refer to the 1st, 2nd (median) and 3rd quartile. Expenditures are in EUR. R&D expenditures are not included in expenditures on innovation projects.

Among companies that reported expenditures on R&D or innovation projects,[81] high technology firms invest the most, and less-knowledge-intensive service firms the least. Median expenditures on R&D projects among high technology companies that reported this type of expenditure were EUR 32,500 per year, 2.5 times more than among KIS and low technology companies, and over 12 times more than among LKIS companies (Table I.3). Similarly, high technology companies spent more than others on innovation. One reason for these disparities is size differences: the median manufacturing company employs twice as many people as the median service company.

KIS and high technology companies spend the most on R&D per employee, and high technology companies spend the most on innovation per employee. The median KIS company invests EUR 1,430 per employee on R&D, compared to EUR 1,200 for a high technology company, more than twice as much as low-tech and LKIS companies (Figure I.10). High technology companies have the highest innovation expenditures per employee of over EUR 970. For both types of expenditures, LKIS companies spend the least.

FIGURE I.10 *LKIS spend the least on R&D and innovation per employee*



Source: Staff elaboration based on survey data.

81 Expenditures on technological R&D projects (as a proxy for R&D innovation) and expenditures on other innovation projects (as a proxy for non-R&D innovation) were collected separately. R&D expenditures are not included in innovation projects expenditures.

With the shortages in the labor market, especially for qualified staff, retaining staff and increasing their competences may become a priority for companies. High technology companies and KIS companies offer higher salaries to their employees. A median management employee at a KIS firm or high technology company earns around EUR 1,300 gross per month, EUR 100–180 more than at LKIS companies and low technology manufacturing firms (Table I.4). A similar pattern can be seen for operational and support staff salaries. As expected, mature companies pay more than young companies.

TABLE I.4 *KIS and high-tech firms pay the highest salaries*

	Management and Supervision Salaries				Management and Supervision Salaries			
	P25	P50	P75	Mean	P25	P50	P75	Mean
KIS	910	1,310	1,950	1,690	780	1,040	1,430	1,290
LKIS	850	1,120	1,440	1,260	650	830	1,040	960
HIGH TECHNOLOGY	1,040	1,330	1,950	1,830	770	980	1,210	1,070
LOW TECHNOLOGY	910	1,200	1,560	1,400	650	830	1,040	950

Source: Staff elaboration based on survey data.
Note: Monthly salaries above 13 000 EUR were excluded for mean calculations as these may be outliers (8 salaries for operational staff and 5 for management). P25, P50, P75 mean 1st, 2nd (median) and 3rd quartile. Salaries are in EUR.

One in two employees received training in 2017, and 70 percent of companies provided or funded some form of training for their staff. Median expenditure on training is EUR 100 per employee and 1,800 per firm. KIS and high-tech firms, which likely build their competitive advantage on knowledge, are more likely to provide training than LKIS and low-tech firms. Medium-sized companies train their employees more frequently than small and micro companies. However, among companies that provide training, service companies train more of their employees than manufacturing companies. Firms that did not provide training to their employees indicated three main reasons: knowledge and technical skills of employees are adequate (55 percent), there are no tangible results of training (48 percent) and high costs (33 percent).

BOX I.3 Results of the World Bank study on management practices in Croatia

An average Croatian firm scores better on structured management practices than an average firm from most developing countries, but worse than an average firm from the United States, a frontier country. There are substantial differences in managerial capabilities between firms in Croatia, mostly because of a relatively large share of badly managed companies. Service firms are further from the frontier than manufacturing firms, a finding that may indicate the lack of a pro-competitive environment, which lowers the pay-off from adopting better management practices. Croatian firms perform particularly poorly on practices related to performance monitoring (that is, collecting and analyzing information on daily activities of the firm, such as absenteeism, inventory, or sales). But Croatian firms' scores on target setting (setting and using short and long run targets, tracking outcomes, and taking appropriate action) are close to those in the United States. KIS firms and high-tech companies are better managed than LKIS firms and low-tech companies. Firms in Zagreb have the highest-rated management practices, and those from Northern Croatia the lowest. Interestingly, age is negatively correlated with management practices in Croatia, which is the opposite of what surveys show in Mexico and the United States.

BOX I.3
(continued)

Management matters for firm performance outcomes. Better managed firms have higher sales per employee, higher profits, and other indicators of better performance. The result is consistent with findings from other countries and datasets. The gains from improving management practices can be substantial. In Croatia, improving a firm's management score from the 10th percentile to the 90th percentile is correlated with an increase in sales per employee of 36 percent, an increase in profit margin by 33 percent, and an 11 percent higher likelihood of introducing new products or processes. Interestingly, monitoring practices are more important for labor productivity and adoption of sophisticated technology, while management practices related to incentives and targets have a greater association with profits, innovation and access to external finance.

Improving business regulation in Croatia is urgent to boost the competitiveness of Croatian firms. As noted earlier in the analysis, compared to peers, Croatia does not rank well in Doing Business or the Global Competitiveness Report. Policies to foster internationalization of Croatian firms would help, because participation in foreign markets encourages learning and better management practices. Further, providing firms with funds for training to boost their capabilities is important to make firms aware of their weaknesses. Most firms' perceptions of their own managerial practices are too high.

Source: Staff elaboration based on Grover et al. 2019.

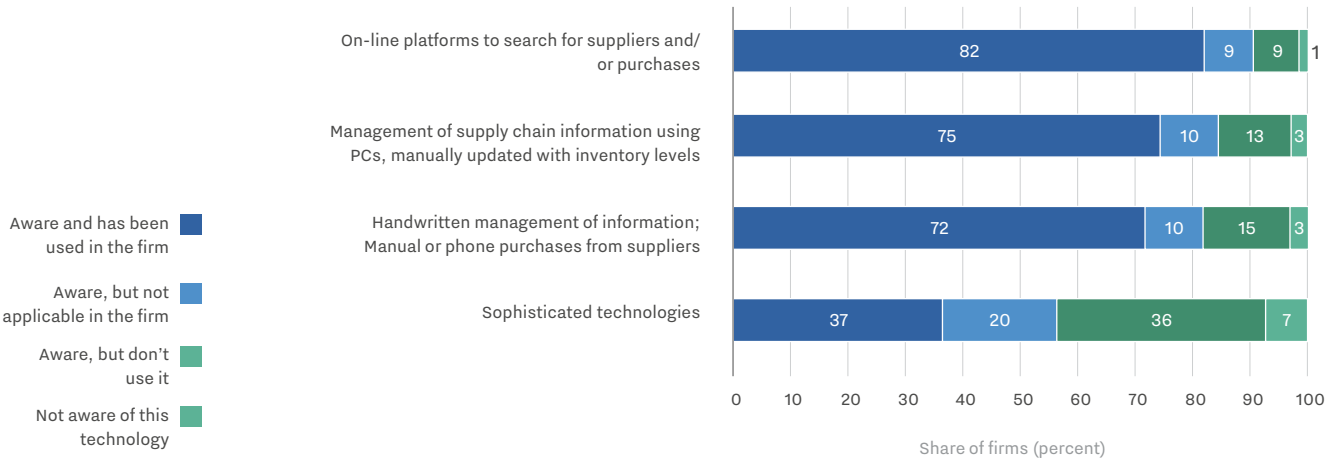
Manufacturing companies have more quality, environment and security certificates.[82] Almost one-third of companies had a quality certificate in 2017, with manufacturing companies twice as likely as service companies to have them. Some 18 percent of manufacturing companies and 7.5 percent of service companies report having an environment certificate, and manufacturing companies are twice as likely to have security certification compared to service companies (18 percent vs 9 percent).

The vast majority of companies use simple methods of procurement, inventory and supply chain management. Most use handwritten systems of information management and PCs with manually updated inventory lists (Figure I.11). Only 1 in 3 companies uses more sophisticated technologies, such as customer relationship management, warehouse management systems or cloud applications. Moreover, 7 percent of respondents are not aware of the existence of these sophisticated technologies. High technology companies are the most likely to use PC and sophisticated technologies to manage procurement, inventory and supply chains.

High technology companies use sophisticated technologies for quality control two to three times more often than other companies. Most companies use PCs or basic electronic systems for quality control, and only around 1 in 4 uses sophisticated technology, such as distribution resource planning, lean manufacturing, the Kaizen method, just-in-time, Total Quality Management, business certification or certification renewals, six sigma or other quality management systems (Figure I.12). A substantial number of respondents are not aware of sophisticated technologies for quality control. High technology companies are the most likely to use both types of quality control (often in parallel).

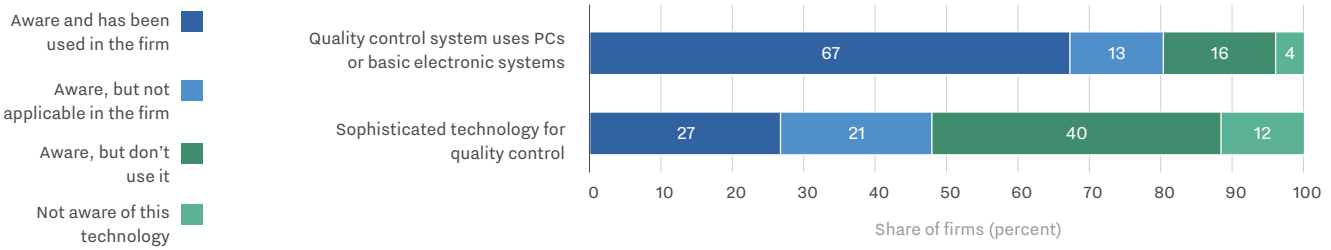
81 Firms were asked about any type of certificate they received. Among the most important, the following stand out:
Quality: ISO-9001: 2000, ISO-9001: 2008, TS-16949: 2009 and ISO-13485: 2003;
Environment: ISO-14001: 2009, ISO-14001: 2004 and clean industry;
Social responsibility: SA 8000: 2008, ESR and ISO-26000: 2010;
Security: the NMX-SATS-001-IMNC-2008, OHSAS 18001: 2007, CTPAT and ISO / IEC 27001: 2005;
Sanitary: HACCP and ISO-22000: 2005.

FIGURE I.11 *On-line platforms are the most popular form of procurement, inventory and supply chain management*



Source: Staff elaboration based on survey data.
Note: Firms were asked to indicate their awareness and use of procurement, inventory and supply chain management. Sophisticated technologies: Customer Relationship Management (CRM) software, Warehouse Management System (WMS) Software, Cloud system to manage information (Software-as-a-Service-SaaS model).

FIGURE I.12 *Croatian firms use mostly simple quality control systems*



Source: Staff elaboration based on survey data.
Note: Firms were asked to indicate their awareness and use of quality control systems. Sophisticated technology for quality control includes such things as distribution resource planning (DRP), lean (modern) manufacturing, the Kaizen method, just-in-time (JIT), Total Quality Management (TQM), business certification or certification renewals (such as ISO 9000 and ISO 14000), six sigma, quality management systems and similar methods.

II. Portfolio Mapping Variables

Variable	Variable description	Attribute
General	Provide general and administrative information on the specific call.	Program /Instrument full name
		Program /Instrument short name (for the purpose of this review)
		Reference number of the call for proposals
		Conventional instrument definition (standard)
		Source of financing
		Priority Axis
		Thematic objective
		Investment priority
		Specific objective
		Measure/ submeasure
		Managing authority (MA)
		Sector/Department
		Ministry (Implementing Body 1)
		Contact person from Implementing Body 1
		Sector/Department
		Implementing Agency (Implementing Body 2)
		Contact person from Implementing Agency
		Website/URL
		Program start
		Start of operation (date of contract signing)
		Program end
		Number of projects supported (as of ...)
		Will the program continue in the future? (Yes / No / Uncertain)
		Number of calls
		Number of amendments to the call
Call type	Indicate the modality of the call with respect to eligible beneficiaries.	Open call
		Restricted call
		Direct award
Economy/ society outcomes	Indicate general objectives for the economy/society. These are desired impacts or effects of the intervention. Mark direct objectives only.	Productivity growth, firm upgrading in existing business, technology adoption and diffusion
		Diversification, new ventures, new markets
		Knowledge creation
		Jobs, skills, and human capital
		Societal development outcomes, inclusion
		Environment, climate change

Variable	Variable description	Attribute
Alignment with national (S3) objective	Indicate the alignment of the objectives of the call with S3 specific strategic objectives.	Increased capacities of RDI sector to perform excellent research and to serve the needs of the economy
		Overcoming the fragmentation of innovation value chain and the gap between research and business sector
		Modernizing and diversifying Croatian economy through increasing private R&D
		Upgrading in global value chain and promoting internationalization of Croatian economy
		Working in partnerships to address societal challenges
		Creating smart skills - upgrading the qualifications of existing and new work force for smart specialization
		S3 goal/connection explicitly stated (0-no, 1-yes)
Instrument objective	Scope and objective of the call in relation to the objectives of innovation support. Mark **direct objectives** only. Multiple objectives may be selected. If the objective changed during the lifetime of the call, fill out according to the latest change and provide an explanation in the last field of this section.	Research excellence
		Technology transfer and science-industry collaboration
		Business R&D and R&D-based innovation
		Non-R&D innovation, technology adoption/diffusion
		Management practices
		Access to finance
		Export promotion
		Skills formation
		Entrepreneurship
		Improving business regulatory environment/business climate
		Market access and integration
		R&D infrastructure
		Environment, climate change
		Government technological innovation, adoption and diffusion
		Regional development
		Has the instrument objective changed over the life of the program (yes/no), and if so, why?
Type of support	Only one type of support may be selected.	Direct
		Indirect
Mechanism of intervention	Type of instruments or actions used to deliver and implement the call. Multiple mechanisms may be selected.	Grants and matching grants
		Vouchers
		Equity finance
		Loans and credit
		Guarantees for innovation, SMEs and entrepreneurship
		Tax incentives - R&D, and Non-R&D innovation
		Public procurement for innovation and pre-commercial procurement
		Crowdsourcing and open innovation instruments and awards

Variable	Variable description	Attribute
		Business advisory and technology extension services
		Early stage infrastructure and advisory: incubators and accelerators
		Science/technology parks, industrial parks, EPZs
		Quality infrastructure and standards for innovation
		Research infrastructure
		Business education for entrepreneurship
		Scholarships
		Regulatory instruments
		Collaborative networks and cluster policy
		Public goods (e.g., platforms that are accessible to the public)
Grant usage/ eligible costs	Purpose and usage of the funds when they are established ex ante as part of the support. Multiple selections are allowed. If all costs are eligible fill in all categories.	R&D machinery, equipment, instrumentation
		R&D space & rent incl. labs
		R&D materials
		Non-R&D machinery, equipment, instrumentation
		Non-R&D space & rent
		Specialized software and licenses
		Rent
		Access to research infrastructure offered by academia
		Research services offered by academia
		Networking events
		Working capital
		PhD and postdoc salaries
		Other staff salaries
		Consultants
		Business advisory, training and services offered by business support institutions
		Other training
		Information systems and websites
		Testing and certifications
		Patents
		Marketing campaigns
		Missions to fairs and exhibitions
		Investments for adapting products and services to meet markets requirements, standards
		Technical and economic feasibility studies
		Investments in introduction of effective environmental management systems, pollution prevention technologies, integration of clean technologies into firm production

Variable	Variable description	Attribute
		Market research
		Social or environmental impact studies
		Legal and regulatory studies
		Physical infrastructure, e.g. building/ warehouse construction, renovations
		Company operations
		Are there any limits for eligible expenditures domestic vs. foreign? (y/n)
Sector orientation	Where interventions (calls) are targeted. The call could be cross-sectoral or focused on specific niches. Specific sector to which the call is oriented.	Smart specializations
		Horizontal
		Vertical - sector specific
		Agriculture
		Manufacturing
		Services: knowledge-intensive
		Services: non-knowledge intensive
Geographic coverage	Indicate whether the call is targeted to the national level, a specific region or city.	National
		Regional
		City
Direct beneficiaries (eligible)	Group of persons or institutions which are eligible to receive support. Direct beneficiaries only. Select female researchers, female-owned firms, or youth entrepreneurs only if they are specifically targeted. Select categories of grant users as well as partners, if partners are eligible to receive support.	Researchers
		Universities
		Faculties
		Other research entities
		Private research entities
		Female researchers
		Research institutes
		Formal firms
		Female-owned formal firms
		SOEs
		Consortia, associations, clusters, partnerships
		Business support institutions
		Financial institutions
		Informal firms
		Cooperatives
		Individuals
		Crafts
		Women entrepreneurs
		Youth entrepreneurs
		Other government agencies (e.g., regulators, LGUs)
		NGOs

Variable	Variable description	Attribute
Final beneficiaries	Beneficiaries that directly enjoy the benefits of the support but may not necessarily be eligible to apply and sign an agreement within the call. (e.g. researchers in cases where grants are formally allocated to their home institution)	Researchers
		Universities
		Faculties
		Other research entities
		Private research entities
		Female researchers
		Research institutes
		Formal firms
		Female-owned formal firms
		SOEs
		Consortia, associations, clusters, partnerships
		Business support institutions
		Financial institutions
		Informal firms
		Cooperatives
		Individuals
		Crafts
		Women entrepreneurs
		Youth entrepreneurs
		Other government agencies (e.g., regulators, LGUs)
		NGOs
Partnership		Mandatory
		Optional
		Not allowed
Life cycle	Indicate which phase in the life cycle is supported by the intervention. Usually (but not exclusively) related to firm age. Only complete if firms are direct beneficiaries.	Idea/concept stage (pre-seed/seed)
		Young and start-ups (entering the market)
		Scale-up (accelerating young firm)
		Mature (incumbent)
Size	Indicate targeted firm size.	Micro
		Small
		Medium
		Large

Variable	Variable description	Attribute
Supported R&D and implementation phases	Indicate which R&D phase is supported.	Basic research
		Applied research
		Experimental development
		Early developmental stage (incl. initial prototype preparation, demonstration/pilot implementation)
		Pre-implementation activities (incl. securing patent)
		Late developmental stage and implementation (incl. validation in real settings)
		Post-implementation activities (incl. preparing for commercialization, establishing product-market fit, promotion, looking for investors, licensing, feasibility studies, legal and regulatory studies, market research, etc.)
		Starting production
Supported TRL phase	Indicate which TRL phase is supported. Ensure that the selected variables are consistent with the previous category.	Basic principles observed
		Technology concept formulated
		Experimental Proof of Concept
		Technology validation in lab
		Technology validation in relevant environment
		Demonstration in relevant environment
		Demonstration in operational environment
		System complete and qualified
		Successful mission operations
Budget	Indicate total allocation within the financial perspective.	Original currency
		Budget (total within financial perspective) in original currency
		Budget (total within financial perspective) in EUR
Budget source and split	Indicate the contribution of EU funds, national public funding and private funding in EUR and the EU co-financing rate.	Of which EU funding (EUR)
		Of which other IFI/bilateral funding (EUR)
		Of which national public funding (EUR)
		Of which national private funds (EUR)
		External Co-financing rate (%)
Co-financing	Indicate the overall percentage of the subsidy (EU+national funds) and/or the matching contribution requirement.	Minimum subsidy (%)
		Maximum subsidy (%)
Support value parameters	Indicate the minimum and maximum amount of support per project (application)	Minimum beneficiary input as % share of eligible costs
		Minimum support amount (original currency)
		Maximum support amount (original currency)
		Minimum support amount (EUR)
		Maximum support amount (EUR)

Variable	Variable description	Attribute
Awarded funds	Total funds contracted within the operation.	Awarded funds in original currency
		Awarded funds in EUR
Applicable state aid rules		De minimis aid
		Regional investment aid (Art. 14)
		Investment aid to SMEs (Art. 17)
		Aid for consultancy in favour of SMEs (Art. 18)
		Aid to SMEs for participation in fairs (Art. 19)
		Aid for start-ups (Art. 22)
		Aid for research and development projects (Art. 25)
		Investment aid for research infrastructures (Art. 26)
		Aid for innovation clusters (Art. 27)
		Innovation aid for SMEs (Art. 28)
		Aid for process and organizational innovation (Art. 29)
		Training aid
		Investment aid for local infrastructures (Art. 56)
		Reg. on European Maritime and Fisheries Funds (Art 95)
		Rural Development Fund

III. List of Programs Covered in Portfolio Mapping Analysis

1	Science and Innovation Investment Fund - I	SIIF1
2	Science and Innovation Investment Fund - II	SIIF2
3	SRCE -Providing graphics processors as resources in advanced computing	CRO NGI
4	BIOCentre	BIOCENTER
5	Development of research infrastructure at the Rijeka University Campus	Rijeka
6	Preparation of RDI infrastructural project I	PP I
7	Preparation of RDI infrastructural project II	PP II
8	Preparation of RDI infrastructural project III	PP III
9	Strengthening capacities for research, development and innovation	STRIP
10	Research scholarships for professional development of young researchers and post-doctoral students	Research Scholarships
11	Strategic project: Science and Technology Foresight Project	Foresight
12	Centres of Research Excellence performing excellent science	CoRE
13	Investments into organizational reform and infrastructure of R&D&I sector	R&D Infrastructure
14	Science and Innovation Investment Fund	SIIF OPKK
15	Preparation of RDI infrastructural project	Preparation of RDI infrastructural project
16	Strengthening capacities for research, development and innovation	STRIP OPKK
17	Enabling synergies with HORIZON 2020 initiatives for spreading excellence: Twinning and ERA chairs	Synergies with HORIZON2020
18	Major Project: Children Centre for Translational Medicine at the Children's Hospital Srebrnjak	CCTM
19	Providing Feasibility Study And CBA For Four (4) R&D&I Infrastructure Projects	STP2 Feasibility
20	Strategic project: HR_ZOO Croatian Science and Education Cloud	HR_ZOO
21	Strategic project: Centre for advanced laser techniques - CALT	CALT
22	Improved Access to Electronic Sources of Research and Technical Information - e-Sources	e-Sources
23	Young Researchers' Career Development Project – Training of Doctoral Students	ASOO - Young Researchers' Career Development Project
24	Young Researchers' Career Development Project – Training of Doctoral Students	DOK1
25	Young Researchers' Career Development Project – Training of Doctoral Students	DOK2
26	Cooperation Programme with Croatian Scientists in Diaspora ´RESEARCH COOPERABILITY´	PZS
27	Croatian-Swiss Joint Research Projects - Call for Proposal 2017	CSRP

28	Promotion of Tenure Track Model – the Tenure Track Pilot Programme	TTPP
29	Support to researchers for the application to the ERC programmes	ERC
30	Installation Research Projects	UIP
31	Partnership in Research	PAR
32	Research Projects	IP
33	Programme for financing Research and Development activities to fight Climate Change	PKP
34	Connectivity Program, Gaining Experience Grant	UKF-GE
35	Research Cooperability Program, Crossing Borders Grant	UKF-CB
36	Research Cooperability Program, My First Collaboration Grant	UKF-MFC
37	Increasing the development of new products and services that result from research and development activities	IRI
38	Support for development of centers of competence	CEKOM
39	Commercialization of innovations in entrepreneurship	Commercialization
40	Innovations in newly established SMEs	Startup innovation 1
41	Innovations in newly established SMEs - Phase 2	Startup innovation 2
42	Innovations in S3 areas	S3
43	Increasing competitiveness and efficiency of SMEs in areas with special development needs through ICT	ICT Regional
44	Increasing competitiveness and efficiency of SMEs through ICT	ICT 2
45	Innovation vouchers for SMEs	Innovation Vouchers
46	Reaching markets through product certification	Certification
47	Quality labels	Quality labels
48	Internationalization of SMEs through business support organizations	BSO SME Intl
49	Internationalization of SME operations	SME Intl 1
50	Internationalization of SME operations – Phase 2	SME Intl 2
51	Introduction of systems of management of business processes and quality (ISO and similar norms)	ISO Norms
52	Strategic project to support for cluster competitiveness initiatives	Clusters
53	Strategic Project for support of establishment of Innovation Network for Industry and Thematic Innovation platforms (Project INI)	INI
54	Law on State Support for Research and Development Projects	R&D Tax Break
55	Public Procurement Law - Partnership for Innovation	PPL
56	Establishment of Business Support Institution Network	BSIN
57	Eureka	Eureka
58	Eurostars	Eurostars
59	Smart Factory Hub Voucher scheme	Smart Factory Hub
60	“B Light”- Fostering value added business cooperation between SMEs operating on different sides of the Hungary-Croatia border	B Light

61	Second Science and Technology Project (STP II), Component B1.1. Proof of Concept Program	PoC 4-6
62	Second Science and Technology Project (STP II), Component B1.1. Proof of Concept Program	PoC 7 Private
63	Proof of Concept 8	PoC 8
64	Second Science and Technology Project (STP II), Component B1.2. RAZUM Program - Development of knowledge-based SMEs	RAZUM
65	Second Science and Technology Project (STP II), Component B1.3. IRCRO Program - Collaborative Research and Development	IRCRO
66	Second Science and Technology Project (STP II), Component B1.4. TTO Program - Technology Transfer Office Support Program	TTO
67	Measure I.1 Innovation	M.I.1
68	Partnerships between scientists and fishermen	M.I.3
69	Measure II.1 Innovation	M.II.1
70	Support for establishment and operation of operational groups of EIP for agricultural productivity and sustainability	EIP
71	Development of business infrastructure	BSOs
72	Business Services for SME through BSOs	BSOs services
73	ITU - IT Park	IT Park Osijek
74	ITU - Innovation Infrastructure Slavonski Brod	Innovation Infrastructure SB
75	ITU - System of Startup Incubators Rijeka	Startup Incubators Rijeka
76	ITU - Development of Business Support Organisations Split	ITU BSO Split
77	Croatian Venture Capital Initiative (Fil Rouge Capital)	Fil Rouge VC
78	Scheme for strengthening applied research for climate change Adaptation measures	Climate

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