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BULGARIA COUNTRY NOTE

Enhancing the Contribution of Bulgaria's Public Research to Innovation: A Survey-based Diagnostic



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Abbreviations and Acronyms

AA	Agricultural Academy
BAS	Bulgarian Academy of Science
CoC	Centre of Competence
CoE	Centre of Excellence
EC	European Commission
ERDF	European Regional Development Fund
ESF	European Social Fund
EU	European Union
GBARD	Government Budget Appropriations on Research and Development
GDP	Gross Domestic Product
GERD	Gross Expenditures on Research and Development
HEI	Higher Education Institution
IP	Intellectual Property
M&E	Monitoring and Evaluation
MoES	Ministry of Education and Science
NCID	National Center for Information and Documentation
NSF	National Science Fund
PBRF	Performance-based Research Funding
OP SESG	Operational Programme Science and Education for Smart Growth
PER STI	Public Expenditure Review for Science, Technology, and Innovation
PRO	Public Research Organization
R&D	Research and Development
STI	Science, Technology, and Innovation
TTO	Technology Transfer Office
WIPO	World Intellectual Property Organization

Executive Summary

While Bulgaria has experienced strong economic growth in the decades following its transition from communism, it remains a largely factor-driven economy reliant on low wages and resource-based exports. Catching up to the living standards of regional peers will require boosting productivity, and a key step to increase productivity is to strengthen Bulgaria's science, technology, and innovation (STI) performance, which ranks among the worst in the EU across multiple indicators. Transitioning to a more productive, innovation-based economy will require improvements to the country's poor performing research system – particularly the public research sector, which plays a smaller role both in funding and performing research and development (R&D) compared to regional peers. Bulgarian public research institutions are largely under-funded compared to European peers, suffer from fragmented research competencies, and lack a critical mass of researchers, which contribute to the poor performance of public research institutions in terms of scientific and technological outputs and impacts. Further, these institutions lack linkages to the private sector, which inhibits the transfer of knowledge and technologies from the public sector into the economy and society.

This country note was prepared as a background paper for the Country Needs and STI Policy Mix Assessment report¹; a deliverable of the World Bank's Bulgarian Public Expenditure Research on Science, Technology, and Innovation (PER STI) Project. It explores the research, knowledge exchange, and technology transfer activities of public research institutions in Bulgaria and aims to identify the factors that enable or constrain these activities. The findings in this report are based on two surveys: an in-person survey of administrators from a sample of public research organizations (PROs) and higher education institution (HEI) technology transfer offices (TTOs); and an online survey of over 4,000 public sector researchers in Bulgaria.

Key findings from the survey include:

Institutional Governance: A lack of clear missions and objectives at the institutional level restricts the ability of Bulgarian PROs and HEIs to develop long-term strategies, with a majority of public research institutions lacking long-run research and technology investment strategies. Although the legal framework officially makes PROs/HEIs autonomous, in practice this autonomy is limited by the dependence on public funding and practical restrictions to strategic decisions. External stakeholders, such as representatives from industry, are not represented in the governance of PROs (although they are in HEI governance), and most public institutions do not consult with

1 Aridi, et al. 2020. *Bulgaria Country Needs and STI Policy Mix Assessment*. Washington, D.C.: World Bank Group.

industry or other external actors in the definition of research or educational agendas. As a result of the lack of external stakeholder input, research agendas are not oriented toward industry needs, which is a major impediment to public-private collaboration, technology transfer, and research impact. Performance-based research funding (PBRF), which can help concentrate resources in high-performing institutions, has been introduced but currently only accounts for a small share of direct institutional funding.

Research and Technology Transfer Capacity and Policy: PRO/HEI policies for research are generally in line with national policies and strategies, but the lack of research capacity, especially in the area of human capital, appears to be a major barrier to improved research outcomes. Lack of funding for research and a lack of adequate research facilities are also cited as major challenges. Bulgaria has key elements of intellectual property (IP) law in place, but there is no clear legislation governing who owns IP generated by public research institutions and there is also no specific technology transfer law that governs the transfer of public research to private applications. Public institutions generally lack sustainable funding and resources for IP and tech transfer activities, and there is a general lack of awareness among researchers of national and institutional technology transfer policies.

Research Outputs and Innovation Linkages: Public sector publication and patent activity are largely aimed at addressing accreditation requirements and meeting career development milestones, rather than the pursuit of impactful research, and there are very low levels of patenting overall. Knowledge linkages through personnel mobility, PhDs in industry, or through other staff exchanges with industry are not common, which severely limits opportunities for networking and collaboration with industry. The general lack of linkages to industry is cited as a major challenge to knowledge exchange and tech transfer activities with the private sector. Very little commercialization activity is reported among surveyed institutions and researchers.

Incentives and Obstacles: The career development framework for public researchers does not provide adequate or coherent incentives for commercialization. Although incentives for career promotion recognize intellectual property outputs, such as patents and other IP, the actual transfer of knowledge and its exploitation by innovation actors is not recognized. By contrast, the evaluation system for institutions does include an economic impact component. Financial incentives for commercialization activity are not in place, as it is not mandatory to recognize researchers' participation in revenues from technology commercialization and licensing, nor are there provisions of equity participation rights from academic spinoffs.

Survey evidence shows that reinforcing both financial and non-financial incentives and the recognition of knowledge collaborative linkages boosts technology transfer performance among Bulgarian researchers:

- Researchers who receive financial and non-financial incentives from their institutions participate in more industry-science collaboration.
- Researchers who participate in staff mobility activities (PhD projects with industry, joint positions, exchanges, sabbaticals in industry, etc.) engage in more public-private collaboration and technology transfer.

To address these challenges, this report provides a set of recommendations for improving research and technology transfer outcomes in public research institutions:

- **Reinforce governance and strategic orientation** of public research institutions and ensure that they have clear missions and objectives, in line with national strategies and priorities. Provide support for PROs and HEIs in the articulation of their institutional research and technology transfer strategies for achieving these objectives.
- **Strengthen monitoring and evaluation (M&E)** for research and operation of PROs and HEIs and align M&E frameworks with institutional objectives and missions. M&E schemes should place more weight on knowledge transfer and research collaboration activities than they do presently.
- **Strengthen PRO/HEI-Industry linkages.** Mandate representation of industry and other relevant external actors in the governance bodies at both PROs and HEIs and encourage formal consultation with these actors in the definition of research and technology transfer agendas. Strengthen public-private connections and idea flows by allowing and incentivizing personnel exchanges between public research and industry.
- **Increase the role of PBRF.** Revise indicators and weighting schemes for performance-based funding to focus on research quality indicators (impact factors, external research funding, PhDs), and research commercialization and tech transfer activities (licenses, spin-offs, contract research, industry research collaboration, etc.).
- **Foster a coherent national IPR and technology transfer framework,** rather than devolving the question of ownership of IP to individual institutions. Clarify ownership of equity stakes in spin-offs from academic research institutions at both individual and institutional level.
- **Improve resources and capacity for technology transfer support,** including sustainable financial commitments and training to support TTOs and staff.
- **Improve incentives for public researchers** to engage in high quality research, knowledge transfer, and commercialization activities by including technology transfer and collaborative research activities in career development and salary progression schemes and by allowing researchers to financially benefit from the commercialization of their research.

Introduction

Despite strong economic growth over the last three decades, Bulgaria has not achieved a transition from a factor-driven economy to an innovation-driven economy. While the economy and income levels grew rapidly during the period following the transition from communism, Bulgaria's innovative outputs plunged post-1990 due to an erosion of the country's technological and scientific competences (World Bank, 2012). Although Bulgaria's research capacity has experienced a slow recovery, it still lags behind most European countries in innovation performance. One of the primary areas for improvement is Bulgaria's low performing public research sector. There is an urgent need to strengthen both the capacity of researchers and the impact of public research on the economy and society through technology and knowledge transfer activities.

Part of the reason for the weak role of public research in the Bulgarian innovation system is that government investment in public R&D is the lowest in the EU on a per capita basis (€19.50 per inhabitant, compared to the EU 28 average of €206.30 per inhabitant), resulting in poor scientific productivity and low impact of research outputs. Private investment in R&D is also low, which further constrains the potential for knowledge exchange and collaboration between science and industry. Yet, despite the relatively low levels of spending and performance, the public sector still represents a significant portion (29 percent) of R&D performed nationally. Bulgaria has set an ambitious new GERD target of three percent of GDP by 2030 (currently 0.7 percent of GDP), and achieving this target will require a significant increase in both public spending and performance of R&D, along with a sustained expansion of private R&D.

With significant new investment in public R&D will come expectations for new knowledge and technologies that address major national needs, and new innovative companies that grow and generate employment. A more efficient public research sector will also require more effective use of public resources through improved management procedures and oversight to ensure public value is generated from public money, which is ultimately the goal of modern public science and technology organizations.

Modernization of the public research sector will require continuing institutional and policy reforms to improve the performance, accountability, and governance of public research organizations. This includes the need to review their strategic orientation (e.g., better orient research and educational agendas around industry and societal needs); revisit funding mechanisms; diversify sources of funding; increase knowledge linkages within the national innovation system, especially with firms; and increase focus on technology commercialization and entrepreneurial activities. A comprehensive approach to the reform of the public research sector, as has been undertaken in other countries (see Box 1), is essential to success.

Box 1: The 2018 Science Law of Poland: A package of structural reforms touching institutional change, incentives, and funding systems



In many cases, countries need to engage in system-level structural reforms to modernize the public research and higher education sector to make the system more efficient and globally competitive and ensure societal impact. Examples include Spain's reform of its public research organizations (PROs) in 1986 and the 2008 reform of science in the Czech Republic.

More recently, the Polish 2018 Science Law ("the Constitution of Science") introduced a series of institutional and funding reforms to strengthen research capacity and institutional settings to foster performance, research excellence and impact. The main reforms include:

- A major financial injection with long term perspective, anticipating an increase in funds in the science and education system by PLN 47.5 billion (€10.7 billion) over 10 years (compared to 2018).
- Increased autonomy of higher education institutions (HEIs), allowing for more independence in the setting of research priorities and in the internal allocation of funds.
- Governing bodies of public HEIs will include a new body, the university council, chosen by the university community. These councils are required to include industry representatives for consultation on defining research strategies.
- The law creates a special career paths for researchers and introduces several amendments to salaries, raising minimum salaries for academic teachers.
- Changes are made to university performance assessments so that money will follow individual researchers and their field of specialization, and no longer faculties. Universities will then be assessed based on aggregate measurements of individual scientist performance.
- The law introduces a more equitable evaluation of scientific achievements and requires researchers to select the 3 most meaningful outputs for evaluation. Three criteria are considered (reducing the number of metrics): (i) publications and patents; (ii) income from grants, R&D projects, and commercialization; and (iii) societal impact.
- The law also allows the creation of federations of universities to boost inter-disciplinary research. The University of Warsaw is already planning to establish such a federation with the Medical University of Warsaw, a move that could boost interdisciplinary research.

This country note aims to provide evidence on the state of progress in knowledge and technology transfer activities from public research institutions in Bulgaria and to identify the factors that enable or constrain these activities. The analysis is guided by the following policy questions:

- What is the role of public research organizations (PROs) and higher education institutions (HEIs) in the provision of new knowledge and innovation opportunities in Bulgaria? What is the state of development and what are the most common types of knowledge and technology transfer?
- Are the current governance and regulatory frameworks conducive to technology transfer and industry-science collaboration?
- Are external stakeholders (e.g., industry, government, etc.) considered in research strategies and priorities in PROs and HEIs?
- Are academic incentives in line with technology transfer policy goals? Are academic and financial incentives in place and in line with international practices?
- What are the key barriers that keep public research organizations from better contributing to national innovation and development?

The analysis and findings in this report are based on a recent methodology and survey design developed by Zuniga (2020) and Cirera, Kuriakose, and Zuniga (2020) that aims to identify and measure the different channels through which public research institutions and researchers transfer knowledge and technologies to industry (and other innovation actors), as well as the policy and institutional factors that influence such activities. Data for this report were gathered through an online survey for researchers employed at public institutions and through in-person surveys of directors and TTO managers for a sample of public research organizations and university TTOs.

The first part of this report reviews the general conditions of public sector R&D in Bulgaria in terms of funding, performance, and outputs of public R&D activities and provides an overview of the STI policy framework and institutions in the country. The second section describes the surveys utilized by this report, including topics covered and methodology, while the third section presents the survey findings. The final section of the report provides policy recommendations for improving public research performance and outcomes.

1.

The Bulgarian Public Research System: The Challenges



1. The Bulgarian Public Research System: The Challenges



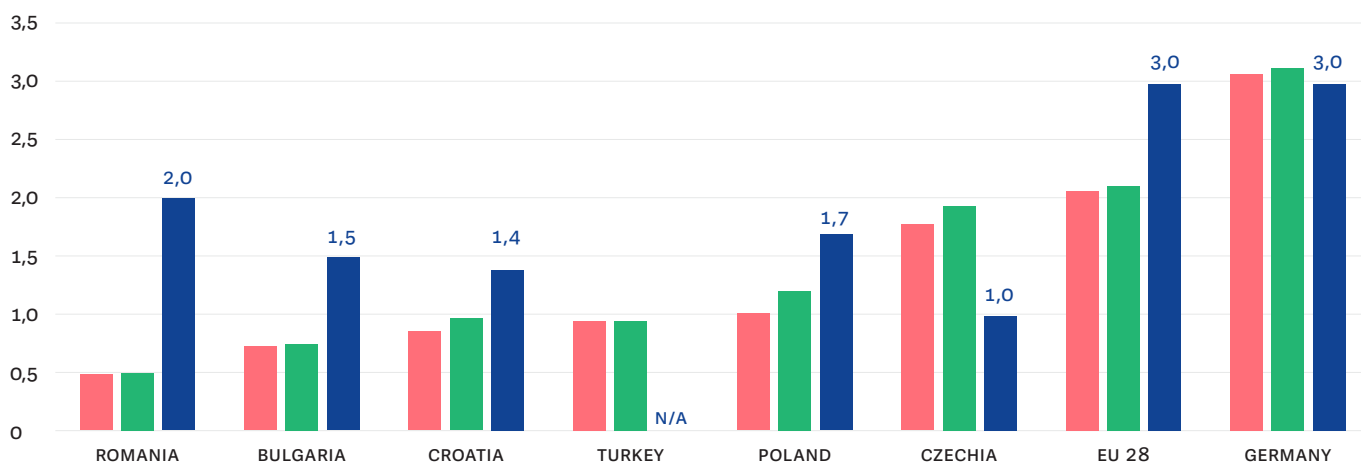
Public investments in R&D are low compared to peer² economies and public institutions suffer from a lack of stable funding and resources. Although steps in reforming and modernizing the public R&D system have taken place, further work is needed to consolidate research competences, better organize the sector, and improve performance standards and impacts.

Public research institutions in Bulgaria face important challenges in improving the quality and relevance of their research. We first discuss general trends, then turn to recent efforts at reform and finally describe the institutional structure of the research sector.

1.1 General Trends

Bulgaria lags behind all peers except Romania in terms of gross expenditure on R&D (GERD) as a percentage of GDP, which can be seen in Figure 1. GERD as a percentage of R&D has been trending down since 2015, dropping to 0.7 percent in 2018, well below the country's 2020 target of 1.5 percent of GDP and its new 2030 target of three percent. The country also has the lowest level of government budget appropriations on R&D (GBARD) per capita in the EU at €19.5 per inhabitant, compared to the EU 28 average of €206.3 per inhabitant.

Figure 1: Bulgaria lags behind most peers in terms of GERD as a percentage of GDP



Source: Eurostat.

● 2017 ● 2018 ● 2020 TARGET

2 For this country note, Bulgaria is benchmarked against the following peers: the Czech Republic, Croatia, Germany, Greece, Poland, Romania, Slovakia, and the EU 28 average.

The Bulgarian public sector plays a smaller role both in funding and performing R&D relative to peers. Bulgaria reports the lowest share of GERD financed by the national government among peers (Figure 2), and the public sector (higher education and government) performs a lower share of GERD than found in peer countries. In particular, Bulgaria's institutions of higher education contribute very little to R&D, only performing six percent of GERD in 2017, the lowest rate among peers by far and less than a third of the EU average (Figure 3).

Figure 2: The Bulgarian public sector played a relatively small role in funding R&D in 2017

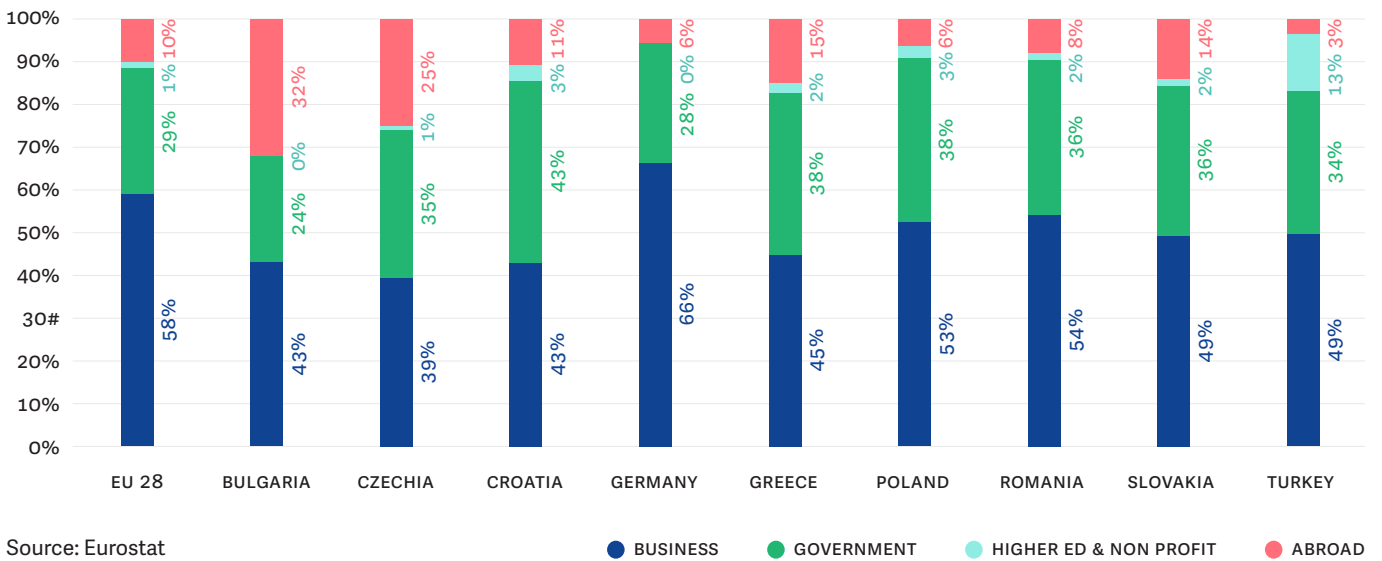
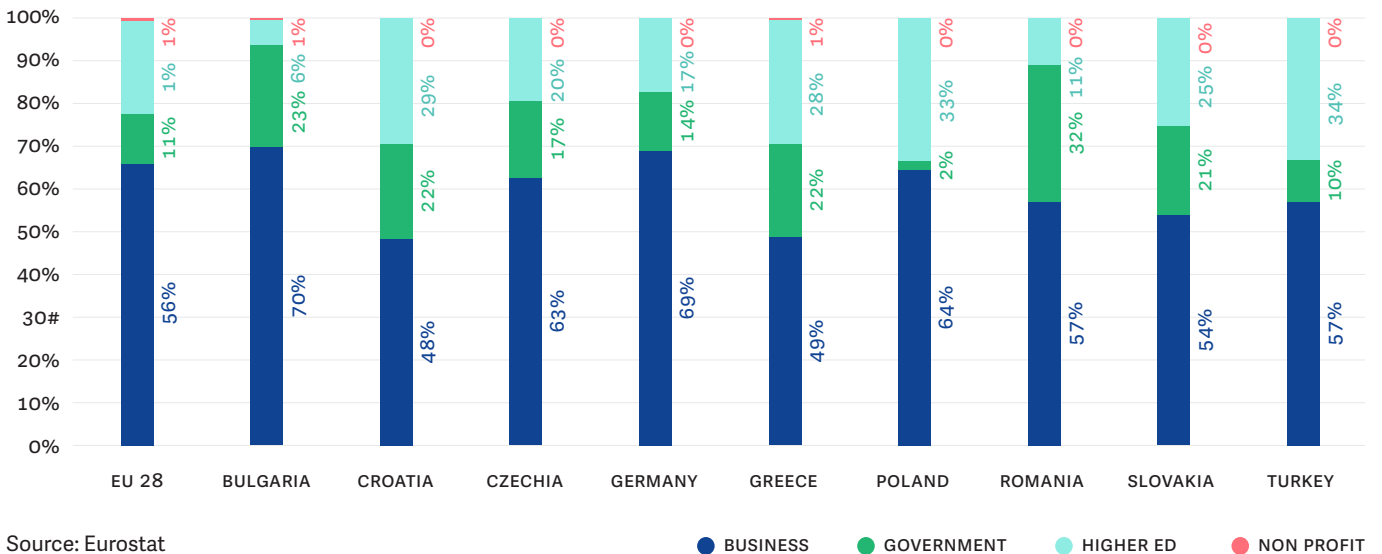


Figure 3: The Bulgarian public sector played a relatively small role in performing R&D in 2017



The low R&D contribution and poor performance of the public and higher education sectors are due to several issues, the largest of which is a lack of funding; Bulgarian research institutions are largely under-funded compared to peer institutions in Europe. The absence of lasting multiannual commitments for the support of scientific research has been cited as one of the main reasons for the deterioration of science and scientific performance in Bulgaria, and improving financial commitments are one of the main focus areas of the current *National Strategy for the Development of Scientific Research, 2017-2030*. Research funding for national research grant programs (as opposed to EU-funded programs) is very low and has been relatively static since 2014, with the total research grant allocations from the National Science Fund hovering at or below €12 million from 2014 to 2018, before increasing slightly to €15.6 million in 2019.

Another key factor in the poor research performance is the fragmentation of research capabilities across many small- or medium-sized public research institutions in different areas of specialization, which results in a high dispersion of competences and a lack of concentration of resources. There is a lack of critical mass of research talent necessary for specialization and impact due to this fragmentation and to the continuous exodus of research and technology talents in Bulgaria, which stems from low salaries and a poor incentive structure for public sector research careers (European Commission, 2015; World Bank, 2013).

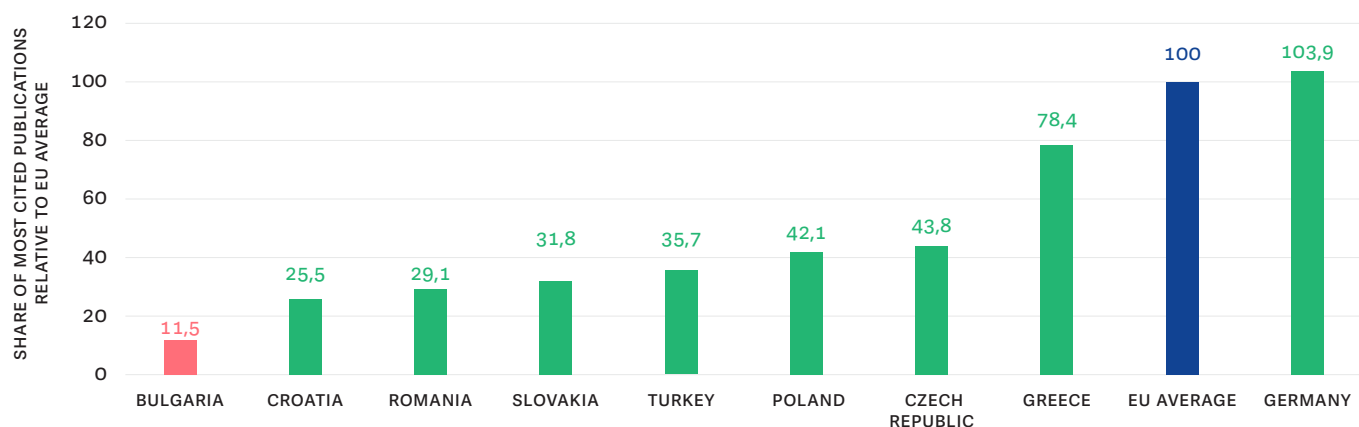
The recruitment of new scientists is a major challenge. As discussed in Zhechkov and Mahieu (2017), there are only 0.6 new doctoral graduates per 1,000 population (aged 25-34) in Bulgaria, compared to the EU average of 1.7, even though the number of doctoral candidates in the country almost doubled between 2000 and 2015. The lack of researchers demonstrates the need to stimulate human resource development policy in higher education and public research institutions and in the economy more broadly.

The lack of national funding and resources for public research in Bulgaria underscores the importance of EU structural funds as a source of STI investment in the country, as the current Operational Programme for Science and Education for Smart Growth 2014-2020 (OP SESG) represents the only new source of funding for public research in a fiscally constrained environment. OP SESG has thus far focused exclusively on the development of a series of research centres (the Centres of Excellence [CoEs] and Centres of Competence [CoCs], detailed further in Section 1.2) that aim to bring together the research capabilities of the BAS, national universities, and other key scientific and business organizations, with the primary objectives of consolidating research capabilities and improving research infrastructure. Notably, OP SESG does not currently include research grant programs or technology transfer support programs outside of the CoC and CoE projects. Implementation of the CoC and CoE projects has been slow, with the funding only being allocated in 2019, which has added to the fiscal constraints experienced by public research bodies over the last five years.

In terms of research outputs, Bulgaria lags behind most of its peers in both quantity and quality of research outputs, though publication productivity has improved markedly in recent years, with publication output increasing at a rate of almost 9 percent per year from 2015 to 2019. Research outputs, in terms of scientific publications and intellectual property (IP) are lower than in most peers and tend to have little impact on the international scientific community, while commercialization outcomes (licenses and startups) from public research are extremely limited. Only a small number of Bulgaria's PROs conduct research that meets international standards (World Bank, 2013; Scimago, 2020), and beyond the Bulgarian Academy of Sciences and a few high performing universities in Sofia, there are very few national institutions that meaningfully contribute to the scientific literature.

Bulgaria's publications tend to be less cited and less impactful than those of its peers. Bulgaria ranked last among its peers in scientific publications among the top 10 percent of most cited publications worldwide as a percentage of total publications in the country in 2019 (Figure 4). Bulgaria and Romania had the lowest share of publications that were cited from 2013-2018, with 46 percent of all publications going uncited during that timeframe (Scimago, 2020).

Figure 4: Bulgaria lags behind all peers in top ten percent most cited publications as a share of total national publications relative to EU average, 2019



Source: European Innovation Scoreboard (2019)

Other bibliometric indicators such as the H-index³ and the average citations per publication also show under performance compared to most peers and leading European economies (see Appendix II). During the period 1996-2018, Bulgaria ranked the last among peers in the H-index,

3 The H-index is a metric that measures both the productivity and citation impact of a body of publications. The index is based on the most cited papers in a set and the number of citations that they have received in other publications. 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 publishing and citing frequencies. For more information, see Hirsch 2005.

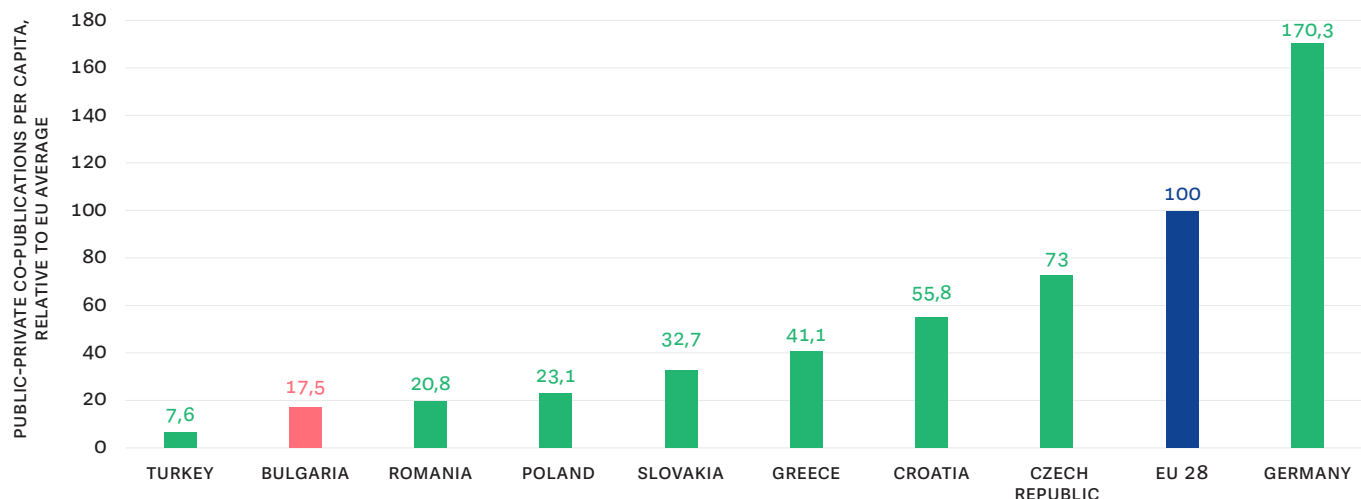
which is a measure of scientific impact of publications based on citations. In terms of average number of citations per publication, however, Bulgaria ranked slightly above Romania, Croatia, Slovakia, and Poland, but only half of the average number for German publications.

Looking at the institutions contributing to scientific production, the Bulgarian Academy of Sciences plays an outsized role nationally in academic publication outputs; researchers from the Academies authored or co-authored 46 percent of the publications in Bulgaria from 2010 to 2019. However, the importance of BAS has diminished somewhat in recent years, with the University of Sofia and a few other high-performing universities in the Sofia region accounting for a larger share of the competitive funds available and producing research outputs of similar quality to those of BAS. Only the Academies, the University of Sofia, and the Medical University of Sofia had an H-index score above 50 from 2010-2019 (See Appendix Table A2.1).

For a relatively small national research system that is part of the European research area, international collaborations (both within and outside the EU area) should be an area of emphasis for Bulgarian research institutions, yet participation in international networks of research, in terms of international co-publications adjusted per million inhabitants, is low relative to peers (see Figure A2.4 in Appendix II).

Bulgaria also underperforms relative to peers in public-private collaboration, with the number of public-private co-publications per capita ranking behind all peers except Turkey and only 18 percent of the EU average in 2019 (Figure 5).

Figure 5: Bulgaria is well below the EU 28 average in public-private co-publications per capita, 2019



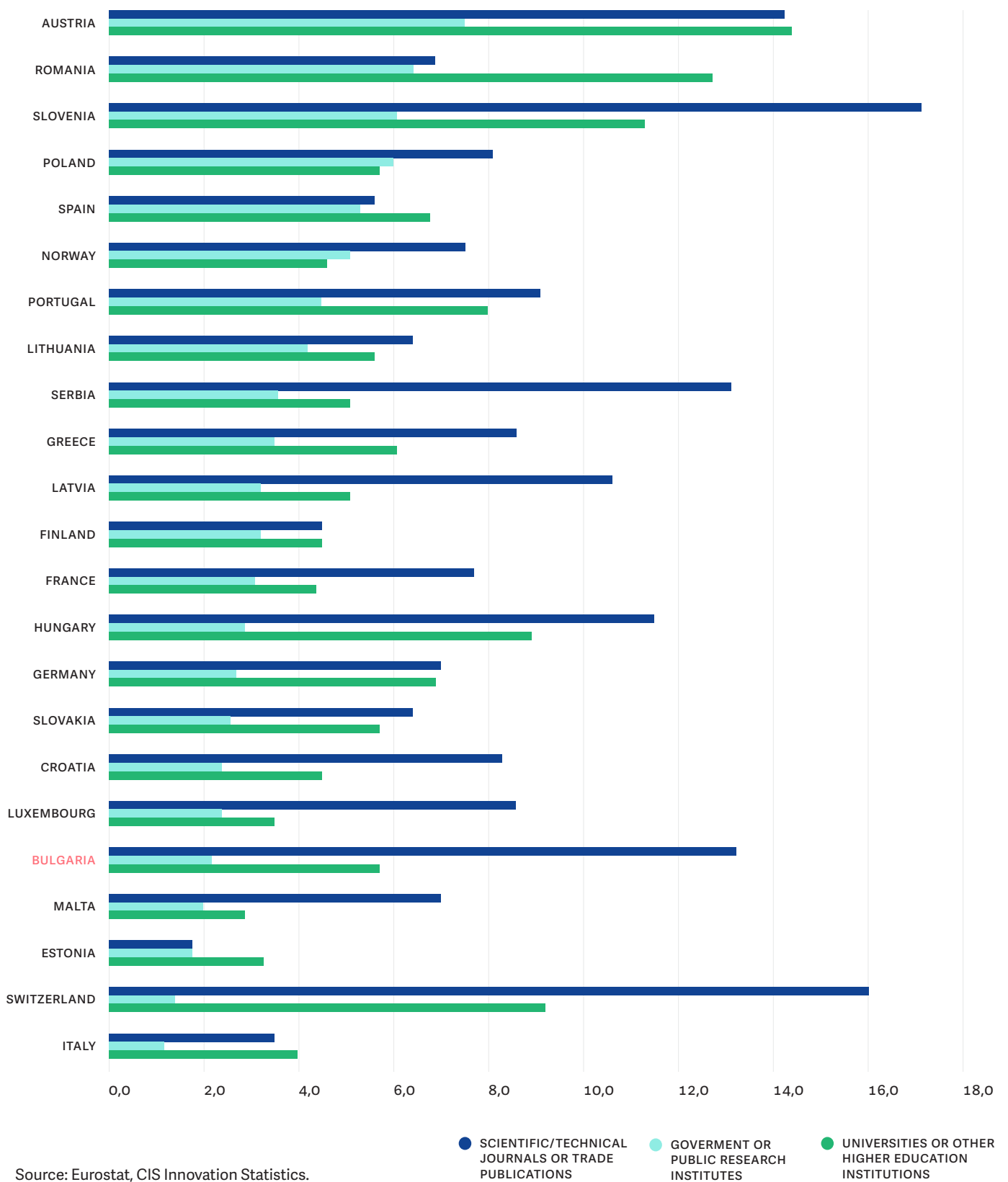
Source: European Innovation Scoreboard (2019)

A key factor in the weak linkages between public R&D institutions and industry is low demand for innovation from the private sector. Bulgarian firms very rarely rely on knowledge from public research institutions for their innovation activities, as reported in national innovation surveys (Figure 6). Only two percent of firms consider knowledge from government or public research institutes as an important source of innovation and less than six percent believe that information from higher education institutions are a meaningful source of knowledge and innovation. Yet the share of firms that consider scientific publications as very important source of information is not minor (13 percent, or about twice the European average), which suggests that companies mostly rely on international scientific outputs, rather than on local institutions, as sources of innovation and new product development. This suggests either a lack of relevance of local research for business innovation and/or insufficient quality or novelty of this research to impact innovation in domestic firms.

A weak absorptive capacity of firms also limits the potential for interaction and collaboration with public research institutions. Bulgaria ranked 47th globally in the economic complexity index (ECI) in 2018, reflecting lower levels of economic sophistication than most peers in the types of products and services in the country's export basket (Observatory of Economic Complexity, 2020). Commodities, such as oil, copper, and wheat, and basic assembling (e.g. pharmaceuticals) continue to have a large share of the export basket. Furthermore, there are major constraints to competitiveness in several sectors, which make innovation and R&D second order priorities.⁴ The labor and skills shortages are also cross-cutting innovation obstacles in Bulgarian industries (World Bank, 2015).

4 For instance, in food processing industries the lack of technological and equipment upgrading and insufficient supply chain is a major constraint for competitiveness, whereas in R&D-based industries such as pharmaceuticals the lack of transparent regulations and procedures for clinical trials are major issues (World Bank, 2015).

Figure 6: The importance of knowledge sources of innovation as reported by product and process innovators, 2016



1.2 Policy Reforms for HEIs and Public Research Organizations

The country's current science technology policy framework is set by several key documents, including the *Innovation Strategy of the Republic of Bulgaria* of 2004, the *National Strategy for Development of Research 2020* of 2011, the *Innovation Strategy for Intelligent Specialization of the Republic of Bulgaria 2014-2020* (i.e., Smart Specialization strategy) of 2014, as well as the current *National Strategy for Development of Scientific Research 2017-2030*. These documents lay out the legal basis for developing STI policies and programs, define the government ministries and agencies involved in STI policy formulation and implementation, and establish the mechanisms for funding research and innovation programs. Under this framework, the key national actors for research policy are the Ministry of Education and Science (MoES), which oversees the public education and research system and designs and develops national science and scientific research policy; the National Research Fund (NSF), which is the primary national funder of basic research; and the Managing Authority for OP SESG, which implements OP programs focused on science and education funded by ESF and ERDF.

Bulgaria's policies and legislation governing public research have seen continuous reform since early 1990s. These efforts include laws governing public research institutions, development of the national IP system, and establishment of statutory career paths and incentives for public sector researchers.

The 1990s saw the passage of important legislation that laid the framework for the establishment and operation of public research institutions (HEIs and PROs) in the *Higher Education Act* of 1995 and laws governing patents, utility models, and copyrights (1993), and industrial designs (1999). The 2010 *Law on the development of academic staff* and the corresponding *Rules for the implementation of the Law on the development of academic staff* established statutory incentives for public researchers to engage in impactful research by stipulating the minimum national requirements for obtaining an academic title or being promoted into an academic title. The 2018 amendments to the *Rules for the implementation of the Law on the development of academic staff* added career development requirements related to IP generation (for example, number of applications for patents, number of published patents, and number of copyrighted works), depending on the researcher's field of study.

The last five years have seen a number of important regulatory developments related to technology transfer and commercialization of public research. The 2016 amendments to the *Higher Education Act* state that every HEI should have a system for IP protection, management, and ownership. It also removed the nonprofit status of HEIs and PROs and gave them the right to own shares in other companies and establish spin-offs. More recently, a new regulation set out the rules for

PROs and HEIs to create commercial units: the 2020 *Terms and Conditions for Establishment of Commercial Companies from State Higher Schools for the Purpose of the Economic Realization of the Results of Research and Objects of Intellectual Property* regulation defines the procedures for the establishment of commercial companies by public research institutions. Public HEIs/PROs can establish limited liability companies and joint stock companies in accordance with the *Terms and Conditions for Establishment of Commercial Companies*, as well as hold shares in such companies. While the amendments to the career paths of academic staff are well understood and fully implemented by public research institutions, there is still a large degree of confusion around the recent reforms that allow the establishment of academic spinoffs. Bulgarian institutions find the *Terms and Conditions for Establishment of Commercial Companies* vague, lacking in concrete details and procedures needed to create such spinoffs.

In parallel to these legal developments, many recent national R&D strategies have focused on strengthening the country's lagging STI capacity and ensuring long-term continuity in the implementation of national priorities. The most important of these strategies are the *Better Science for a Better Bulgaria 2025* and succeeding *National Strategy for Development of Scientific Research of the Republic of Bulgaria 2017-2030*, both developed by MoES. *Better Science 2025* lays out plans for several structural reforms, such as a gradual shift to the use of performance-based research funding (PBRF), an increase of competitive funding (i.e., project-based funding) as a share of total funding for public research, and consolidation and other measures to address fragmentation of the research system. The *National Strategy for Development of Scientific Research* sets out and defines activities and measures in many of the policy areas envisioned in *Better Science 2025*.

PBRF was introduced in the *Strategy for the Development of Higher Education in Bulgaria 2014-2020*, with the aim of concentrating resources and consolidating research competencies. A 2014 revision to the *Higher Education Act* states that at least ten percent of direct institutional funding to public research institutions should be performance based. The BAS General Assembly has adopted an even higher target of 20 percent of the total government subsidy to BAS institutions should be performance based. However, at present the share of direct institutional funding that is performance-based varies from roughly 2.5 to five percent, depending on the type of institution. Performance is measured through a complex set of indicators, which include quality of education, the volume and value of research and publication outputs, the educational environment, services, direct contribution to the labor market, and accreditation scores. In 2018, the PBRF indicators were amended to include measures of knowledge and technology transfer activities, including research funding received from external sources and commercialization revenue (a full list and weighting of Bulgaria PBRF indicators is provided in Appendix III).

The development of six Centres of Excellence and ten Centres of Competence, funded under the OP SESG, are key components of the research system consolidation effort. These Centres are intended to bring together the research capabilities of the BAS, national universities, and other key scientific and business organizations, with the objective of consolidating research capabilities, improving research infrastructure, forming partnerships and linkages between research actors, and raising the level and market orientation of the research activities of participating research organizations. However, the design and implementation of these Centres have faced a number of challenges, including delays due to administrative and public procurement processes. Other challenges include the supply-driven design of the Centres, lack of coordination, and uncertainty as to how the Centres fit within a larger national R&I vision. The EC Joint Research Centre is currently providing expert support services to the CoC and CoE effort with a focus on developing improved legal and organizational frameworks and guidance on the use of state aid, and technology transfer and commercialization practices. The JRC recommendations are intended to inform the development of the centers and their future sustainability.

Another key initiative aimed at developing research infrastructure and spurring public-private collaboration and technology transfer is the Sofia Tech Park (STP). STP, which opened in 2015, is a public-private partnership that provides commercialization support services, educational programs, and incubation space for companies in ICT, energy, life sciences, as well as other tech-based industries. STP is the first science and technology park in Bulgaria and received funding from EU operational programmes from both the current and previous programming periods. Several leading universities, Sofia University, Technical University of Sofia, and the Medical University Sofia, are members of a research consortium that manages the laboratories and other research infrastructure in the park, though no other universities or PROs have a role in STP. A recent evaluation of the Park by the European Commission Joint Research Centre found that the park is highly focused on upstream (or academic) research activities, indicating a lack of interest and engagement from the private sector, and STP has thus far experienced a lack of R&D commercialization, IP generation, start-up finance, and similar activities to target a pipeline of start-ups and spinouts in non-ICT sectors (European Commission 2018b).

1.3 Public Research Institutions in Bulgaria

The public research sector in Bulgaria comprises public higher (or tertiary) educational institutions; the Bulgarian Academy of Sciences (BAS); the Agricultural Academy (AA); and a small set of research institutes and hospitals under different sectoral ministries or agencies. The largest research-performing institutions in Bulgaria are the BAS institutes, followed by several Bulgarian universities that are based in the Sofia capital region (e.g. Sofia University and Technical

University of Sofia). According to recent data, the number of researchers employed by industry and academia has been steadily growing since the early 2000s (particularly in academia), while the number employed by the government and PROs has been declining over the same period (Zhechkov and Mahieu, 2017).

The national *Higher Education Act* defines four types of HEI institutions: colleges (non-university higher education institutions); universities; specialized higher education institutions (equivalent to technical universities); and academies (such as the institutions of the BAS and AA). The Higher Education Act specifies all of these as self-governing and autonomous institutions overseen by MoES.

Bulgaria's HEI system is comprised of 51 institutions, of which 14 are private and 37 are public institutions. Of the 51 HEIs in the country, 37 have STEM-related programs and degrees and 12 have university research centers.

There are also 91 PROs in Bulgaria:

- The Bulgarian Academy of Science (BAS), a public-funded autonomous body overseen by the Ministry of Education and Science and composed of 50 independent institutes, with 36 institutes in STEM fields. BAS is the preeminent Bulgarian research organization.
- The Bulgarian Agriculture Academy (AA) is a public research organization, managed by the Ministry of Agriculture, Food and Forestry that carries out fundamental and applied research and service and support activities in the fields of agriculture, breeding, and food. AA is composed of 25 institutes; 4 research centres; and 13 experimental stations.
- There are also three military research centers, three national medical centers, and four university hospitals.

2.

Survey Results: Enabling Factors and Policy Drivers of Technology Transfer Performance



2. Survey Results: Enabling Factors and Policy Drivers of Technology Transfer Performance

This study aims to capture the extent to which Bulgarian public research institutions (HEIs and PROs) transfer knowledge and technology to industry (and to other innovation actors). In the European Union and around the world, there is a growing recognition of the need to demonstrate the returns of public investments in R&D – i.e., to show how public investments in research activities lead to economic and societal benefits in the form of new knowledge, new or improved products and services, new companies, and ultimately to improved productivity and living standards. Identifying the returns on public R&D investments requires recognition of the different channels through which research impacts economic development and innovation, including particular focus on the factors that enable or constrain industry-science collaboration and knowledge transfer (Aridi & Cowey, 2018). These factors include availability of advanced skills and human capital and the ability of that human capital to move across sectors and institutions, as well as incentives for public-private collaboration (Zuniga, 2020). In designing research and technology transfer assessments, governments also need to consider the differences across scientific disciplines when measuring and evaluating the results of research and technology transfer activities.

This study uses two surveys designed to measure Bulgarian HEIs and PROs knowledge and technology transfer and the factors that influence these activities⁵: 1) an online survey of active public sector researchers in science, technology, engineering and mathematics, conducted from February to April 2020;⁶ and 2) an in-person surveys of administrators from Bulgarian PROs and university TTOs between March and June 2020, based on institutions' academic field, location, and size.⁷ More details on the methodology, survey population, and a complete list of institutions interviewed can be found in Appendix I.

5 These surveys were conducted as part of the World Bank Public Expenditure Review on science, technology, and innovation.

6 The sample of public sector researchers was drawn from the website of the National Center for Information and Documentation (NCID), which maintains an online register of public sector research staff. Academic fields were identified using the ISCED-F 2013 classification provided by UNESCO, which identified 4,260 researchers; 739 completed responses were received.

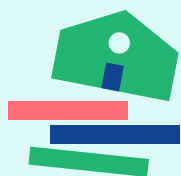
7 A total of 13 PROs and seven university TTOs were interviewed.

The surveys cover three key enabling factors that influence a public research organization's ability to perform high quality research, engage in knowledge exchange activities, and translate research results into societal and economic impacts (Correa and Zuniga, 2013; OECD, 2003; 2018; Zuniga, 2020; Cirera *et al.*, 2020):

- **Governance and institutional settings:** These factors include institutional autonomy and governance structures; external stakeholder representation in governance; funding schemes, such as the inclusion of performance funding systems; and monitoring and evaluation practices (OECD, 2014; 2018).
- **Research competences, and research quality and relevance:** These factors include resources and policies for carrying out research, having adequate human capital for research and administration, and connection with industry and societal needs for knowledge and innovation.
- **Technology transfer policies and regulatory frameworks:** These factors include the set of rules and regulatory frameworks (incentives) for institutions and researchers to engage in collaboration and technology transfer, and funding and specialized resources for technology transfer, such as IPR skills and management.

Each of these enabling factors are explored in the following sections, along with an analysis of the research outputs and knowledge and technology transfer activities of the surveyed institutions.

2.1 Governance and Performance Evaluation



In Bulgaria, in principle most PROs and all universities are autonomous as defined in their governing laws and statues. However, their governance and level of independence, including at the operational decisions and policy levels, differs widely across institutions, especially across PROs. The survey shows that PROs, in particular, suffer from weak governance design, as they do not include external actors (such as industry representatives) on their governing boards or councils. Universities have industry representation on their governing bodies, but in practice do not consult with the business sector for the definition of research and educational agendas and strategies. The survey also confirms that most public institutions surveyed are heavily reliant on institutional block funding, as opposed to PBRF or competitive funding. These factors limit the effective functioning of these institutions and their performance, in terms of interactions with external actors and knowledge transfer impact.

The governance of research institutions, including the level of institutional autonomy in decision making, funding schemes (e.g., the combination of block funding with performance-based funding and competitive funding) and monitoring and evaluation systems, influences the effectiveness of research and knowledge exchanges (Zuniga, 2020; Cirera et al., 2020). The experiences of leading PROs in Germany, Taiwan, Japan, Australia, and the US show that industry involvement in steering and advisory boards and funding schemes are key factors that influence how relevant research is to industry and society, as well as influence the level of knowledge transfer outside of institutions. Governance structures also influence the way institutions maintain research standards, engage in collaborative research, and interact with other actors in the innovation system (Intarakumnerd and Goto, 2018). This section reports survey results on institutional autonomy, stakeholder representation in governance, institutional funding sources, and monitoring evaluation and performance management.

2.1.1 Institutional Autonomy

In developed countries, institutional autonomy has been key for PROs and HEIs to develop their own internal policies and procedures regarding major strategic decisions, such as recruitment procedures, criteria for career promotion, rules regarding IP creation and technology commercialization, and the setting-up of support programs for knowledge transfer and commercialization (Zuniga, 2020). Recent evidence from Cirera, Kuriakose and Zuniga (2020) for East Asian countries (Malaysia, Thailand and Vietnam) shows the key role autonomy plays in enhancing technology transfer and collaborative linkages with industry in both PROs and university research departments. Autonomous institutions (both PROs and HEIs) are by far more intensively engaged in collaborative linkages and technology transfer activities.

Although the legal framework officially makes most Bulgarian PROs and higher education institutions autonomous (although there are some exceptions among the BAS institutions, as described in Box 2), in practice the level of independence and autonomy varies across PROs and across decisions. PROs tend to look to their parent ministries for the definition of institutional policies and setting research agendas, despite their legal autonomy to act independently in these areas. As described in the next section of this report, autonomy is limited by a large dependence on public funding, which means PROs focus their strategies and policies on the research objectives, targets, and indicators attached to institutional funding from their parent ministries.

Box 2: Governance Structure of the BAS and AA



Bulgarian Academy of Sciences

BAS was established by the *Bulgarian Academy of Sciences Act*, which specifies the Academy's structure and management, as well as the conditions for creating, transforming and closing down the BAS institutes and the other independent research entities. However, the institutes under BAS do not have uniform legal statutes: while most institutes were registered under the *BAS Act*, granting them the status of a public research organization, some of the institutes were established by a decision of the National Assembly or the Council of Ministers, which makes them autonomous units following national and European regulations. Still other BAS institutes were created through consolidation of several separate units by a decision of the General Assembly of BAS and are not recognized by MoES as public research organization, creating problems related to funding, eligibility for research programs, and reporting. BAS' highest governing body is the General Assembly that oversees and guides BAS as a whole, while each BAS institute has a scientific council that guides the strategic development and research agenda of the specific institute. By statute, industry representation is not permitted on these scientific councils.



Agriculture Academy

The Bulgarian Agricultural Academy is classified as an autonomous organization under the Ministry of Agriculture, Food and Forestry according to the 2018 *Agricultural Academy Act*. The management structure of AA consists of a Board of Directors and an Executive Bureau, while individual institutes have a director's council, which performs a similar function to the BAS scientific councils. Like BAS, by statute industry is not represented in the governance of AA institutions.

Universities, as defined by the *Higher Education Act* (see Box 3), are independent and self-governed; they can independently define their governing structures and regulations, their management, research strategies, and the development of curricula and research projects. Unlike the BAS, university boards must include industry representatives, although survey responses show that, in practice, industry is not consulted in the definition of research or education agendas at Bulgarian universities.

Box 3: Governance in Higher Education Institutions (HEIs)



HEIs are governed by the Higher Education Act, which states that Bulgarian higher education institutions have academic autonomy, including the academic freedoms and academic self-government. Academic autonomy is expressed in election of the internal governing bodies, the right to regulate institutional structures and activities based on internal regulations, management of the structure and career path of scientific and teaching staff in accordance with the national legislation, development and implementation of curricula and research projects, selection of the specialties in which training is carried out, formation of own funds and conditions for their spending, the ability to conclude contracts for carrying out scientific and applied research; etc. Unlike BAS, the *Higher Education Act* specifies that universities' boards of trustees must include representatives from the private sector.

Sources: *Bulgarian Higher Education Act* and European Commission (2017)

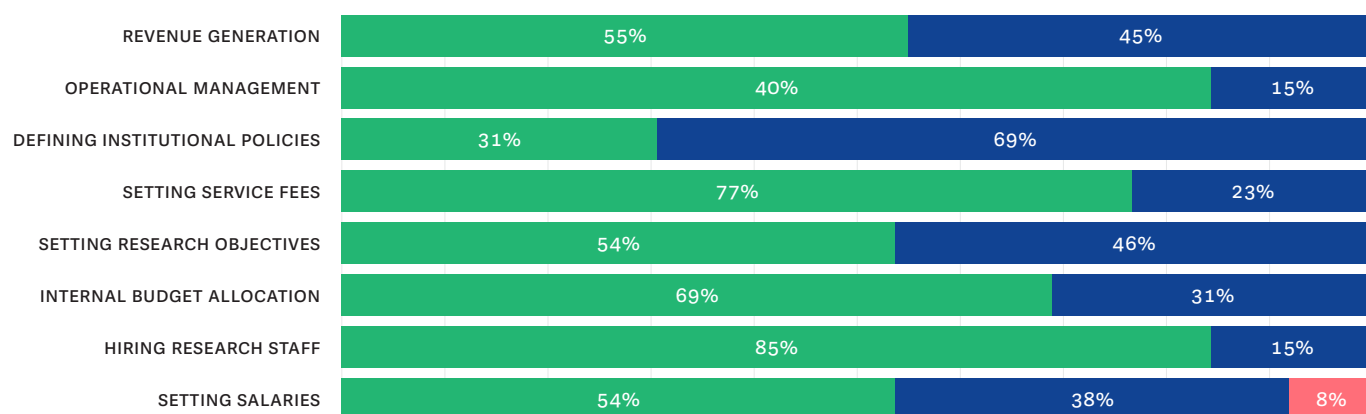
The survey shows that perceived autonomy varies a lot by institution:

- University TTOs perceive they have much less autonomy than PROs. In every area included in the survey, from operational management to setting research objectives to hiring staff and setting salaries, TTOs believe they have less autonomy than PROs.
- Surveyed PROs and HEIs believe they have the most autonomy in the operational management of the institution, with 85 percent of PROs and 40 percent of TTOs believing they are fully autonomous in the day-to-day operations of their institutions (Figures 7 and 8). PROs also largely feel they have full autonomy in hiring research staff, with 85 percent reporting full autonomy in staff hiring.
- However, only half of the interviewed PROs and no TTOs believed they have full autonomy in setting staff salaries. While all public research institutions have legal autonomy to set staff

salaries, HEI budgets (including staff budget pools) are allocated based the total number of students at the institution. Therefore, as the survey results show, in practice HEIs feel constrained in their ability to set salaries for research staff. A 2015 peer review of the Bulgarian research system finds that, while Bulgarian institutions have a high level of autonomy in terms of setting salaries when compared to other EU countries, this autonomy is meaningless because the overall low level of funds available for salaries gives PROs and HEIs little ability to use their discretion to attract researchers and reward excellence (European Commission, 2015).

- PROs and HEIs reported less autonomy in defining institutional policies and setting research agendas. Only 21 percent of the surveyed PROs and no TTOs feel they were fully autonomous in defining institutional policies, while 60 percent of TTOs believe they have no autonomy in setting institutional policies. Roughly half of surveyed PROs and 20 percent of TTOs believe they have full autonomy in setting research objectives (Figures 7 and 8). It should be noted, however, that very few institutions reported having a research strategy in place (see Section 2.2). These responses are likely due two key factors: First, many public institutions feel that they do not have clear institutional missions and objectives (see Section 2.1.4), limiting their ability to develop long-run research objectives. Second, PROs and HEIs depend heavily on public funding (e.g., direct institutional funding, operational programmes, National Science Fund programs, or government contracted research) for a large share of their budgets, and thus they focus their research agendas on the priorities defined by these government programs.

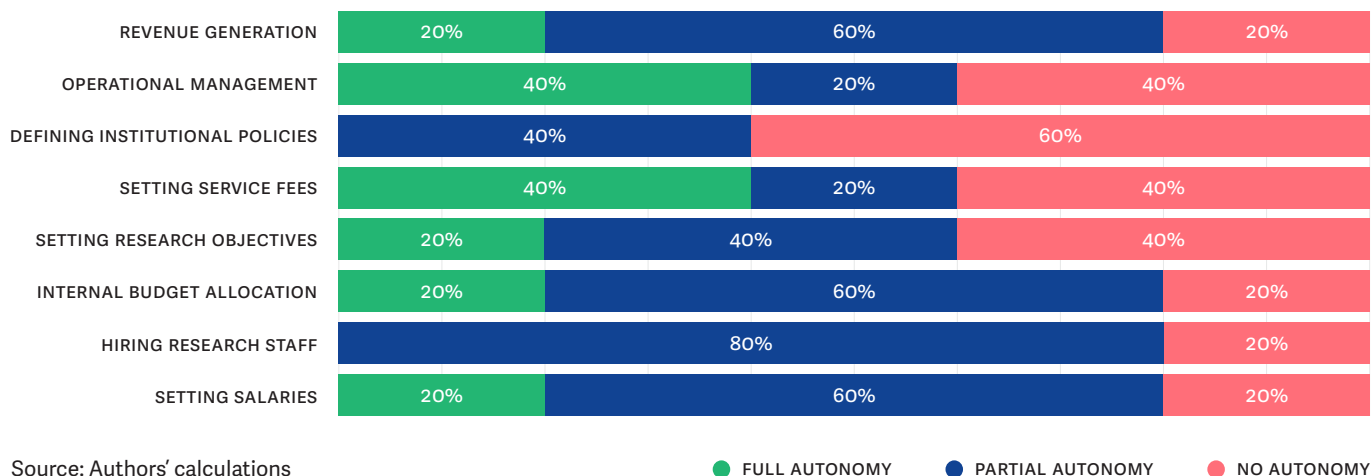
Figure 7: Perceived PRO Autonomy



Source: Authors' calculations

● FULL AUTONOMY ● PARTIAL AUTONOMY ● NO AUTONOMY

Figure 8: Perceived TTO Autonomy



2.1.2 Stakeholder representation in governance

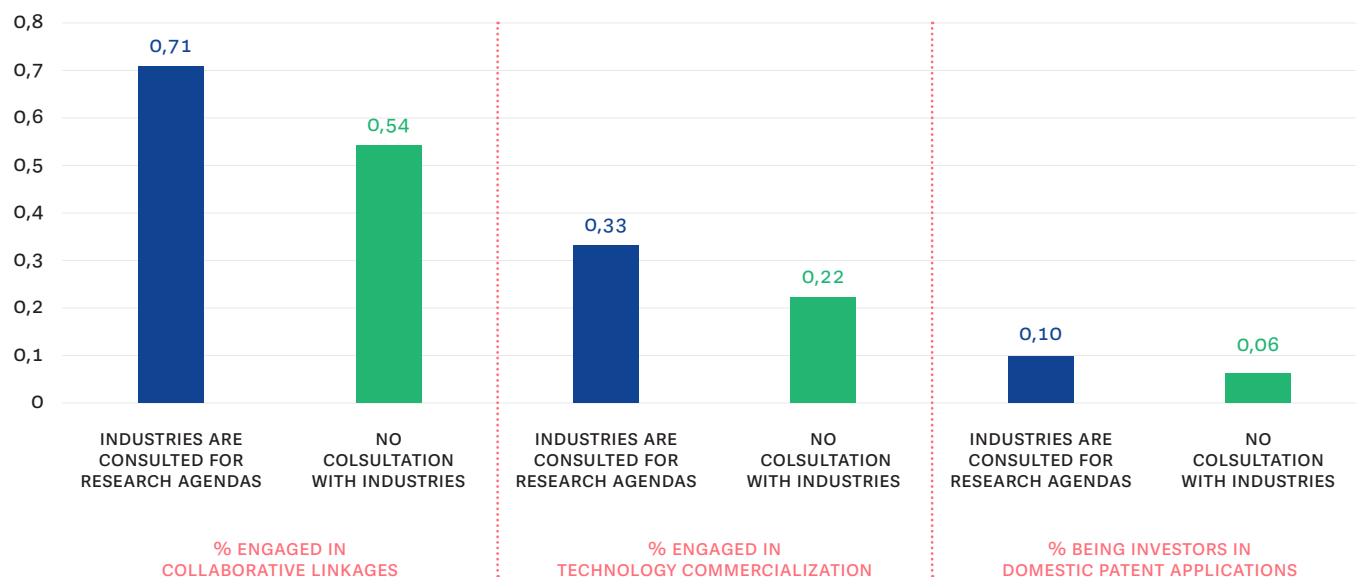
In most OECD countries, public research institutions' governance structure includes a board, which is typically the main decision-making body responsible for setting institutional priorities in education (in the case of universities), research, and knowledge transfer. Stakeholder representation (e.g., private sector, government, and civil society organizations) in such governing bodies is important to help institutions understand the research and innovation demands of society and industry and to develop research agendas that respond to these demands. A recent study by the OECD (2018) shows involvement of external stakeholders in governance is a widespread practice: university boards in 28 of the 34 countries studied have outside stakeholder representation (industry or government-civil society or both); in 25 countries, these boards include private-sector representatives – mostly from large firms, but sometimes from SMEs – while 21 countries have boards with representatives from both the private sector and civil society.

Bulgarian PROs do not have industry representatives on governing boards due to statutory restrictions, nor is industry consulted on the definition of institutional research priorities by PROs or HEIs. These statutory restrictions do not apply to universities, and Bulgarian universities are mandated to have industry representation on governing boards. All public research institutions have some form of governing body (e.g., scientific councils, boards of trustees, etc.) to help articulate research priorities and objectives; of the surveyed institutions, 93 percent of PROs and 66 percent of HEIs reported that they have a steering or trust board for the definition of strategic goals. However, for PROs the lack of formal consultation mechanisms with industry and society limits the effectiveness of such steering bodies and hinders the relevance of research undertaken by these organizations.

None of the surveyed organizations have formal mechanisms to consult with industry on defining research priorities. This is a major gap in the link between the public and private sectors and means that decisions that inform the supply of public research are not necessarily in line with industry demands. However, 53 percent of public researchers believe that their institutions consult with industry for the definition of research agendas and human capital formation, which indicates that more informal consultations with industry are occurring at these organizations.

The consideration of industry demands for knowledge (largely in the form of technological challenges) in public research agendas is a fundamental factor in making publicly-funded research relevant to the economy, and mechanisms for soliciting industry input must be in place in public research institutions. Evidence from the researcher survey (Figure 9) shows that researchers whose institutions have mechanisms in place for consultation with industry show higher propensity to engage in collaborative linkages and technology commercialization. Researchers in institutions that have such mechanisms report a much higher rate of engagement in collaborative research (71 percent) and commercialization activities (33 percent), as opposed to researchers located in institutions without such consultation (54 percent and 22 percent respectively).

Figure 9: Researchers whose institutions consult with industry on research priorities engage in more knowledge exchanges and technology transfer activities



Source: Authors' calculations

2.1.3 Institutional Funding Sources and Performance Implications

Sources of funding, to a large extent, influence the strategic focus and innovation activities of research organizations. For example, performance-based funding can help direct PROs to further engagement in technology commercialization (if commercialization outcomes are part of an institution's performance metrics), whereas access to private funding for R&D allows institutions to strengthen linkages with industry. Performance-based funding, where a portion of the agency budget is allocated according to specific performance targets, is way to incentivize desired institutional behaviors and outcomes, such as research excellence, greater industry-research linkages, and knowledge transfer (see Box 5). In Europe, the introduction of performance-based funding systems has been one of the central mechanisms through which many EU member states have tried to increase the effectiveness and performance of public sector research systems (European Commission, 2011; Jonkers and Zacharewicz, 2016).

External funding is also highly encouraged by policy makers (e.g. industry funding and competitive grants) as a signal of research relevance and linkages with industry and the international community in research and innovation. Boxes 5 and 6 report examples of performance-based research funding systems in Scandinavian countries and Czech Republic.

Box 4: Bulgarian PRO/HEI funding schemes



Bulgarian Academy of Sciences

For the Bulgarian Academy of Sciences, institutional funding represents the largest source of funding overall, on average making up over 45 percent of funds received by institutes in 2018. Institutional funding for BAS is made up of three components:

1. Block funding (i.e., unconditional funding) makes up about 85 percent of direct institutional funding of total annual revenue for BAS institutes;
2. Performance-based funding, which makes up approximately 10 percent of direct institutional funding for BAS institutes and is allocated based on reported scientometric impacts, the research capacity of the unit, the number of PhD students, and external funds raised; and
3. Facility overhead and maintenance funds, which make up the remaining five percent of direct institutional funding.

Internal revenues (revenues from the commercialization of IP; access to research infrastructure, services provision, fees, etc.) were the second largest funding source in 2018, representing on average 28 percent of funding received by institutes. Competitive funding (project-based funding and collaborative research agreements) was the smallest source of funds in 2018, making up on average about 25 percent of funding received by institutes.



Agricultural Academy

The budget for the Agricultural Academy primarily comes from direct institutional funding, which accounted for 63 percent of AA funding in 2017 and 2018. AA is eligible to receive performance-based funding, but it is difficult to discern the exact share of direct institutional funding that is performance based.⁸ All other funding sources, which include revenues from research contracts and consulting services, funding from competitive grant programs,

⁸ Correspondence with MoES indicates that PBRF makes up a maximum of three percent of total direct institutional funding to AA institutions.

revenue from commercialization, and other sources, accounted for the remaining 37 percent of AA funding. It is difficult to separate these external revenue sources from each other due to the way AA funding is reported.



HEIs

Bulgarian HEIs receive direct institutional funding for research activities amounting to approximately ten percent of their budget for education. Like BAS and AA, HEIs are eligible to receive performance-based funding.⁹ A 2003 ordinance stated that each HEI's academic council should determine the internal allocation of the funding among professors, researchers, and departments on a competitive basis. However, in practice these councils instead aim to maintain a relative balance of funding among departments, faculties, natural and social sciences. Between 2011 and 2014, HEIs allocated an average of 2.6 percent of their budget on research. A 2016 ordinance removed much of HEIs autonomy to internally allocate budgets (Zhechkov and Mahieu, 2017). Universities can also receive other external funding for research through contract research, donations, and other sources.

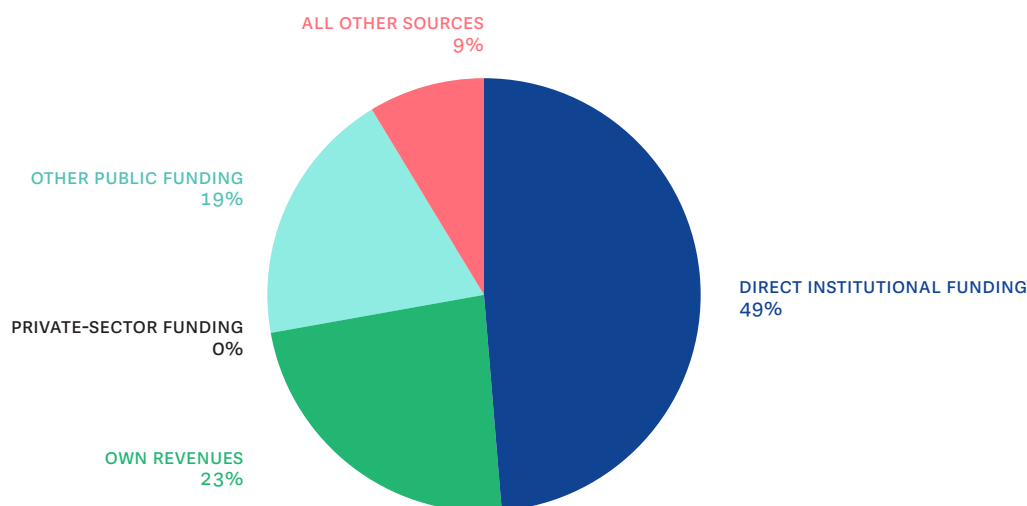
Source: BAS 2019 Annual Report; Agriculture Academy 2019 Annual Report; Ministry of Education and Science 2019 Annual Report

Interviewed institutions are highly dependent on direct institutional funding, accounting for about half of total funding (49 percent) for PROs (Figure 10). PROs' own revenues from consulting, contracts, and fees made up 23 percent of funding received; other public funds, largely in the form of competitive grants, represented 19 percent of funds, while private-sector funded research was less than one percent of funding received (only two of the 13 surveyed PROs received any funding from the private sector). In principle, this ratio of own revenues (in total funding) is not far from the average in European PROs, although it is still low compared to leading PROs such as VTT in Finland, where about two thirds of funding comes from external sources, or the Fraunhofer Institutes in Germany in, where one third of total funding is self generated.

9 Correspondence with MoES indicates that PBRF makes up a maximum of three percent of total direct institutional funding to public HEIs (private institutions are not eligible to receive PBRF).

The survey of public researchers also shows low levels of private sector funded research: in 2019 only 21 percent of surveyed researchers conducted privately funded research and 11 percent provided technology extension services to companies. This low level of engagement with the private sector may be indicative of a lack of connections between the public and private sectors, but also may be the result of regulatory barriers for such linking.

Figure 10: PRO funding sources



Source: Authors' calculations

While all public research institutions can receive PBRF through the use of multiannual plans and performance contracts (Ministry of Education and Science, 2016), survey results suggest that it is not yet a meaningful source of funding. 46 percent of surveyed PROs receive block funding with no target requirements of any kind, and 23 percent receive “informal” performance-based funding based on negotiated basic performance indicators. While 69 percent receive some formal performance-based funding on an annual basis, only eight percent received performance-based funding from multi-year contracts (Figure 11). When asked about the importance of these different types of institutional funding, 45 percent of PROs consider block funding with no performance requirements to be a very important source of funding, while no PROs consider performance-based funding to be a very important source of funding (Figure 12).

Figure 11: Institutional funding schemes of surveyed PROs

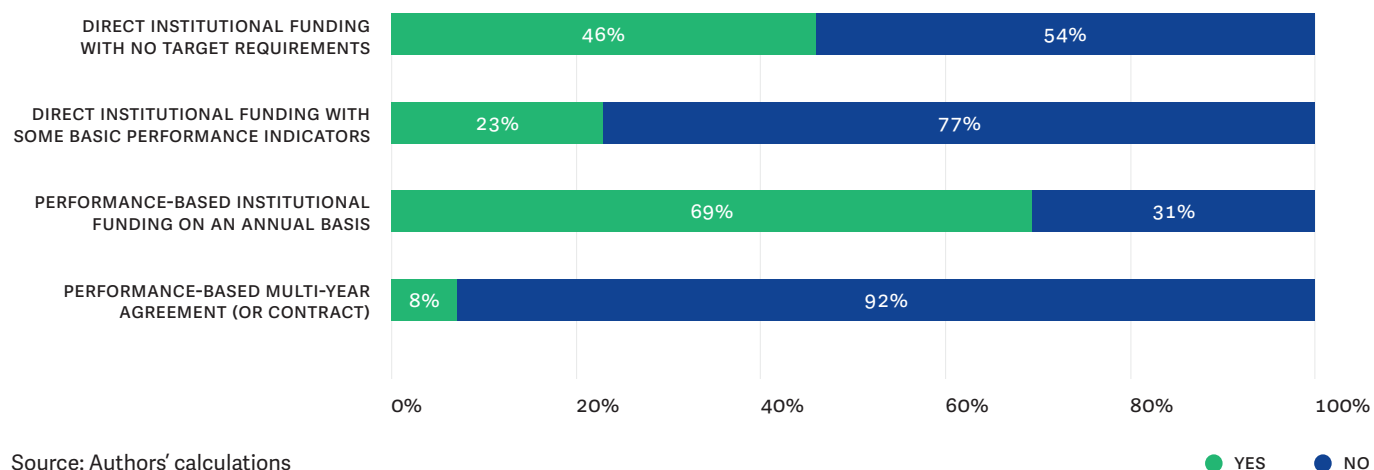
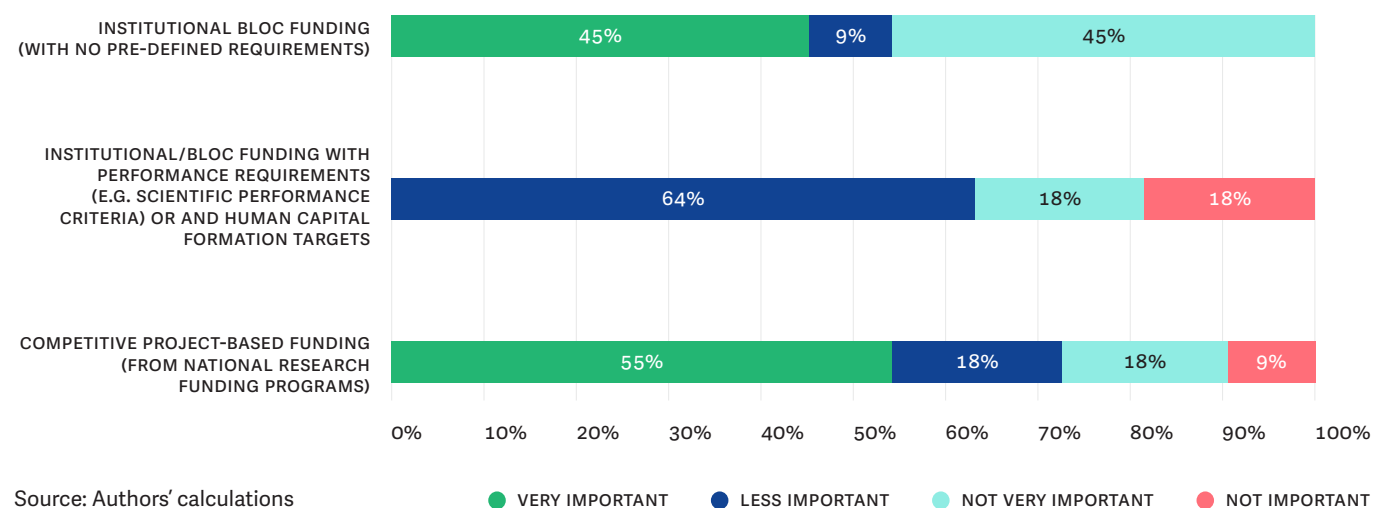


Figure 12: Importance of funding sources for surveyed PROs



Bulgaria has set a target for at least ten percent of direct institutional funding to be performance based. However, at present, PBRF only accounts for roughly 2.5 to five percent of total institutional funding for PROs and HEIs, depending on the type of institutions. Accelerating cultural change will require that Bulgaria gradually increase the share of PBRF to meet and potentially exceed its ten percent minimum target for PBRF. In the Czech Republic, 20 percent of total funding for research is based on the results of research performance evaluation (Box 5). In Denmark and Sweden (see Box 6), this ratio is 19 percent and 20 percent respectively, with planned increases over time. A much higher percentage of PBRF for higher education institutions is found in Finland, where 33 percent of total institutional funding for research is performance based.

Box 5: Research Performance Evaluation and Performance Funding in the Czech Republic: the recognition of non-scientific outputs



In 2016, the research evaluation and funding distribution system was revised. Under the previous evaluation and funding system evaluation was only based on output metrics, making research funding fully dependent on output performance (Srholec, 2015; Good *et al*, 2015). The current system is based on informed peer review and output metrics but relies much less on these types of measures. It has three main components:

- A first part of the assessment concerns **scientific performance** and is based on journal (impact factor)-based bibliometrics.
- A second part of the evaluation is based on **high impact results**. Each organization selects several high-quality results in each scientific domain under consideration. The number of results selected is then related to funding which the organization receives in the preceding year. Results are peer reviewed and the best outputs are selected for funding bonuses.
- A third part of the evaluation concerns **non-scientific outputs of R&D**, including patents and commercialization outputs. The different categories considered come with a set number of points per item. The remaining points are allocated based on an examination of revenue generated through applied projects, technology services and collaboration with industry.

The funding allocation decisions are based 75 percent on an assessment of the scientific output, 10 percent on an evaluation of high impact research outputs, and 15 percent on an assessment of applied research (Malek *et al*, 2014). To stabilize the funding flows, at present 20 percent is allocated using the results of performance evaluation while 80 percent is divided in the same proportion as in the previous year.

Sources: Srholec (2015), Good *et al*, (2015), Jonkers and Zacharewicz (2016).

A recent expert study (European Commission, 2018a) strongly recommended to increase the use of the PBRF in Bulgarian public research institutions as a tool for change. However, greater use of PBRF will not solve all of the structural problems that hamper the performance of the Bulgarian public research sector. The study noted that “It is unlikely that alone it [PBRF] could correct the various inefficiencies, overlaps and systemic failures in Bulgaria’s research system quickly enough and profoundly enough to reverse the current path of decline in the system. Unless the performance-based funding system is combined with a structural reform, it cannot be expected to help overcome research fragmentation”. Structural reforms of the Bulgarian public research landscape are a pre-condition for PBRF to be effective. It is imperative to address the problems of institutional fragmentation and research capacity in order to improve the effectiveness and impact of research and funding policies (European Commission, 2018a).¹⁰

2.1.4 Monitoring, Evaluation, and Performance Management

Bulgaria needs a more consistent and comprehensive research evaluation framework, one that considers the use and expected outcomes of research (on the part of both researchers and institutions) and recognizes knowledge exchange and technology transfer activities.

Public education and research bodies are monitored by the Accreditation Board of the National Agency for Assessment and Accreditation and must renew their accreditation every three to six years, depending on the previous score the organization received. Accreditation is based on the quality of education provided, faculty, and facilities. Beyond this accreditation to ensure specific standards are met, the only institution-level performance evaluation occurs as part of the newly implemented PBRF framework to determine whether and how much PBRF funding an organization will receive on an annual basis.

The new PBRF framework (detailed in Appendix III) includes three primary components: scientific results and impact (accounting for 50 percent of the total score); PhDs produced and international co-publications (accounting for 25 percent); and economic impact (accounting for 25 percent).

The economic impact component includes relevant measures of commercialization, comprising several sub-items: funding received from contracts with foreign companies (weighted at 5X value of monies received), followed by licensing revenues from IP (4X value), funding received

¹⁰ This European Commission study found that Bulgarian authorities need to address the fragmentation in the research system in a direct manner, including a restructuring (concentration/merging) of the higher education sector to reap the full benefit of the Academies’ research capacity. This would be a system-wide reform to create synergies based upon the missions of the research organizations.

from contracts with domestic companies (3X value), and funding from European and national programs (1X value).

Linking this evaluation framework to performance-based funding is a positive step towards enhancing the impact of institutional monitoring and evaluation and fostering cultural change and technology transfer activities in public research institutions. However, the weighting scheme from this framework is not in line with international practices, which typically weight commercialization revenues higher than revenues from contract research. This institutional evaluation framework would also benefit from recognizing other non-monetary knowledge transfer activities, which can be key to enhancing the impact of public research organizations, such as collaborative research with industry, staff exchanges in industry, and researcher involvement in firm creation through startups and spinoffs.

PROs and HEIs are also evaluated at the project level for competitive grant schemes by implementing ministries and agencies. The monitoring and evaluation schemes for EU and nationally funded grants schemes generally do not include indicators for technology transfer or economic impact.

Internationally, there is a policy trend towards the inclusion of technology transfer and innovation impact measures (such as industry linkages and technology commercialization activities) in research performance evaluation assessments. In Scandinavian countries, the use of performance-based research funding started in the early 2010s and currently considers indicators such as external funding and external research as performance metrics (Box 6). In these countries, the adoption of PBRF systems contributed to the institutionalization and consolidation of research performance metrics and as organizing principles of research and strategies (Söderlind *et al.*, 2019). Poland has followed this trend and has been gradually updating its PBRF funding system (Kulczycki *et al.* 2017). The revision of 2013 expanded the evaluation framework and metrics, including research quality indicators (e.g. impact factor and specific journals) and indicators of technology transfer activities such as research and industry cooperation, industry funding and the level of revenues from commercialization.

Box 6: The use of performance-based funding in PROs and universities: Scandinavian countries



Although models differ across countries, the use of PBRF is primarily motivated by the pursuit of research excellence, resource concentration (focusing funding on high performing institutions) and efficiency in the use of resources. The international experience calls for a balance between traditional (block) funding and performance-based funding. This allows PROs and HEIs to have a minimum of funding certainty and stability while still incentivizing desired institutional targets. Maintaining a level of block funding helps to cover operative costs and basic service provision, while PBRF provides focus on more strategic (long-term) commitments, such as research. Performance based funding can also take several forms, including forward-looking (e.g., setting goals for institutions to attain) or backward-looking (e.g., evaluations of performance based on reported metrics) funding, or a combination of these approaches (OECD, 2010; OECD, 2012). There is also an increasing recognition of the need to combine quantitative metrics with qualitative assessments and combining metrics with external expert assessments (i.e. see Czech Republic).

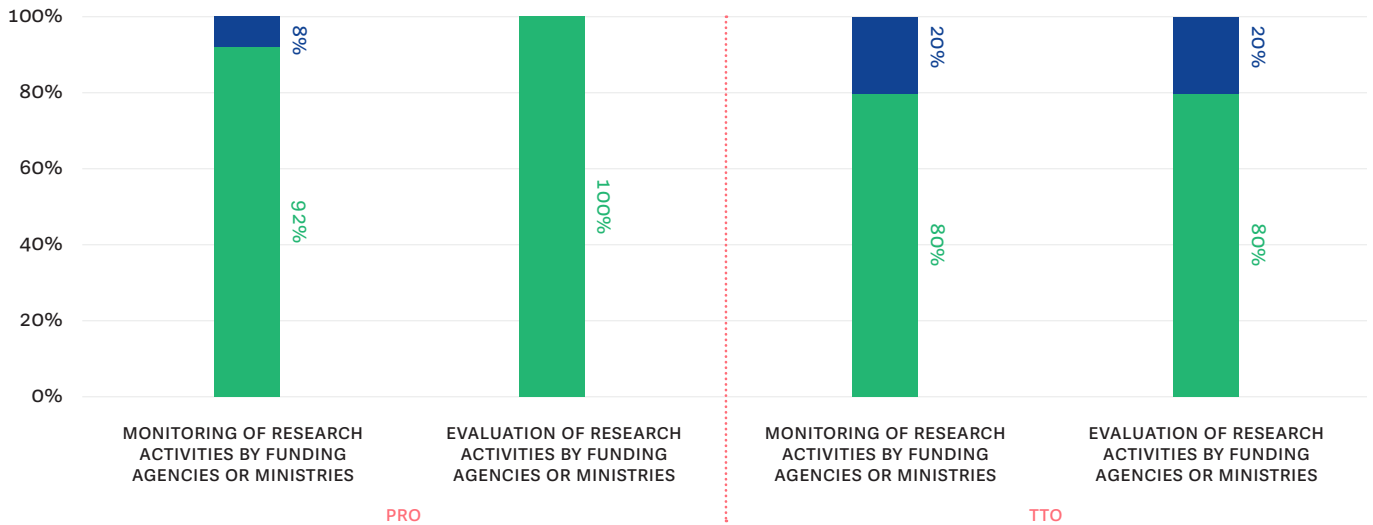
PBRF	DENMARK	FINLAND	NORWAY	SWEDEN
INTRODUCED	2010	2010	2005	2009
SHARE OF FUNDING	19% of institutional research funding and increasing every year	33% of total institutional funding	6% of total institutional funding	20% of institutional research funding and annual additions
INDICATORS	Publications (fractionalized) ¹¹	Publications (fractionalized)	Publications (fractionalized)	Publications (fractionalized)
	External funding (including industry funding)	External funding (including industry funding)	External funding (including industry funding)	Citations External research funding
	PhD production	PhD production	EU research funding	
	Student throughput		PhD production	

Source: OECD, 2010; OECD, 2012¹¹

11 Fractionalized publication counts attribute a share of a publication to each author based on the number of authors of said publication. For example, for a publication with two authors, each author would receive 0.5 publications to their name; while for a publication with four authors, each would receive 0.25 publications to their name.

Nearly all of the surveyed PROs and HEIs are subject to monitoring and evaluation of their research activities by their funding ministry (Figure 13). For most interviewed organizations, M&E procedures are set by the ministry (62 percent) and/or by the institution's strategies and policies (54 percent) (Figure 14).

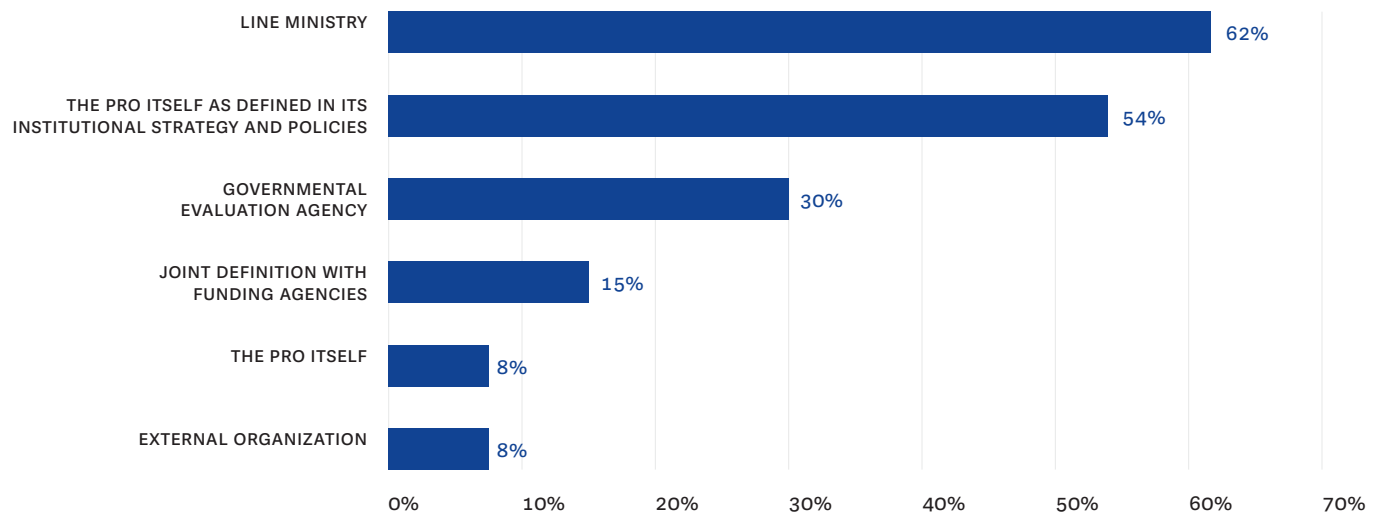
Figure 13: Monitoring and Evaluation of PROs and TTOs



Source: Authors' calculations based on survey results.

● YES ● NO

Figure 14: Who defines monitoring and evaluation procedures for PROs and TTOs



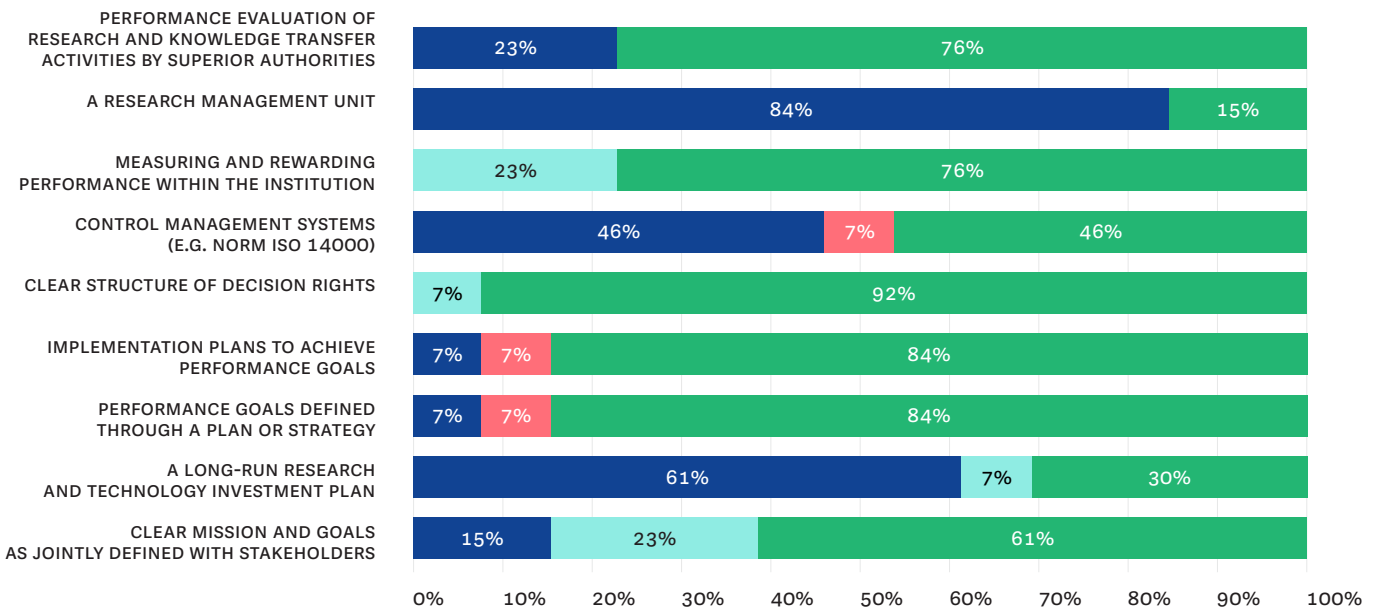
Source: Authors' calculations based on survey results.

Most interviewed PROs and TTOs have established management practices around M&E (77 percent), rewarding performance (77 percent), performance goals (85 percent) and implementation plans to achieve those goals (85 percent). However, only 62 percent of the interviewed organizations feel they have a clear mission and goals, 31 percent have a long-run research and technology investment strategy, and only 15 percent have a research management unit. These deficiencies severely handicap research performance and impact and the effective organization of research efforts over time. Technical support might be needed to help institutions conduct a profiling assessment and define research strategies and investment plans.

Having a research management unit is key for organizing research capacity and funds within institutions. As proven by the experience of leading UK and US universities, an RMU is fundamental to leveraging public and private funds and accessing funding programs, identifying partners, and supporting the preparation of applications.

The lack of clear institutional missions and long-run research strategies reinforces findings from recent assessments (World Bank, 2013; European Commission, 2017; 2018) and interviews with leading administrators at surveyed PROs and HEIs, which report that public STI institutions do not have clearly defined strategic objectives to work towards (Figure 15), making it difficult for them to develop long-term research and investment strategies.

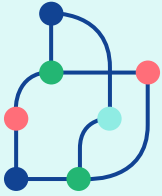
Figure 15: Established management practices at PROs and TTOs



Source: Authors' calculations based on survey results.

● NOT CURRENTLY DEVELOPED
 ● IN THE PROCESS OF DEVELOPMENT
 ● IN PLACE, BUT WITH DIFFICULTIES TO IMPLEMENT
 ● EFFECTIVELY IN PLACE

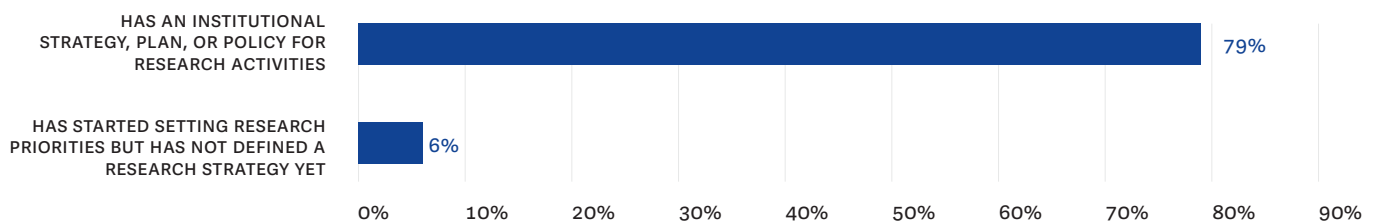
2.2 Research Capacity and Institutional Strategies



Bulgarian PRO and HEI research strategies and plans are largely aligned with national-level strategies, though not all organizations have established such strategies. Research capacity appears to be a major challenge for Bulgarian research institutions, due to limited of funding and human capital and inadequate research infrastructure.

A majority (79 percent) of interviewed PROs and HEIs have a defined research strategy or plan for the institution, and another six percent are in the process of developing one (Figure 16). Public institutions are heavily reliant on public funding, and public funding instruments are aligned with the research priorities in one of the country’s key research strategies, which include the National Strategy for Development of Scientific Research 2017-2030 and the Innovation Strategy for Smart Specialization. PROs and HEIs are monitored by MoES regarding their impacts in achieving the priorities of each program. Because of their dependence on national funding instruments, most PROs and HEIs have established an institutional strategy or plan for research aligned with these national research priorities.

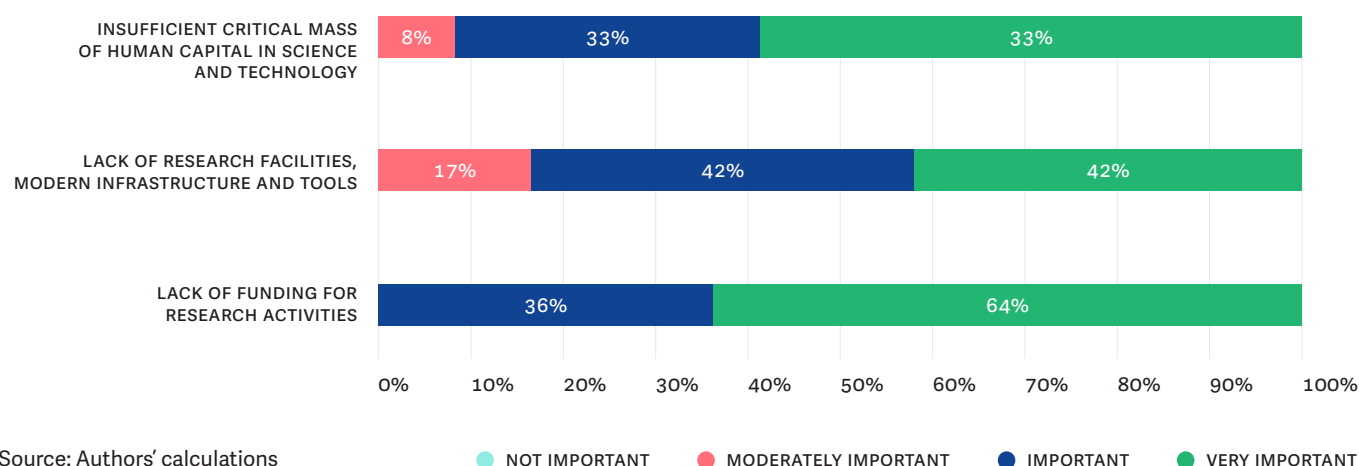
Figure 16: Institutional strategies at PROs and TTOs



Source: Authors’ calculations

Research capabilities appear to be a major challenge for public research institutions, which includes an insufficient critical mass of human capital, lack of adequate research facilities and infrastructure, and lack of funding for research activities (Figure 17).

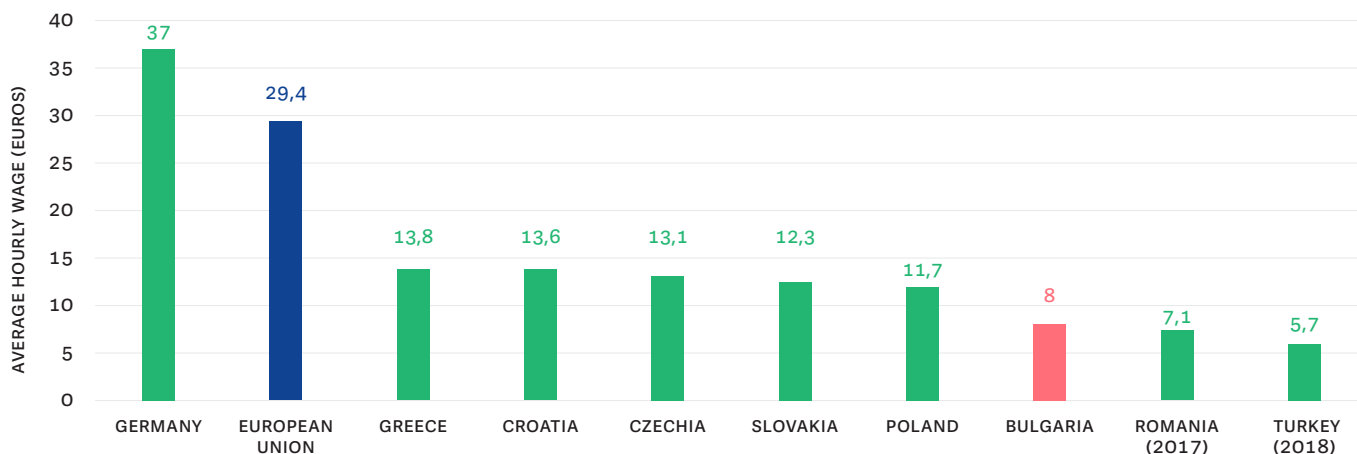
Figure 17: Capacity issues impeding research and technology transfer according to PROs and TTOs



Insufficient research funding was cited as a very important or important challenge by 100 per cent of PROs/HEIs and researchers surveyed. As described in the section on general trends in public research, public investments in R&D are the lowest in the EU on a per capita basis, and public research institutions perform a very low share of research nationally, due in large part to the low levels of research funding available to these institutions. The only new source of public research funding in the current programming period is the OP SESG, which has focused on the development of the Centres of Competence and Excellence and the allocation and disbursement of funds for those centres did not begin until 2019. Outside of the CoCs and CoEs, there are no OP instruments that specifically fund public research, although some of the instruments in the current Operational Programme Innovation and Competitiveness (OP IC) can provide funding to PROs and HEIs as partners in research collaborations with industry. Low levels of public R&D investment also contribute to the lack of human capital and adequate infrastructure.

A lack of a critical mass of human capital was cited as a very important or important challenge to conducting impactful research by 92 percent of PROs/HEIs and 60 percent of public researchers, highlighting the need to improve the size and quality of the public sector research workforce with more competitive salaries for researchers and academics. Public researchers receive very low average salaries relative to their CEE peers (as shown in Figure 18) and the domestic and international private sectors, making it difficult for PROs and HEI to attract and retain researchers. In the 2017 Survey on Researchers in European Higher Education Institutions, Bulgarian public researchers at all career stages expressed dissatisfaction with their remuneration – sentiments shared by researchers in many CEE peer countries (Janger *et al*, 2017). As in the case of Poland with the recent 2018 *Science Law reforms*, it is important to conduct a revision of remuneration policies and more broadly of science careers in the public research and academic sector.

Figure 18: Public research salaries are low compared to those in peer countries, 2019



Source: Eurostat

A lack of adequate research facilities was also cited as a very important or important challenge by 83 percent of PROs/HEIs and 80 percent of researchers. Substantial investments have been made in the construction of new public research infrastructure under the current OP SESG, as well as under the National Roadmap for Research Infrastructure 2017-2023 and National Science Programs 2018-2022. However, there are scant funds available for the maintenance and operation of *existing* infrastructure. PROs and HEIs often need to find funding sources to cover operational costs, such as utilities, replacement equipment parts, and research materials, as these costs are not fully covered by institutional or project funding.

2.3 Technology Transfer Capacity and Policy



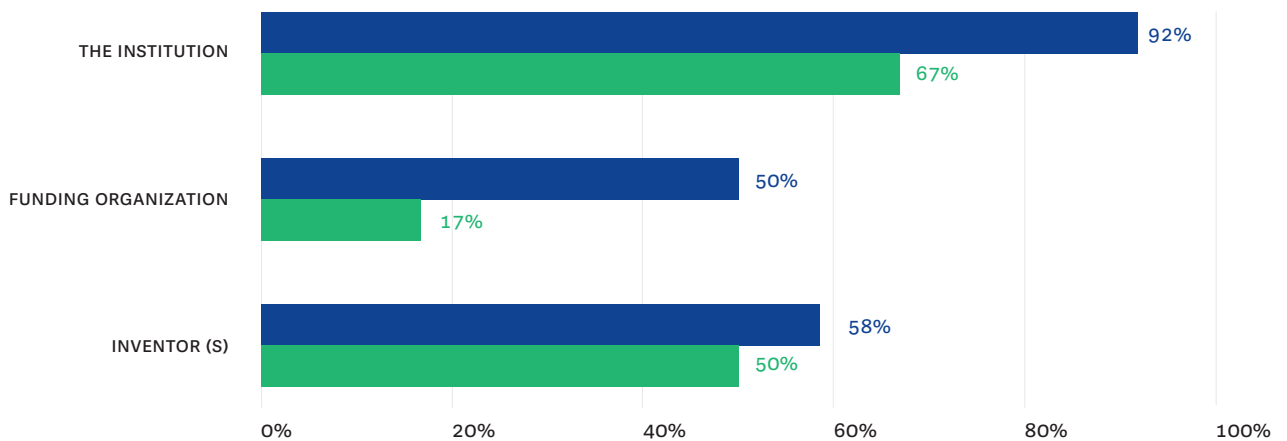
In Bulgaria, IP ownership policies vary significantly by institution. Public institutions generally lack sustainable funding and resources for IPR and tech transfer activities, and few of these institutions have a defined strategy for technology transfer and/or entrepreneurship in place. There is also a general lack of awareness among public researchers of national and institutional technology transfer policies.

Naitonal legislative framework in the areas of IP, technology transfer, and science-business link-ages represent a serious impediment to the capacity of HEIs and PROS to commercialize the results of the research activities. Procedures are vague, bureaucratic, and not well understood

by the public research institutions, which makes it difficult on the part of PROs and HEIs, as well as private sector counterparts, to collaborate in technology transfer or research activities. While national IP and technology transfer legislation is generally in line with international norms and standards, there is no clear legislation governing who owns IP generated by public research institutions (PROs and HEIs) and there is also no specific technology transfer law, such as the U.S.'s Baye-Dole Act, that clarifies the ownership and commercialization rights of actors and governs the transfer of public research to private applications (Spacic et al, 2019). The question of ownership of IP generated by public research institutions was devolved to the individual institutions by the 2016 amendments to the national *Higher Education Act*, which states that every HEI should have a system for IP protection, management, and ownership, as well as IP protection training. To address these requirements, each institution had to develop its own internal regulations, so the ownership of IP derived from public research differs from one academic institution to another.

Among surveyed organizations, most public institutions (92 percent of PROs and 67 percent of HEIs) retain ownership rights over IP resulting from research funded by public sources, while roughly half of the organizations (58 percent of PROs and 50 percent of HEIs) provide ownership rights to inventors (Figure 19).¹² A smaller share of organizations (50 percent of PROs and 17 percent of HEIs) provide ownership rights to public funding organizations.

Figure 19: Ownership of IP funded by public sources at PROs and TTOs



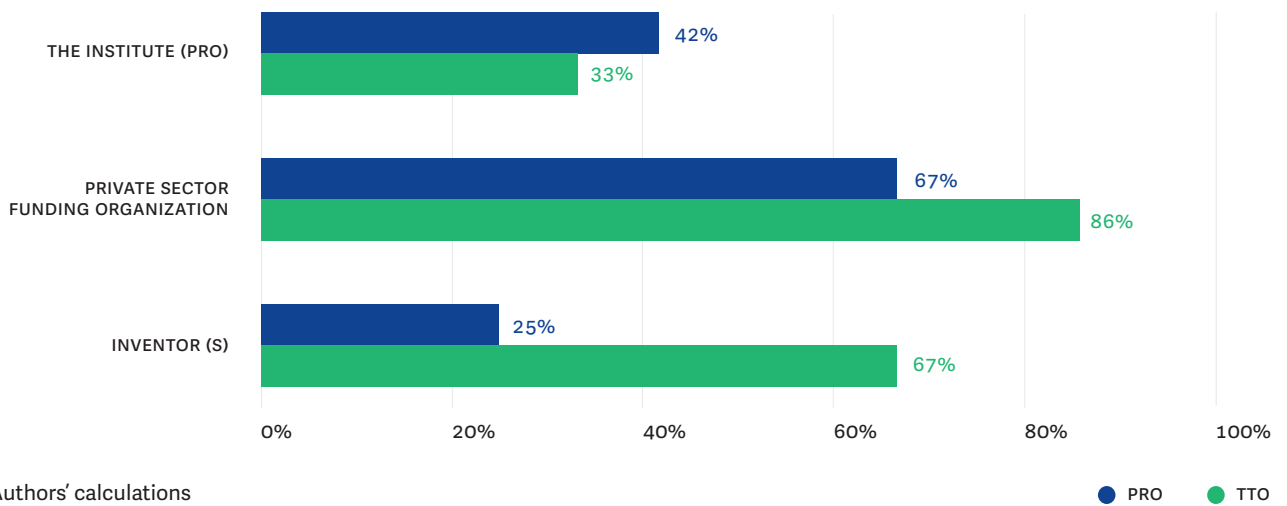
Source: Authors' calculations

● PRO ● TTO

12 Note that in many instances, ownership of IP is not mutually exclusive: ownership can be shared by PROs/HEIs, funding organizations and/or inventors, depending on the circumstances.

Unsurprisingly, IP policies appear more flexible for privately financed research, with PROs and TTOs ceding ownership to third parties more often – 67 percent of PROs and 86 percent of HEIs provide ownership to private sector funding organizations (Figure 20). Still, a relatively large share (42 percent of PROs and 33 percent of HEIs) retain ownership of IP for themselves in privately financed research (which runs counter to standard international practices) and 25 percent of PROs and 67 percent of HEIs provide ownership to inventors. This shows there is a large degree of heterogeneity in IPR ownership rules across public research institutions.

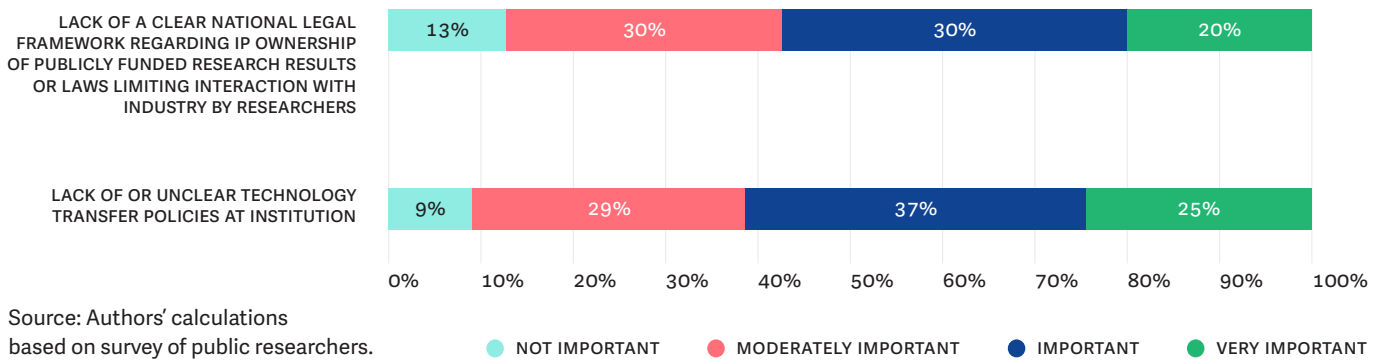
Figure 20: Ownership of IP funded by private sources at PROs and TTOs



Only 16 percent of the interviewed institutions have a defined strategy for technology transfer and/or entrepreneurship; half of the interviewed TTOs have a tech transfer strategy and none of the interviewed PROs have such a strategy in place. As noted in the previous section, public research institutions, which are heavily reliant on public funding instruments, have adopted strategies aligned with the research priorities in one of the country's key research strategies. However, none of the key national strategies have technology transfer priorities. Thus, these institutions do not have funding-related incentives to develop their own technology transfer strategies.

According to the results of the public researcher survey, researchers feel that there are IP and technology transfer policy challenges at both the national and institutional levels. 57 percent of researchers believe that the lack of a clear national legal framework on IPR ownership and laws regulating interactions with industry present an important or very important barrier to technology transfer impacts, and 62 percent believe that the lack of (or unclear) technology transfer policies at the institutional level also represent an important or very important obstacle (Figure 21).

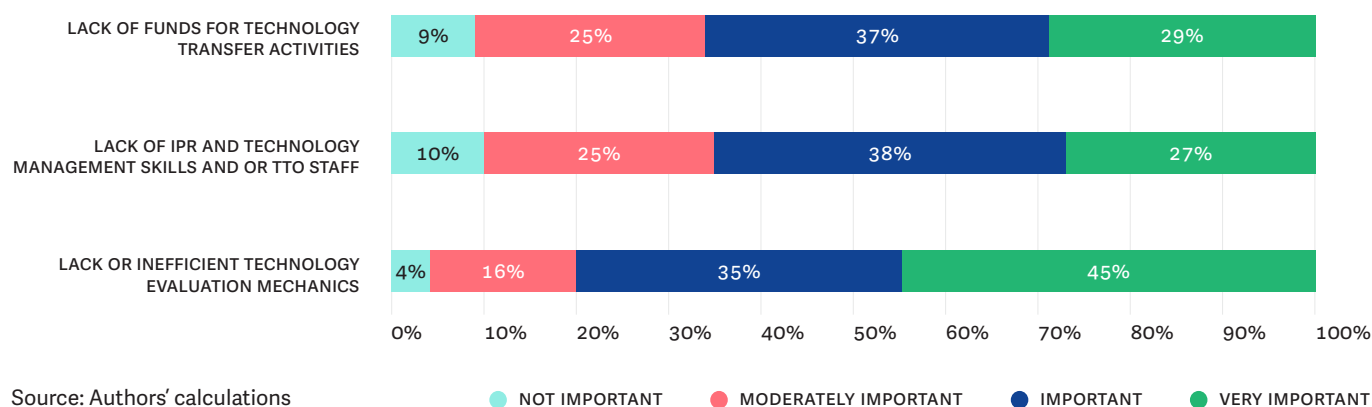
Figure 21: Challenges related to national and institutional TT policies according to public researchers



Public institutions generally lack sustainable funding and resources for IPR and tech transfer activities. Not all PROs and HEIs have dedicated TTOs, and some of the TTOs are more project-oriented and do not have the transfer of technologies from the institution to industry as a central feature of their business model. BAS has a single centralized tech transfer unit, and the individual institutes may not have dedicated IPR experts. Public tech transfer offices suffer from a lack of sustainable funding – in the previous EU programming period, significant investments were made, primarily with EU funding, to develop TTOs at several Bulgarian public research institutions. However, when the EU funding ceased, national funding was not made available to maintain these offices, which then lost much of the staff and skills that had been developed (Spasic *et al*, 2019). A recent World Bank analysis of the Bulgarian STI policy mix finds no instruments that provide direct funding for technology transfer activities or TTOs (Aridi *et al*. 2020). The current OP SESG does not include any instruments that support technology transfer activities or TTOs at public institutions outside of the CoC and CoE projects.

The public researcher survey shows that a lack of resources for technology transfer presents a challenge to improved commercialization impacts of public research, with over 60 percent of researchers stating that the lack of funding, technology evaluation mechanisms and IPR management skills are important or very important barriers to improved tech transfer impacts (Figure 22).

Figure 22: Availability of technology transfer resources according to public researchers



2.4 Research Outputs, Knowledge Transfer, and Technology Transfer Activities



Public sector research outputs, in the form of publications and patents, are largely aimed at addressing accreditation requirements, rather than the pursuit of impactful research. While some knowledge exchange activities are relatively common, such as research collaboration with government and industry, long term staff exchanges with industry (e.g., sabbaticals and secondments) are rare among surveyed researchers. Researchers in engineering fields are more active in knowledge exchange activities than other disciplines, but all fields show very low levels of commercialization outcomes (licenses and spinoffs).

Scientific publications are the most common type of research output of Bulgarian public researchers, with 76 percent of surveyed researchers producing one or more publications from 2018 to 2019, while only 1.6 percent were granted an international patent, and 7.8 percent registered a utility model over the same period (Table 2). As detailed in the general trends in the public research section of this report, Bulgarian publications tend to be less impactful than those produced in peer countries, and public sector publication and patent activity is largely oriented to addressing accreditation requirements and meeting career development milestones, rather than the pursuit of impactful research or the practical implementation of research results by the private sector.

Public researcher career development indicators place equal weight on utility models and patents and do not differentiate between domestic and international patents. Because utility models are less expensive, faster, and easier to obtain, public researchers have increasingly turned to protection through utility models. The widespread lack resources for IPR activities means funding is typically not available for patenting under international patent regimes, which has resulted in the low international patent outputs reported by respondents.

Table 2: Research outputs of surveyed public researchers, 2018-2019

	AVERAGE PER RESEARCHER	SHARE OF RESEARCHERS WITH N>0
Scientific publications in international peer-reviewed journal	44	76.0%
Domestic patents granted	0.7	4.5%
International patents granted	0.2	1.6%
Number of utility models	1.6	7.8%

Source: Authors' calculations | Note: Responses are weighted by distribution of researchers by academic field.

The most common form of collaborative research undertaken by public researchers are collaborative R&D projects with industry: 27.8 percent of surveyed researchers worked on a collaborative project with industry in 2019 and 42 percent have worked on such a project over the course of their career (Table 3). Contract research to companies (R&D services commissioned by industry through a contract) and collaborative research projects with other government agencies are also fairly common forms of collaboration -with about one in five researchers engaged in contract research with firms in 2019, and around 13 percent taking part of contract research with governmental agencies.

However, technical assistance services to firms (such as engineering, design, and quality testing services) and technology extension services (assistance in the transfer and adoption of new technologies) are less common activities, with only 16 percent and 11 percent of surveyed researchers participating in these activities in 2019, respectively (Table 3). These advisory services are important forms of knowledge transfer of public sector expertise to small businesses and are particularly important in the Bulgarian context, where the private sector lags behind EU peers in labor productivity, firm digitization, and the adoption of new technologies.

Table 3: Research collaborations of surveyed public researchers

TYPE OF COLLABORATION	AVERAGE PER RESEARCHER, 2019	SHARE OF RESEARCHERS, 2019	SHARE OF RESEARCHERS, ENTIRE CAREER
Collaborative research involving companies	0.72	27.8%	42.54%
Contract research to companies	0.58	21.38%	35.04%
Technical assistance services to companies	0.42	16.2%	21.87%
Technology extension services to companies	0.19	10.5%	17.22%
Collaborative research with government	0.30	18.14%	28.51%
Research contract services to government	0.43	12.78%	20.85%

Source: Authors' calculations | Note: Responses are weighted by academic field.

Looking at staff exchanges with industry and other research and government organizations, and other forms of knowledge transfer, short-term activities such as consultancy and advisory services are the most frequent form of knowledge transfer, followed by training services and PhD projects with industry (both were performed by 20 percent of surveyed researchers in 2019). (Table 4). Looking more closely at PhD projects in industry, only five percent of junior researchers participated in such projects in 2019, whereas 16 percent of senior researchers participated (likely as a supervisor) in one or more PhD projects in industry in 2019. Personnel exchanges (sabbaticals or secondments or short employment residency) are less common, with slightly more than one percent of researchers being engaged in this activity. The share is larger for researchers engaging in personal exchanges with other government or public research organizations (14 percent of surveyed researchers in 2019).

Table 4: Staff exchange activities and other forms of knowledge transfer by surveyed public-sector researchers (total sample)

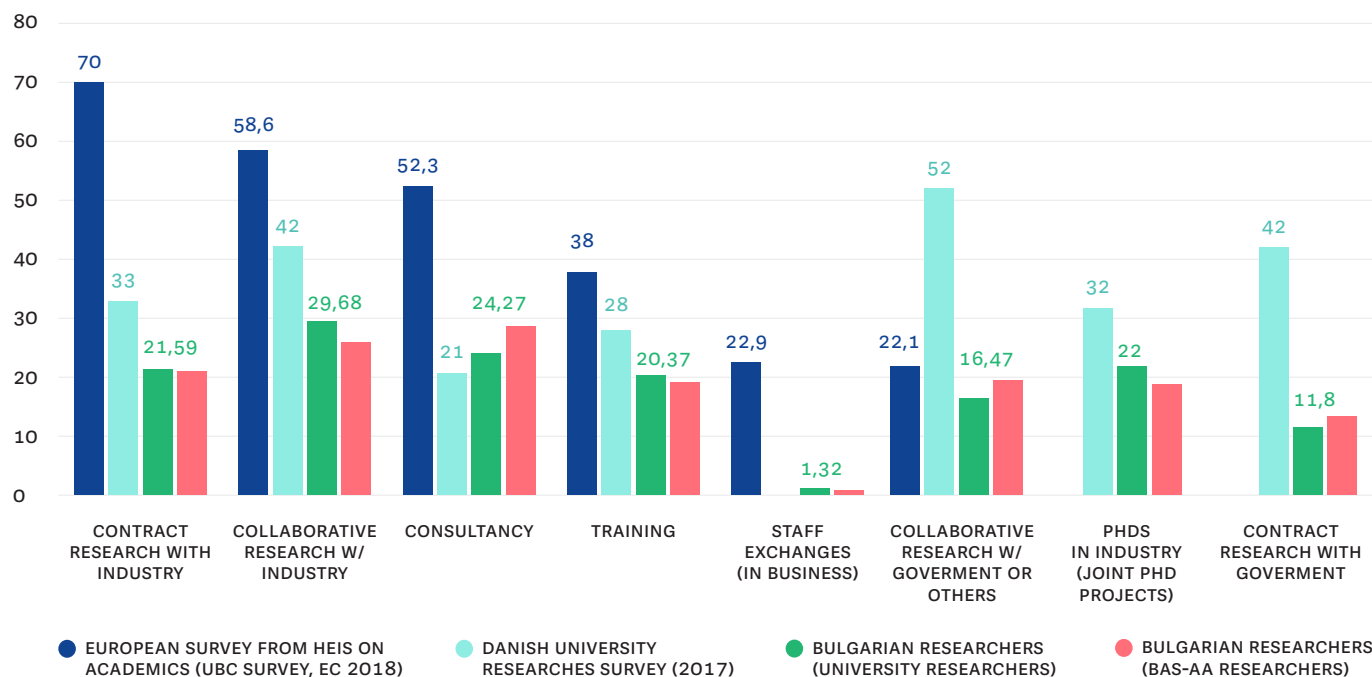
TYPE OF STAFF EXCHANGE	AVERAGE PER RESEARCHER, 2019	SHARE OF RESEARCHERS, 2019	SHARE OF RESEARCHERS, ENTIRE CAREER
Conducting PhD projects with industry	0.39	20.2%	24.1%
PhD projects in industry (junior researchers)	0.35	4.8%	6.4%
PhD projects in industry (senior researchers)	0.40	15.7%	17.7%
Training activities provided to industry or government	0.67	19.8%	25.16%
Sabbatical or short employment residency in industry or spinoff	0.02	1.13%	4.4%
Personal exchanges with other public research institutions or governmental agencies	0.22	13.8%	18.34%
Other consultancy services and advisory work	0.74	26.8%	30.13%

Source: Authors' calculations based on the results of the World Bank Survey of Bulgarian Researchers (2020).

Notes: (1) Responses for Bulgarian researchers are weighted by the distribution of population of researchers (at both PROs and HEIs) per large sector field of research following the classification of UNESCO. (2) We considered researchers as junior researchers if he/she reports job status 1: Full time young researcher (Doctorate student or Post-doctorate) or 3: Part time young researcher or has at least 15 years of experience and without managerial position.

Bulgarian researchers perform far below European average trends in knowledge and staff exchange activities, especially in terms of contract research with industry and training and consultancy services (Figure 23). Only 1.3 percent of Bulgarian researchers participated in staff exchanges with industry in 2019, as opposed to an average of 23 percent in European countries. Similarly, the EU average for collaborative research with industry is 59 percent, while only 28 percent of Bulgarian researchers engaged in such activities. The only area where Bulgarian researchers perform close to the EU average is in collaborative research with government (or with other PROs). While there is no EU survey data on PhDs in industry, a recent survey of Danish academics finds that one-third of Danish academics are or were involved in PhD projects in industry, compared to less than a quarter of Bulgarian researchers. Involvement in contract research with government is also much higher in the Danish survey (42 percent vs 12 percent of Bulgarian researchers).

Figure 23: Participation in collaborative research and research services: Comparison with EU average participation

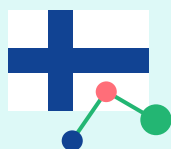


Sources: Indicators for Bulgarian researchers come from the World Bank Survey of Bulgarian Researchers (2020); indicators for the European averages are from Davey *et al.*, (2018), a European Commission study based on a survey of researchers at HEIs. Indicators for Danish researchers are from the 2017 Triple-I-Research Survey of Academics.

Commercialization outcomes, in the form of licensing agreement, spinoffs¹³, or startups¹⁴ are very low. Among surveyed researchers, the leading forms of commercialization outcomes in 2019 were entering into confidentiality agreements¹⁵ (six percent of surveyed researchers entered into such agreements in 2019) or material transfer agreements¹⁶ (three percent of surveyed researchers in 2019) (Table 5). Only two percent of surveyed researchers entered into a licensing agreement or the reassignment of IP rights in 2019, while three percent participated in the creation of a spinoff and only two percent participated in the creation of a startup involving licensing of IP rights or other results from their research. VTT in Finland provides a useful example of an approach to improving incentives for commercialization through the creation of a commercial unit to manage IP and licensing and utilize better strategies for industry collaboration and funding (see Box 7).

13 Spinoffs are defined as new firms involving the participation of an academic or student.
 14 Startups are defined as new companies founded by entrepreneurs external to the HEI or PRO and based on technology created by the HEI or PRO.
 15 Confidentiality agreements are legal agreements that bind one or more parties to non-disclosure of confidential information.
 16 Material transfer agreements are contracts that govern the transfer of tangible research materials between two organizations, where the recipient intends to use said materials for their own research purposes.

Box 7: The transformation and reform of the VTT in Finland: An effective applied research organization and innovation partner to industry



VTT (Technical Research Centre of Finland) is the most important non-university research institution in Finland. It is a multidisciplinary research organization which conducts commissioned research for domestic and foreign companies and organizations, and for public authorities. It primarily provides applied technical and techno-economic research services. It is an interesting example of a public organization that has evolved over time following changes in national and global innovation needs.

In 2006, VTT experienced an important structural reform. The VTT 2006 Law introduced important changes in its regulation and autonomy, which allowed the institution to introduce radical changes in its organization and to establish a better legal and operational capacity for technology commercialization engagement.

- The Law allowed VTT's ownership in spin-offs and technology commercialization through startups. The VTT Act states that VTT's Board can decide on the extent of VTT's ownership of newly formed business enterprises. VTT may use its technology assets as capital contributions and receive shares in the new firm.
- A new commercial unit, "VTT Ventures", was created to manage intellectual property rights (IPR), licensing and the creation of new business ventures for VTT's technologies. External funding became more important, and direct funding budget for research organizations has decreased over the past 10 years.
- The external sources of PRO funding are mainly from commissioned research and co-financed research (industry collaboration). At VTT, external funding represents approximately 70 percent of total funding, with 30 percent coming from contract research.

Table 5: Technology transfer activities of surveyed public-sector researchers -average number of activities or contract/project involvement, 2019 (Total Sample)

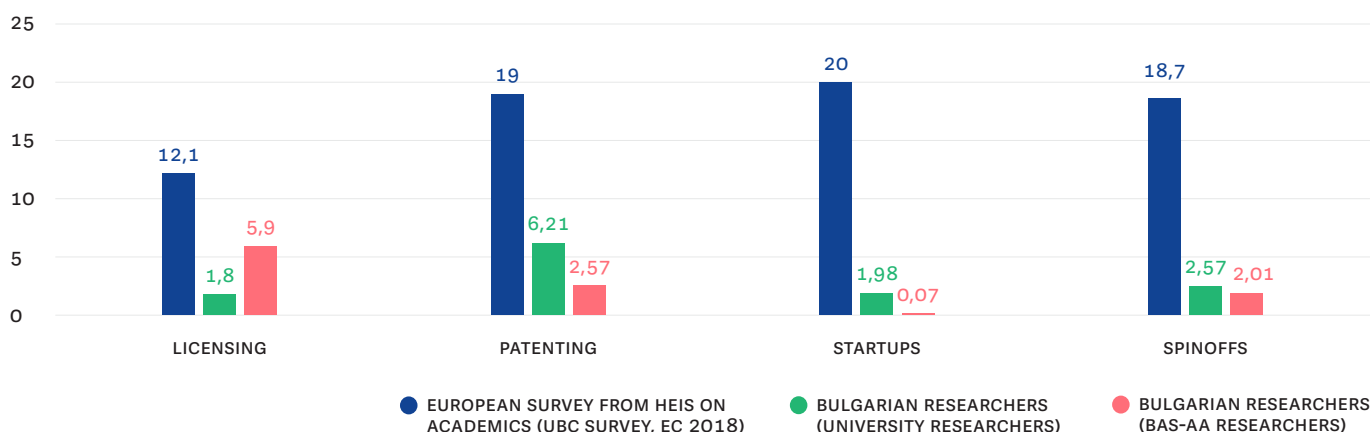
TYPE OF TT ACTIVITIES	TT ACTIVITY PER RESEARCHER	SHARE OF RESEARCHERS WITH N>0
Licensing and/or assignments of IP rights	0.5	1.8%
Material transfer agreements	0.11	2.66%
Confidentiality agreements	1.4	6.1%
Spinoff creation	0.2	2.57%
Startup creation through licensing of IP rights	0.1	1.98%

Source: Authors' calculations based on the results of the World Bank Survey of Bulgarian Researchers (2020).

Notes: Responses for Bulgarian researchers are weighted by the distribution of population of researchers per large sector field of research, following the classification of UNESCO and distribution population of 2017.

Similarly, patenting and commercialization rates of Bulgarian researchers are low compared to the results shown in recent European surveys of public researchers. While 19 percent of researchers in European HEIs were awarded a patent in the 12 months before being surveyed, only six percent of Bulgarian researchers were awarded a patent in 2019 (Figure 24). The share is even lower for Bulgarian researchers working in HEIs (three percent). Only two percent of researchers in Bulgarian researchers participated in startup creation in 2019, while 20 percent of surveyed European researchers did in 2017.

Figure 24: Commercialization of research results through licensing and new firms (total sample)- Comparison with EU trends (% of researchers involved over the last twelve months)

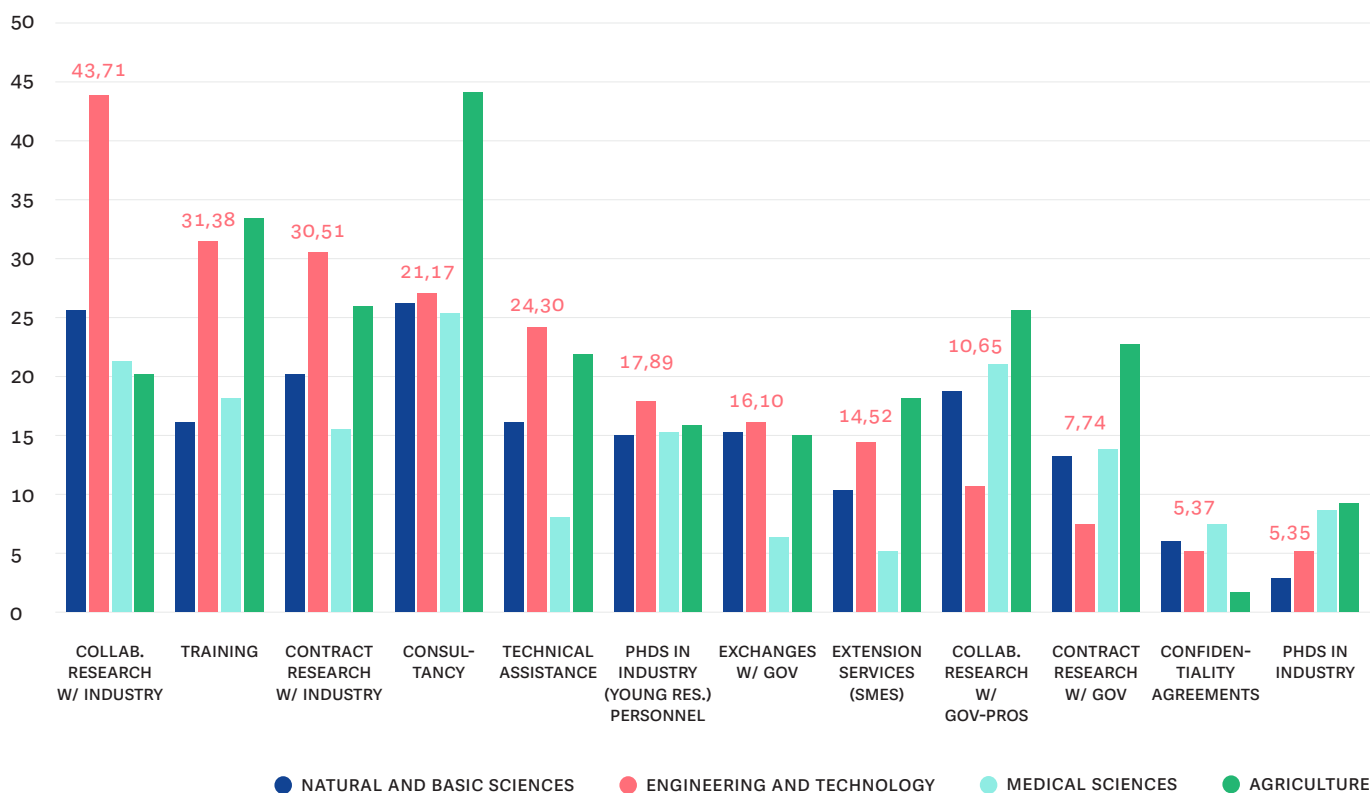


Sources: Indicators for Bulgarian researchers come from the World Bank Survey of Bulgarian Researchers (2020); indicators for the European averages are from Davey *et al.*, (2018), a European Commission study based on a survey of researchers at HEIs. Figures for the Bulgarian data cover researchers at both HEIs and PROs. Notes: In the European Survey, spinoff participation refer to the proportion of academics who have been involved in the creation of one or more spin-offs created from their research in the last 12 months.¹⁷

17 The indicator on patenting in the European Survey refers to registered patents (applied patent applications) based upon their research during the last 12 months. The same definition is used in the Bulgarian Survey, but here we report whether researchers participated in patent applications filed domestically.

Commercialization activity differ across the disciplines of surveyed researchers. Researchers in engineering and technology fields are more likely to engage in knowledge exchange activities with industry and less likely to engage in exchanges with other government or research organizations, compared to researchers in other fields (Figure 25). Engineering fields report the largest shares of researchers' involvement in research collaboration and research contracts with industry -with rates about two or three times larger than the average- as well as high shares in the provision of training services and PhDs in industry. Researchers in computer sciences are more likely than those in other disciplines to participate in knowledge exchanges with government and other research organizations and to engage in technology extension services. Notably, commercialization outputs are low across all disciplines.

Figure 25: Knowledge exchange and commercialization activities by field of respondent



Source: Authors' calculations based on the results of the World Bank Survey of Bulgarian Researchers (2020).

Notes: Responses are weighted by the distribution of population of researchers (at both PROs and HEIs) per large sector field of research following the classification of UNESCO and population distribution of 2017. Engineering and technology research areas covers: Mechanical Engineering: Electrical Engineering Chemical Architecture, construction and surveying, technology Environmental Engineering and operation and Transportation, and biotechnology. Natural and Basic Sciences: biology, chemistry physics, mathematics & computer sciences.

2.5 Academic Incentives



The legal and regulatory framework governing public research in Bulgaria does not provide adequate incentives for industry-science research collaboration and technology commercialization, and there is a widespread lack of knowledge among public researchers on the specific policies and incentives for tech transfer offered at the national and institutional levels. However, evidence from the researcher survey shows that financial and non-financial incentives are associated with stronger industry-science collaboration engagement by scientists, and staff mobility (allowing PhD projects in industry and staff exchanges) is a catalyzer of public-private collaboration and technology transfer.

Academic incentives for engaging in industry collaborations and knowledge and technology transfer activities are set by the national statutes¹⁸ stipulating the minimum requirements for academic titles at HEIs and PROs. These statutes, while including measures for IP generation, do not include indicators for commercialization outcomes (such as licenses or spinoffs) and collaborative research activity in the career development metrics of faculty and research staff in HEIs and PROs. Such indicators are also not present in the reviewed policies of individual institutions. This is a major gap in the incentive framework, as the international experience has showed performance evaluations that only include IP metrics without considering the actual transfer and exploitation of research results are limited in their ability to change behavior to achieve desired tech transfer results.

There is also no legislation that defines the benefits that should come to inventors if their inventions are commercialized; these issues are regulated by institutional IP policies and the individual contracts between PROs and researchers. This regulatory gap is in large contrast with national incentive frameworks in most European and OECD countries, which in many cases cover these matters in national technology transfer laws, innovation laws, and in national-level reforms to S&T regulations.

Previous reports on the incentive framework in Bulgaria reinforce these findings; Soete et al, (2015) find a lack of coherent policies and incentives for encouraging the creation of IP, which has impeded the commercialization of public research. Galev (2011) and WIPO (2019) find that,

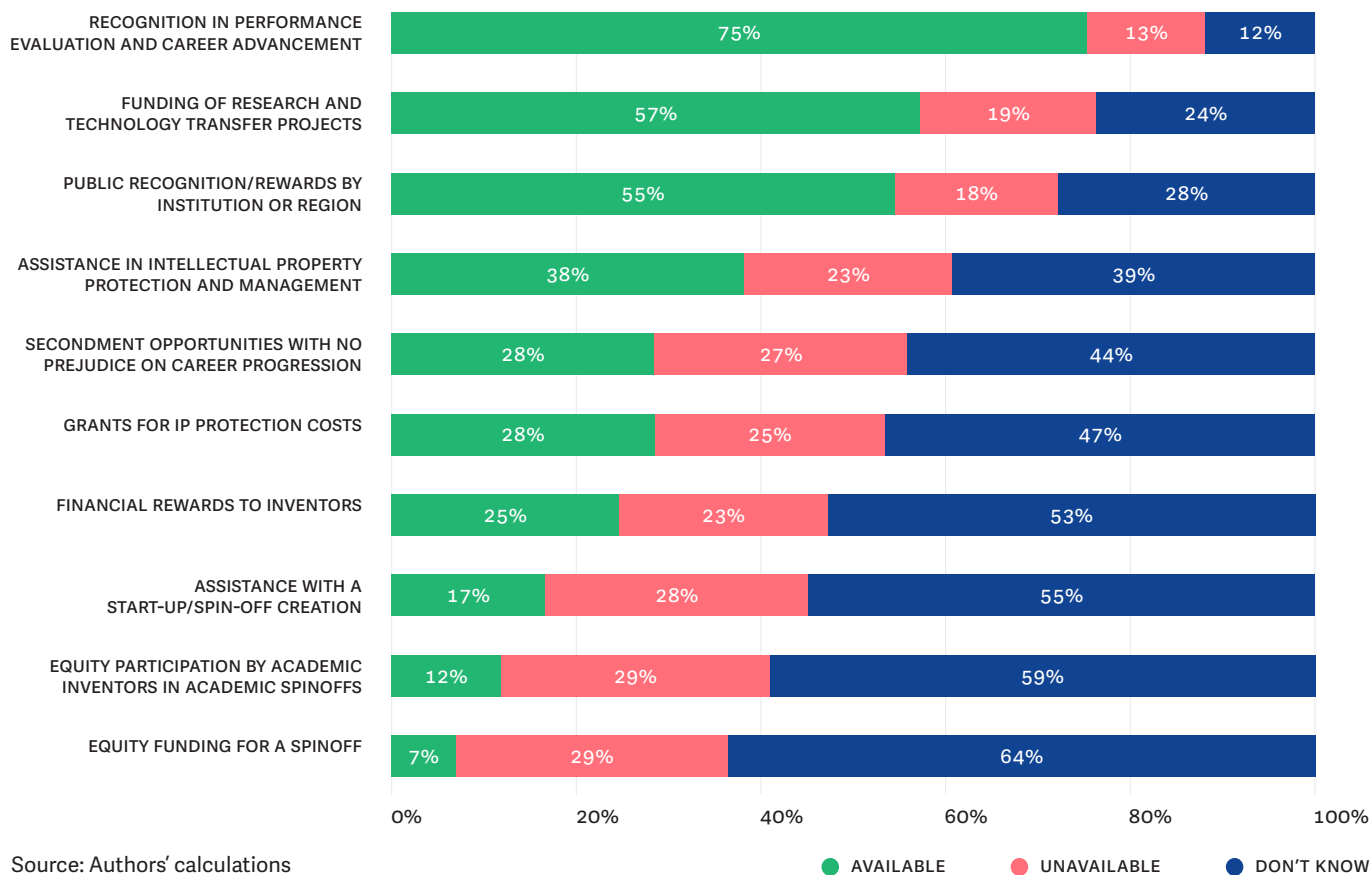
¹⁸ Law on the development of academic staff and the corresponding Rules for the implementation of the Law on the development of academic staff.

due to the lack of incentives and resources for technology transfer, public researchers will often commercialize IP as individuals and sometimes create their own spinout companies without institutional knowledge or support.

The most common incentives are related to recognition of research and tech transfer achievements and funding for research projects, as more than 50 percent of surveyed researchers said these incentives were offered by their institutions. Assistance in IP protection and management (38 percent), grants for IP protection costs (28 percent), and secondment opportunities (28 percent) were less common, while financial rewards for inventors (25 percent), assistance with start-up/spinoff creation (17 percent), equity participation in spinoffs (12 percent), and equity funding for a spinoff (7 percent) were very uncommon incentives offered to public researchers.

Surveyed researchers are largely unaware of their institution’s policies and incentives related to technology transfer and knowledge exchange, with more than half of respondents unaware of the availability of many of the forms of incentives included in the survey (Figure 26).

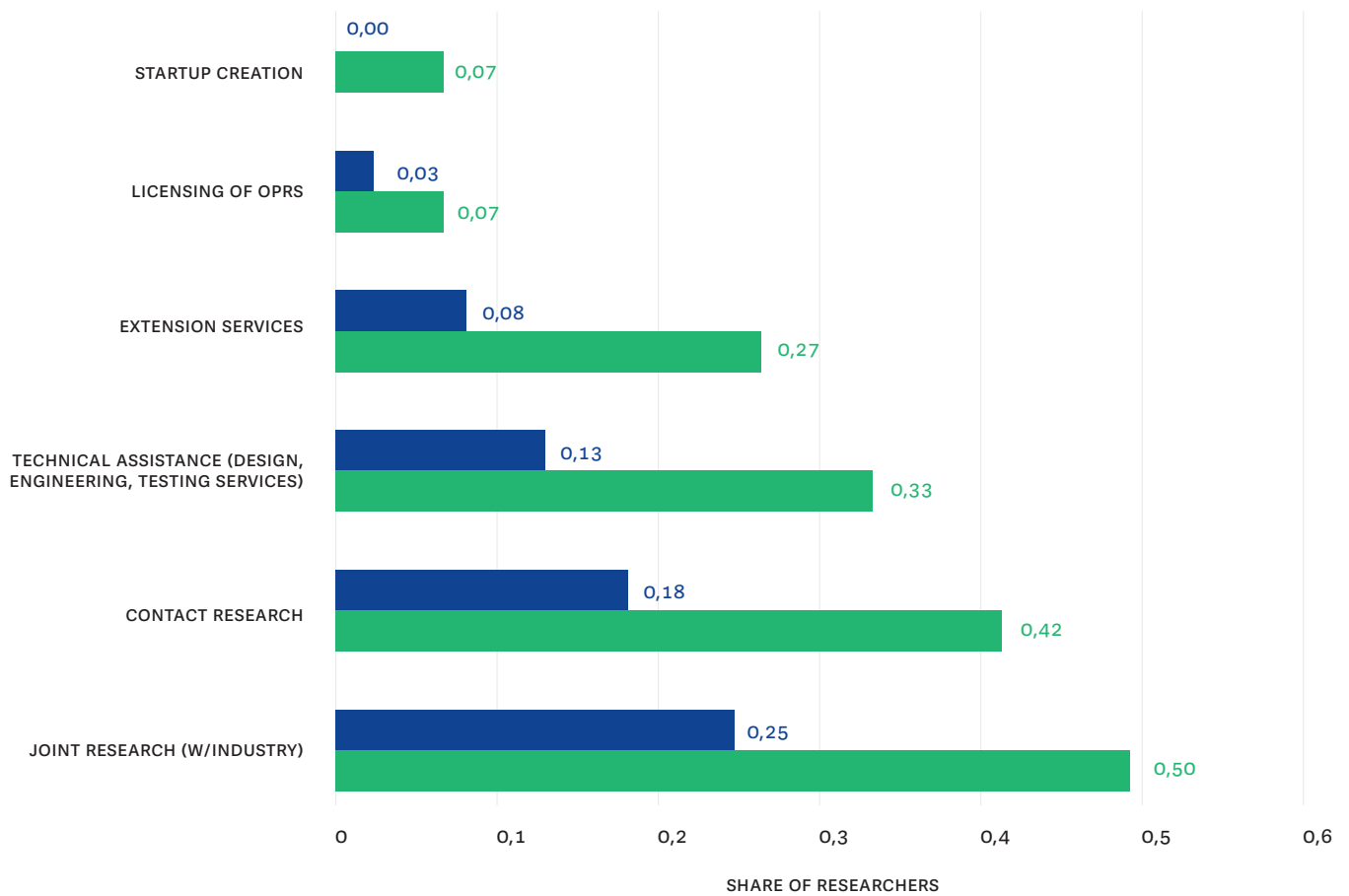
Figure 26: A large share of Bulgarian researchers had little information on incentives for technology transfer engagement, 2020



The lack of incentives offered to public researchers is concerning because the availability of such incentives has a demonstrated impact on Bulgarian researchers' knowledge activities, IP outputs, and commercialization outcomes.

Among surveyed researchers, those researchers who engaged in mobility programs with industry, such as sabbaticals and secondments (or having joint positions industry-academia) are more likely to engage in research collaboration and contract research with the private sector, and have higher levels of licensing and startup activity (Figure 27).

Figure 27: Staff exchanges with industry are key catalyzers of knowledge exchange and technology transfer



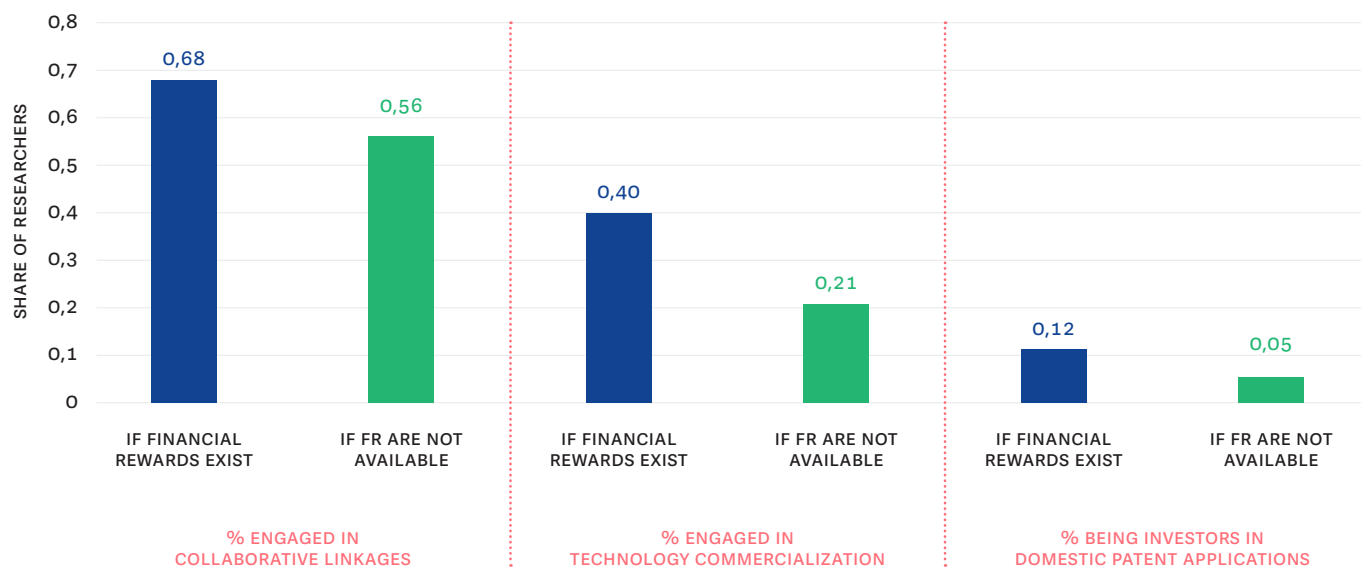
Source: Authors' calculations

● NOT ENGAGED IN INDUSTRY EXCHANGES

● MOBILITY EXCHANGES WITH INDUSTRY (SABBATICALS, SECONDMENTS, ETC.)

Similarly, researchers who received financial rewards for licenses of academic spinoffs engage significantly more often in industry collaborations, patenting and commercialization (Figure 28). This is in line with a large body of research that confirms the importance of royalty participation rights in the involvement of university researchers in technology licensing activity and patenting.

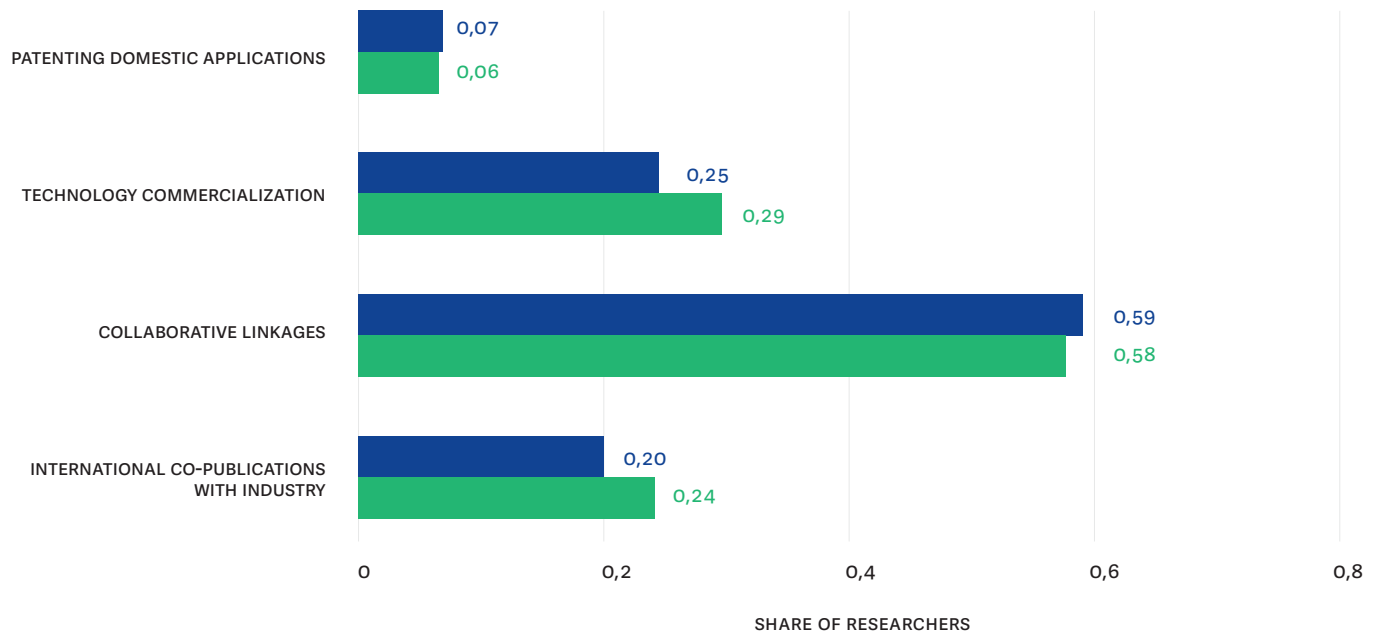
Figure 28: Financial incentives are associated with stronger industry-science collaboration



Source: Authors' calculations

It is unclear whether recognition through performance evaluations and career advancement encourage more technology transfer or knowledge exchange activity among surveyed researchers. There were no significant differences between researchers who receive such evaluations and those who do not in terms of publications, linkages with industry, or commercialization (Figure 29). This could be due to several factors: First, the national performance evaluation framework was only recently amended in 2018 to include IP outputs and project funding raised, and there may not have been enough time for these changes to have an impact. Alternatively, the evaluation framework does not include commercialization outcomes (only IP outputs, such as patents or utility models), and thus does not incentivize technology transfer activities directly. Another possibility is that the effects of the updated framework and its impact on career progression and salaries may not be apparent to researchers, thus limiting its effects on researcher behavior.

Figure 29: It is unclear whether performance evaluations encourage technology transfer participation by researchers



Source: Authors' calculations

● NO PERFORMANCE EVALUATION ● PERFORMANCE EVALUATION & CAREERS (RESEARCH & TT)

3.

Recommended Areas for Action



3. Recommended Areas for Action

Previous studies on the Bulgarian knowledge transfer framework have identified a number of obstacles to technology transfer. A 2015 peer review of the Bulgarian research and innovation system found that public research institutions suffer from a lack of professional management of research and knowledge transfer; a lack of policies that encourage IP disclosure, IP monetization, and public-private collaboration; and a lack of stable funding and resources for existing TTOs. It also found that knowledge transfer is not part of the mission and core strategy of public universities (EC, 2015). A 2019 WIPO assessment of knowledge transfer between the Bulgarian public and private sectors found that public institutions need stronger and more standardized IPR management institutional, legal and organizational infrastructure, as well as improved staff and resources developed to technology transfer activities (WIPO, 2019).

There are several examples from international experience of the need to revise institutional missions and legal or regulatory frameworks to better enable PROs and HEIs to engage more effectively in technology commercialization activities and for research and collaboration. In some country cases, major leading PROs have undergone substantial institutional reforms in order to address these handicaps or regulatory bottlenecks.

Research institutions (PROs and TTOs) and public researchers agree on the major obstacles to research excellence and technology transfer: a lack of communication between the public and private sectors, research that is not aligned with the needs of industry, a lack of policies to promote public-private collaboration, lack of funding for research, insufficient human capital, and a lack of adequate research facilities (see figures in Appendix IV). It is clear that the ongoing structural reforms for the public research system need to continue. In particular, further consolidation of BAS and AA is required to reduce fragmentation and improve specialization and efficiency in research.

This section lays out seven recommended areas for action based on the key challenges identified in this report in the areas of the national policy framework, institutional governance, research and technology transfer capacity and policy, and academic incentives¹⁹.

19 These recommendations are further highlighted and discussed in the policy recommendations section of the *Bulgaria Country Needs and STI Policy Mix Assessment (2020)*

Increase the role of performance-based funding to incentivize research excellence and knowledge transfer impact

PRIORITY TIMELINE

Short-term

APPROACH

- Ensure that MoES meets its minimum target of ten percent PBRF as a share of total direct funding and consider raising this share over time to achieve greater resource concentration and efficiency.
- Review the PBRF weighting schemes to give more emphasis on research commercialization and tech transfer activities (licenses, spin-offs, contract research, industry research collaboration, etc.). The PBRF framework should also recognize other non-monetary knowledge transfer activities, such as collaborative research with industry, staff exchanges in industry, and researchers' involvement in firm creation through startups and spinoffs.

TYPE OF REFORM

Programmatic

RESPONSIBLE STAKEHOLDER(S)

MoES

Improve resources and capacity for tech transfer support

PRIORITY TIMELINE

Short-term

APPROACH

- Address the performance of existing technology transfer offices and non-academic intermediaries active in supporting research commercialization through reliable and sustainable funding, capacity building, and training (invention disclosure, patenting, licensing, market assessment, startup/spin-off formation, etc.)
- Promote awareness of the technology transfer framework and available financial and capacity building resources

TYPE OF REFORM

Programmatic

RESPONSIBLE STAKEHOLDER(S)

MoES, MA SESG, NSF, State Agency for R&I

Improve governance and strategic orientation of public research institutions

PRIORITY TIMELINE

Mid-term

APPROACH

- Strengthen the autonomy and operational independence of PROs and HEIs
- Ensure that public research institutions have clear missions and objectives, aligned with local industry specialization, and in line with national goals and strategies as well as regional Smart Specialization Strategies

TYPE OF REFORM

Institutional (Governance and Coordination)

RESPONSIBLE STAKEHOLDER(S)

MoES

Strengthen M&E for research and operation of PROs and HEIs

PRIORITY TIMELINE

Mid-term

APPROACH

- Align M&E frameworks with institutional objectives and missions.
- Revise M&E frameworks to place more weight on knowledge transfer and research collaboration activities.

TYPE OF REFORM

Institutional (Governance and Coordination)

RESPONSIBLE STAKEHOLDER(S)

MoES, State Agency for R&I

Strengthen PRO/HEI-Industry linkages to ensure alignment in the supply and demand of knowledge and skills

PRIORITY TIMELINE

Mid-term

APPROACH

- Improve the relevance of public research and education agendas through industry representation in PRO/HEI governing bodies (steering/trust boards) and consultation in the definition of research and knowledge strategies.
- Strengthen public-private linkages and opportunities for collaboration by encouraging mobility between public research institutions and the private sector through secondments, sabbaticals, joint positions and especially through PhDs in industry.
- Leverage private sector R&D funding through collaborative grants schemes with industry

TYPE OF REFORM

Legal, Programmatic

RESPONSIBLE STAKEHOLDER(S)

MoES, State Agency for R&I

Develop a coherent national framework for IPR and technology transfer

PRIORITY TIMELINE

Mid-term

APPROACH

- Create national-level legislation or policy that governs ownership of IP generated by publicly funded research and the transfer of public research to private applications, rather than devolving the question of IP ownership to individual institutions.
- Clarify and mandate the provision of financial rights for research. Make inventors' participation in revenues from commercialization obligatory, such as the right to participate in royalties from IP resulting from their research activities (licensing and selling of IP). Additional financial incentives could be considered.
- Clarify ownership of equity stakes in spin-offs from academic research institutions at both individual researcher (rights to participate in equity in startups) and institutional level.

TYPE OF REFORM

Legal

RESPONSIBLE STAKEHOLDER(S)

Council of Ministers, MoES, Bulgarian Patent Board, State Agency for R&I

Improve incentives for public researchers to engage in high quality research, knowledge transfer, and commercialization activities

PRIORITY TIMELINE

Mid-term

APPROACH

- Include technology transfer and collaborative research activities in career development and salary progression of researchers.
- Strengthen financial incentives through researchers' participation in licensing revenues and provision of equity rights (in startups/spinoffs).
- Increase salaries for researchers at both HEIs and PROs at all levels, in order to encourage productivity, reduce emigration of highly qualified researchers and consolidate national research competences in key areas of S&T.

TYPE OF REFORM

Legal, Institutional (Governance and Coordination)

RESPONSIBLE STAKEHOLDER(S)

MoES

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Appendices

Appendix I: Survey Methodology

This study uses two surveys designed to measure Bulgarian HEIs and PROs knowledge and technology transfer and the factors that influence these activities:

1. An online survey of active public sector researchers in science, technology, engineering and mathematics, conducted from February to April 2020; and
2. An in-person survey of administrators from Bulgarian PROs and university TTOs, which took place between 27 February 2020 and 14 April 2020.

Public Researcher Survey

Bulgaria's National Center for Information and Documentation (NCID) maintains a register of all public research staff in the country, from which the survey population was drawn. Because this survey focuses on researchers in the fields of science, technology, engineering and mathematics (STEM), public researchers were filtered by field using the ISCED-F 2013 classification system²⁰ to ensure only researchers from relevant fields were selected. The selected fields were:

- Natural sciences, mathematics, and statistics (ISCED-F 2013 05, excluding 0524 Statistics)
- Information and communication technologies (ISCED-F 2013 06)
- Engineering, manufacturing, and construction (ISCED-F 2013 07)
- Agriculture, forestry, fisheries, and veterinary (ISCED-F 2013 08)
- Health and welfare (ISCED-F 2013 09, excluding 092 welfare)

To ensure that only currently employed researchers were selected, only those staff with data on their current academic rank were included in the survey population (retired or former research staff do not have data on current academic rank in the NCID database).

The resulting population of public researchers engaged in STEM fields was 4,260. The NCID data was downloaded on the 02 January 2020 and includes the name of the researcher, their academic degree, current academic rank, and the name of the public institution for which they are currently employed. Email addresses for the public researchers were retrieved from the PRO/HEI public websites.

²⁰ ISCED-F 2013 is an international classification developed by the United Nations Educational, Scientific and Cultural Organization (UNESCO) to facilitate comparisons of education statistics and indicators across countries based on uniform and internationally agreed definitions.

Table A1.1: Distribution of the survey population by ISCED-F 2013 classification

CLASSIFICATION	NUMBER OF RESEARCHERS
Natural sciences, mathematics, and statistics	1434
Information and communication technologies	208
Engineering, manufacturing, and construction	815
Agriculture, forestry, fisheries, and veterinary	214
Health and welfare	1589

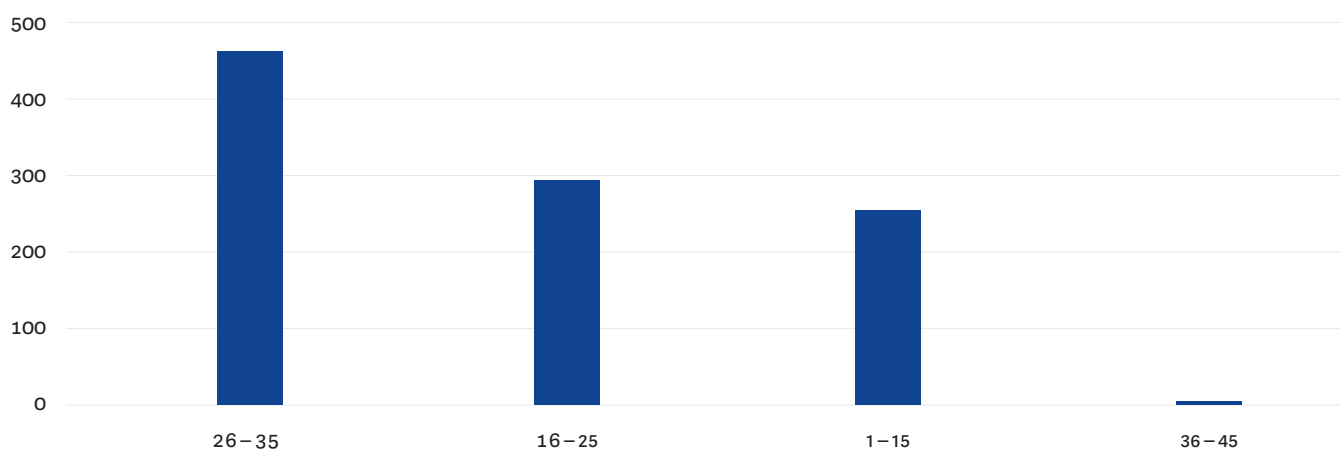
Email addresses for the public researchers were retrieved from their respective PRO/HEI websites. A total of 3700 emails were collected, or 86 percent of the total population. Emails were sent to all the addresses collected with a link directing them to the online survey. To secure as many responses as possible, an additional letter of support, signed and stamped by the Ministry of Education and Science was attached. The dissemination of the emails took place on four waves. The first was sent on 27 February 2020, the second on 05 March 2020, the third on 12 March 2020 and the fourth on 6 April 2020. The survey was closed on 14 April 2020. To boost the response rate, additional reminding letters were sent to the directors of the relevant public research institutions on the 5 March 2020.

A total of 1,010 responses were collected, of which 726 completed the full survey. The responses cover approximately 23 percent of the total population. Table A.1.2 shows the distribution of respondents by field, and Figure A1.1 presents the distribution of the respondents by years of experience. The margin of error is around 3% with a confidence level of 95%.

Table A.1.2: Response rate among research areas

	TOTAL RESEARCHERS	RESPONSES
Natural sciences and mathematics	1434	547
Information and communication technologies	208	142
Engineering, manufacturing and construction	815	175
Agriculture, forestry, fisheries and veterinary	214	94
Health	1589	199
Total:	4260	1157 ²¹

21 The number is higher than the total number of respondents as some of the researchers have marked more than one research area

Figure A1.1 Distribution of the respondents by years of experience

Source: Authors' calculation

PRO and University TTO Survey

PROs and university TTOs was selected for interviews based on several criteria in an attempt to cover the breadth of the Bulgarian public research system. These criteria included:

- Type of research institutions (PRO or HEI)
- Affiliation (BAS, AA, or other)
- Technical field
- Number of employees
- Location

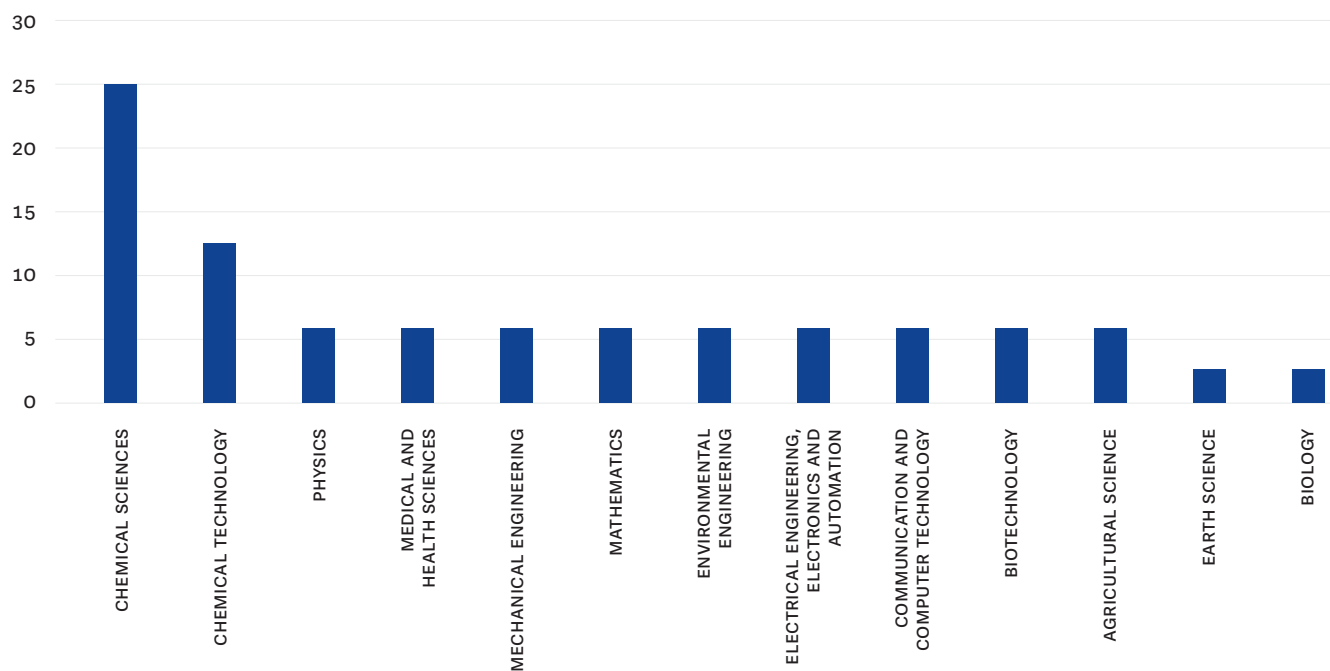
A total of 21 institutions were interviewed, including 14 PROs and seven university TTOs, as shown in table A1.3. The interviews took place between 27 February 2020 and 14 April 2020.

Table A1.3: Interviewed PROs and TTOs

	INTERVIEWED
BAS	Central Laboratory of Applied Physics – Plovdiv
TOTAL NUMBER IDENTIFIED (PUBLIC, STEM) - 38	Institute of Biophysics and Biomedical Engineering
	Institute of Catalysis
TARGETED NUMBER - 12	Institute of Chemical Engineering
	Institute for Information and Communication technologies
	Institute of General and Inorganic Chemistry
	Institute of Information and Communication Technologies
	Institute of Mineralogy and Crystallography “Academician Ivan Kostov”
	Institute of Neurobiology
	Institute of Organic Chemistry with Centre of Phytochemistry
	Institute of Physical Chemistry “Academician Rostislav Kaischew”
	Institute of Polymers
AA	Agriculture Academy – central body
TOTAL NUMBER IDENTIFIED (PUBLIC, STEM) - 1	
TARGETED NUMBER - 1	Agriculture Institute – Shumen
TTOS	Joint Innovation Centre of the Bulgarian Academy of Sciences (JiC-BAS)
TOTAL NUMBER IDENTIFIED (PUBLIC, STEM) ~ 10	Research Centre with TTO at Sofia University
	TTO at Technical University of Gabrovo
TARGETED NUMBER - 6	Intellectual Property Technology Transfer Center at Ruse University
	High-tech park Technical University - Varna EOOD at Technical University Varna
	RC of Technical University -Sofia and TU-Sofia Technology EOOD
	TTO UFT- Plovdiv

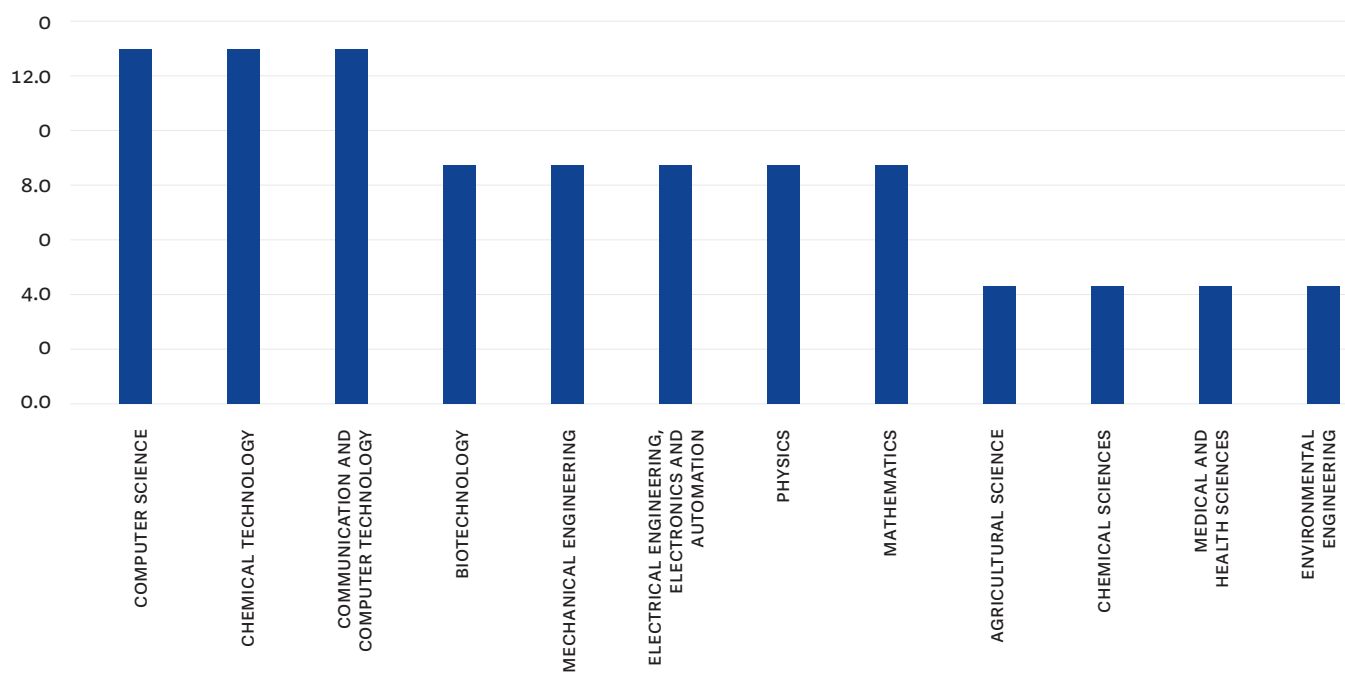
The majority of the respondents of the PRO survey have stated that their organization works mainly in the field of chemistry, and in the TTOs chemical technology is as popular as computer technology (Figures A1.2 and A1.3).

Figure A1.2 PROs by technical field



Source: Authors' calculation

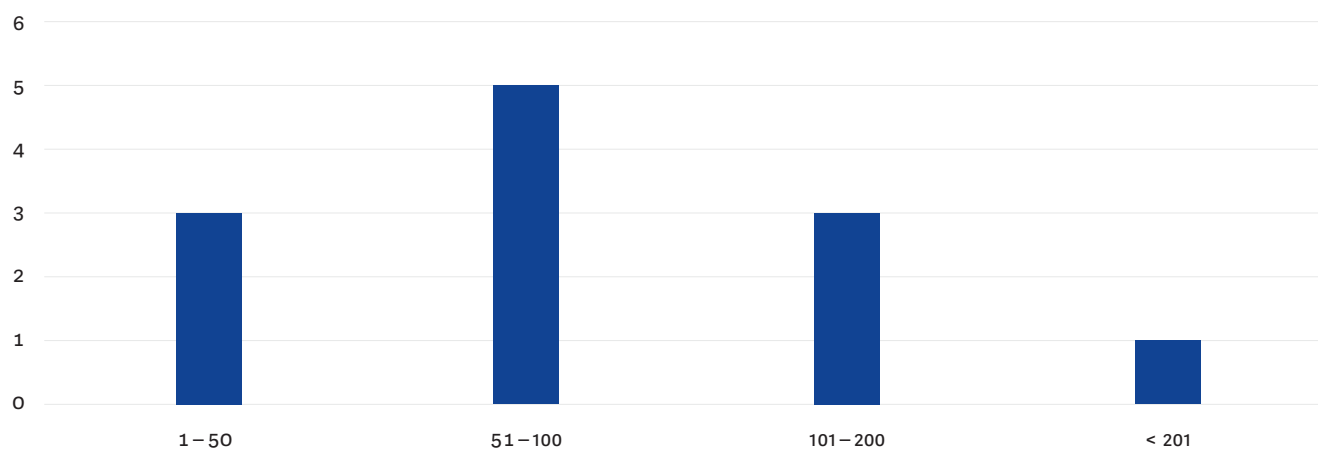
Figure A1.3 TTOs by technical field



Source: Authors' calculation

The majority of the PRO respondents have a total number of employees between 50 and 100 people. (Figure A1.4).

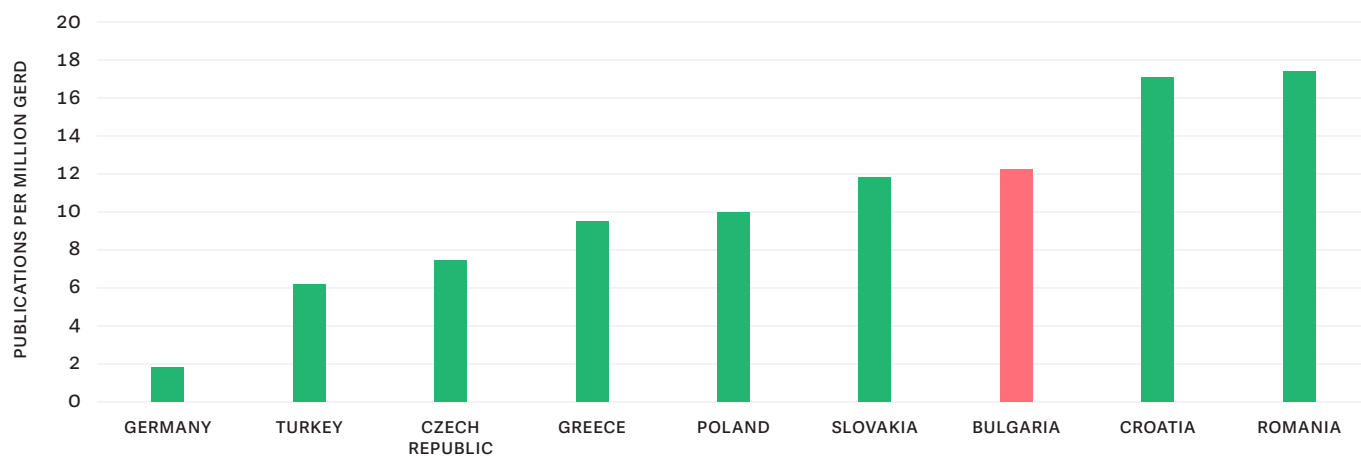
Figure A1.4. Distribution of PROs by number of full-time employees



Source: Authors' calculation

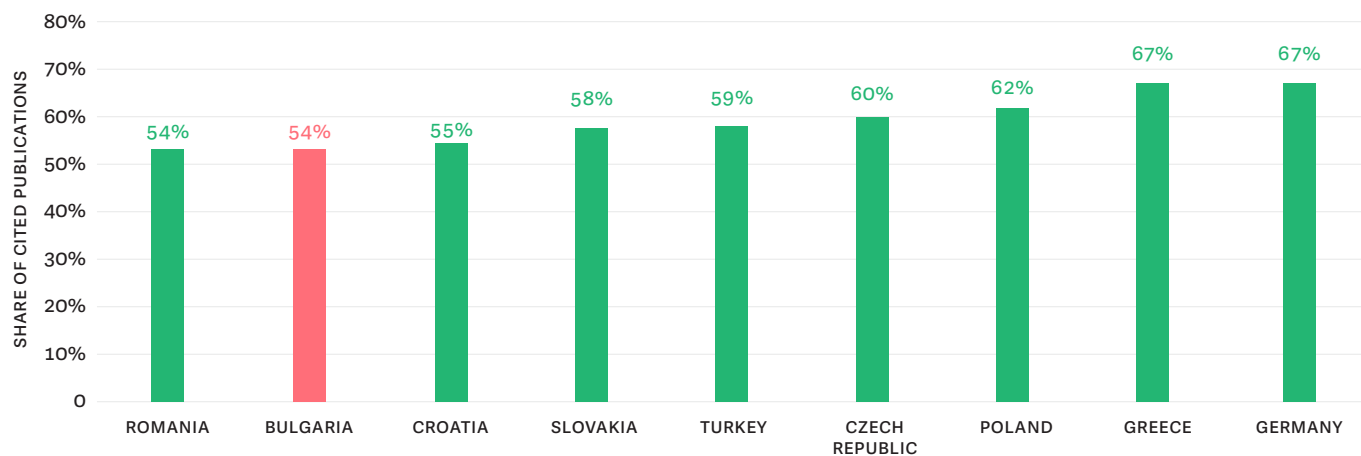
Appendix II: Bulgarian Research Performance

Figure A2.1: Publications per million GERD, 2018



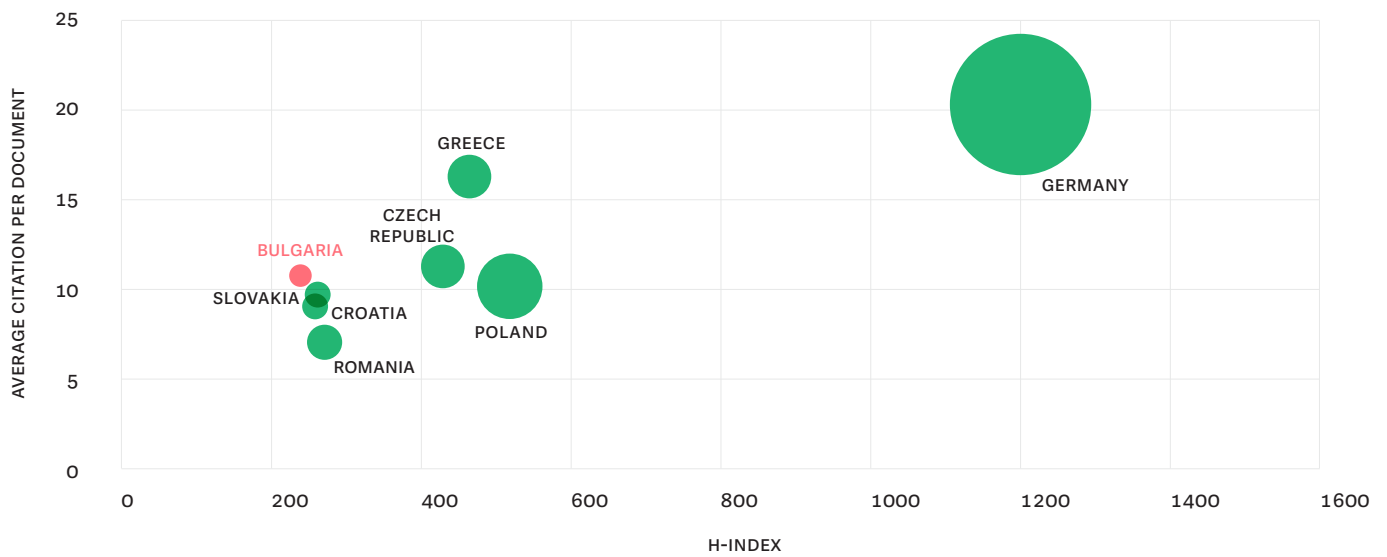
Source: Scimago, Eurostat, authors' calculations

Figure A2.2: Share of publications that have been cited, 2013-2018



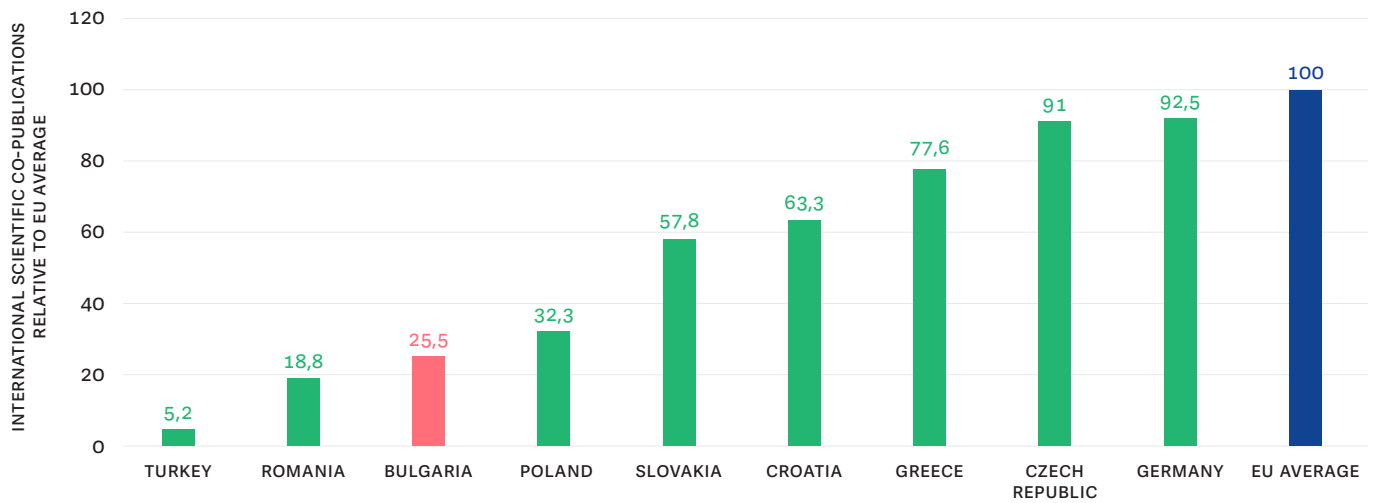
Source: Scimago

Figure A2.3: Ratio of H-Index to average citations per publication, 1996-2018



Source: Scimago | Note: The size of the bubble represents that total number of publications.

Figure A2.4: International scientific co-publications per million inhabitants relative to EU average, 2019



Source: European Innovation Scoreboard

Table A2.1: Top Bulgarian institutions in publication activity, 2010-2019

INSTITUTION	NUMBER OF PUBLICATIONS	AVERAGE CITATIONS PER PUBLICATION	H-INDEX
Bulgarian Academy of Sciences	17,750	9.5	95
University of Sofia	7,206	11.6	111
Medical University Sofia	4,735	11.7	82
Technical University Sofia	2,421	2.1	27
University of Chemical Technology and Metallurgy	2,043	6.9	43
Plovdiv University	1,664	3.5	26
Agricultural Academy	953	4.1	26
Medical University Plovdiv	923	6.5	31

Source: Web of Science

Appendix III: Performance-based Funding Indicators

Table A3.1: Performance-based funding indicators

NO.	CRITERIA	EVALUATION FORMULA
1.	Scientific results and their scientific impact during the reporting period (U ₁)	$U_1 = (a + b + c + d)$
1.1.	Number of scientific publications in journals indexed in Scopus and / or Web of Science (All databases) (a), of which: in magazines of category Q1 (a ₁), Q2 (a ₂) and Q3 (a ₃) on the Web of Science. All other publications in Scopus and / or Web of Science (All databases) fall into the indicator (a ₄). When reporting articles with co-authors of more than ten institutions the number of these articles is multiplied by a factor 0.1.	$a = 5a_1 + 3a_2 + 2a_3 + a_4$
1.2.	Number of scientific monographs indexed in Scopus databases and / or Web of Science (b ₁)	$b = 10b_1$
1.3.	Arithmetic mean of the number of independent citations in Scopus and Web of Science, obtained during the estimated period, of publications of researchers from the current list composition (c ₁), taking into account the impact of citations normalized by scientific fields, according to indicators from Web of Science and SCOPUS with coefficient a and coefficient k, reflecting the specifics of citations in different areas from table. 2. Taking into account the citations of an article with co-authors from more out of ten institutions the number of citations to this article is multiplied by a factor of 0.1.	$c = 0.5c_1ak$
1.4.	Number of patents registered by HEIs and research organizations and patent applications, incl. from concluded contracts with companies, from who: Patent applications: national (d ₁) and PCT (d ₂) Registered patents: national (d ₃), European, US or etc. international patents (d ₄)	$d = d_1 + 3d_2 + 3d_3 + 6d_4$
2.	Scientific capacity and reproduction of the academic community during the reporting period (U ₂)	$U_2 = e + f$
2.1.	Number of PhD students defended during the reporting period: within 5 years from their enrollment (f ₁) and after 5 years from their enrollment (f ₂)	$e = 10e_1 + 2e_2$
2.2.	Number of "doctors of science" defended during the reporting period (f ₁)	$f = 10f_1$
2.3.	Share of publications co-authored with institutions from other countries (a _i) relative to the total number of publications (indicator in stage on observation)	$pi = a_i / (a_1 + a_2 + a_3 + a_4)$
3.	Social and economic impact during the reporting period (U ₃)	$U_3 = (g + 1) / 25$
3.1.	Cash spent during the reporting period in thousands BGN received from the European Framework Programs for Research and innovation (g ₁) and other international scientific projects (g ₂)	$g = 5 (g_1 + g_2)$
3.2.	Cash spent during the reporting period in thousands BGN, received from external financing for the organization under national projects and programs (l ₁), from scientific contracts activity with Bulgarian (l ₂) or foreign companies and enterprises (l ₃), from sold copyrights, prepared concepts, expert opinions and licensing agreements for the realization of intellectual products (l ₄)	$l = l_1 + 3l_2 + 5l_3 + 4l_4$

Overall rating: $U = 0.5 \times U_1 + 0.25 \times U_2 + 0.25 \times U_3$

Notes:

- In the analysis of the effectiveness of higher education institutions and research organizations, the obtained evaluations are divided by the number of researchers for the respective evaluated faculty or institute (e.g., $U_1e = U_1 / N, \dots, U_e = U / N$, where N = number of researchers in the unit).
- When publishing results of clinical trials, only those included after the title of the publication should be accepted as co-authors.
- WoS's Journal Citation Reports ranked scientific journals in each scientific category in four quartiles (quarters) - Q1, Q2, Q3 and Q4 - <https://incites.thomsonreuters.com>.
- Indicators 2.3 and 3.3 are used in the preparation of the analysis of the research activity of the organizations and are not taken into account when forming the evaluations

Appendix IV: Researchers and Institutional Views on Major Barriers to Research Excellence and Technology Transfer

Figure A4.1. Institutional barriers according to PROs/TTOs

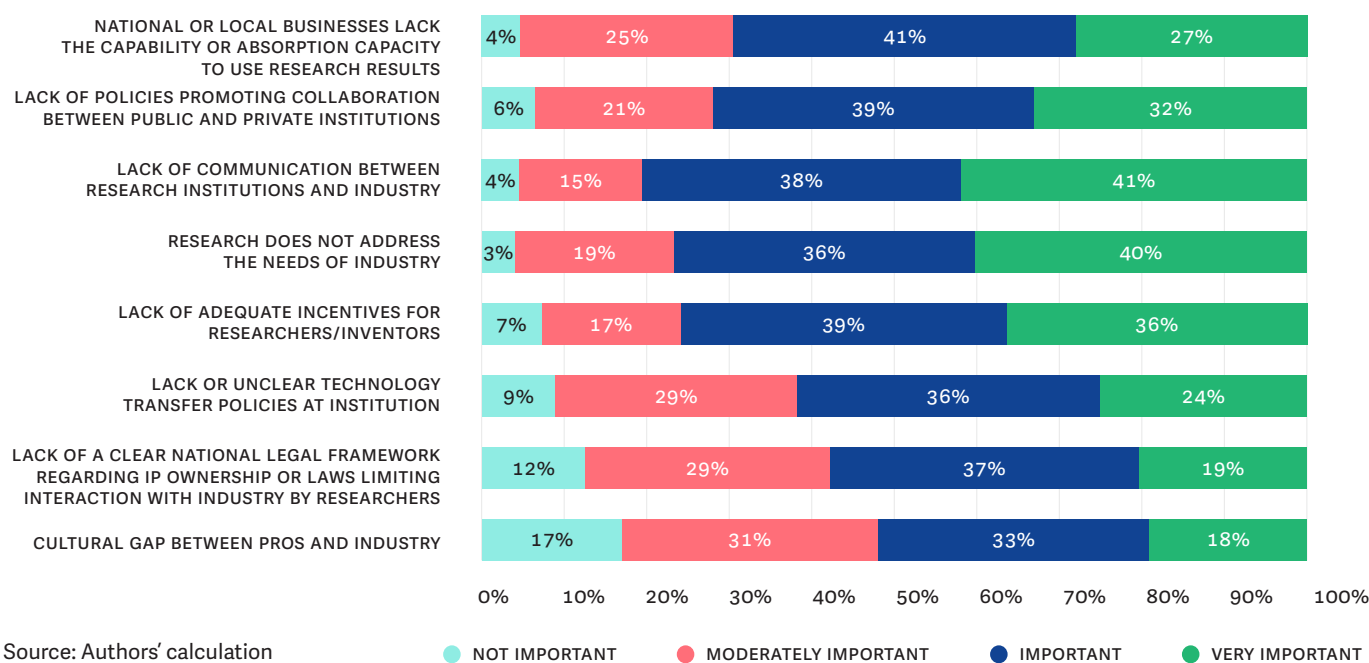


Figure A4.2. Institutional barriers according to researchers

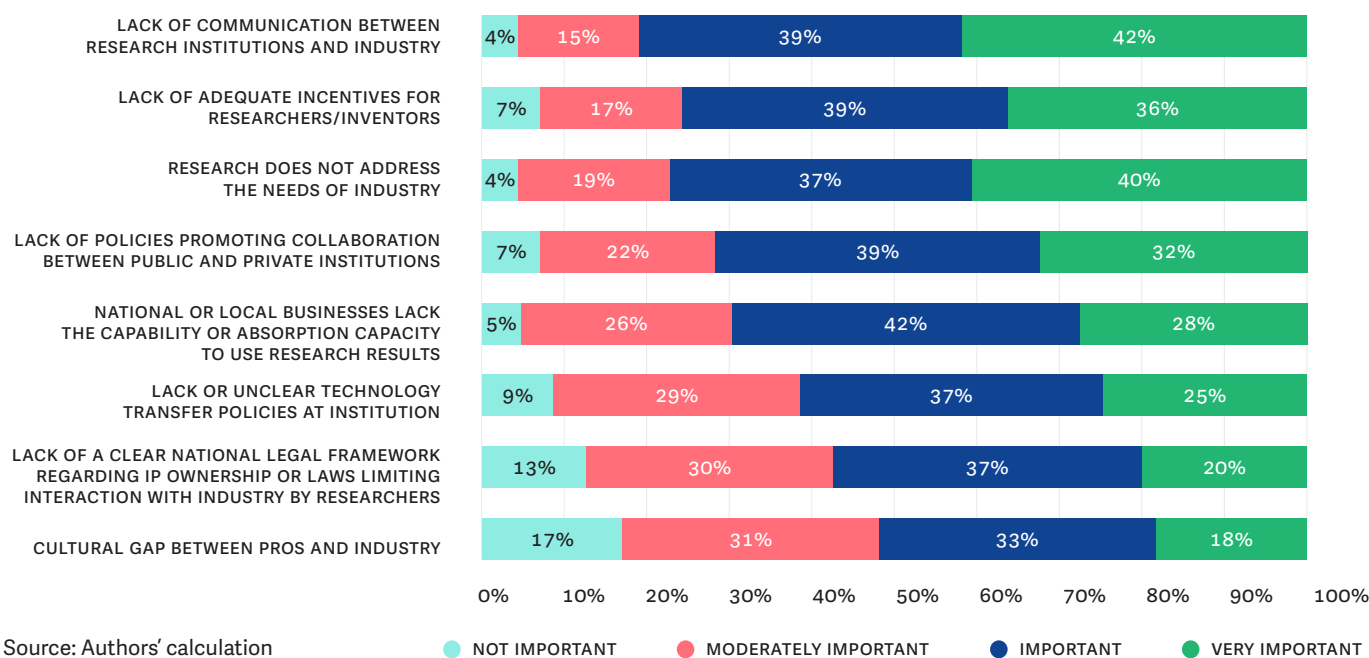


Figure A4.3. Research and technology transfer capacity barriers, according to PROs

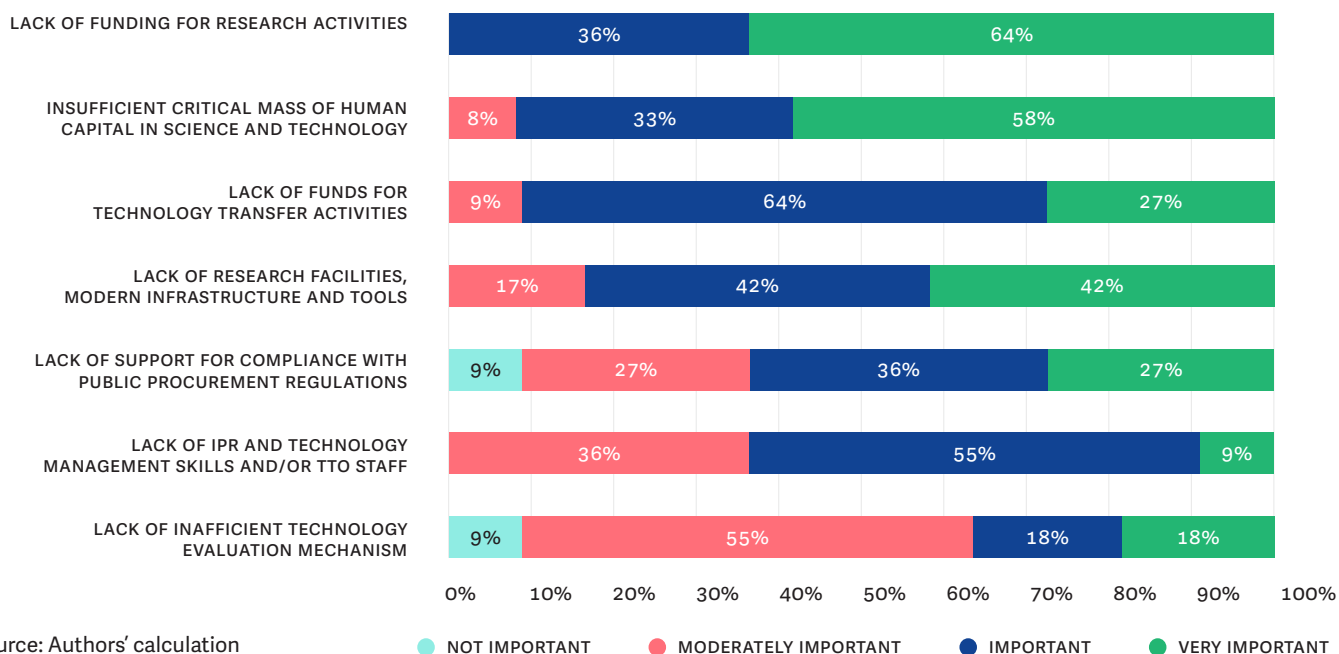
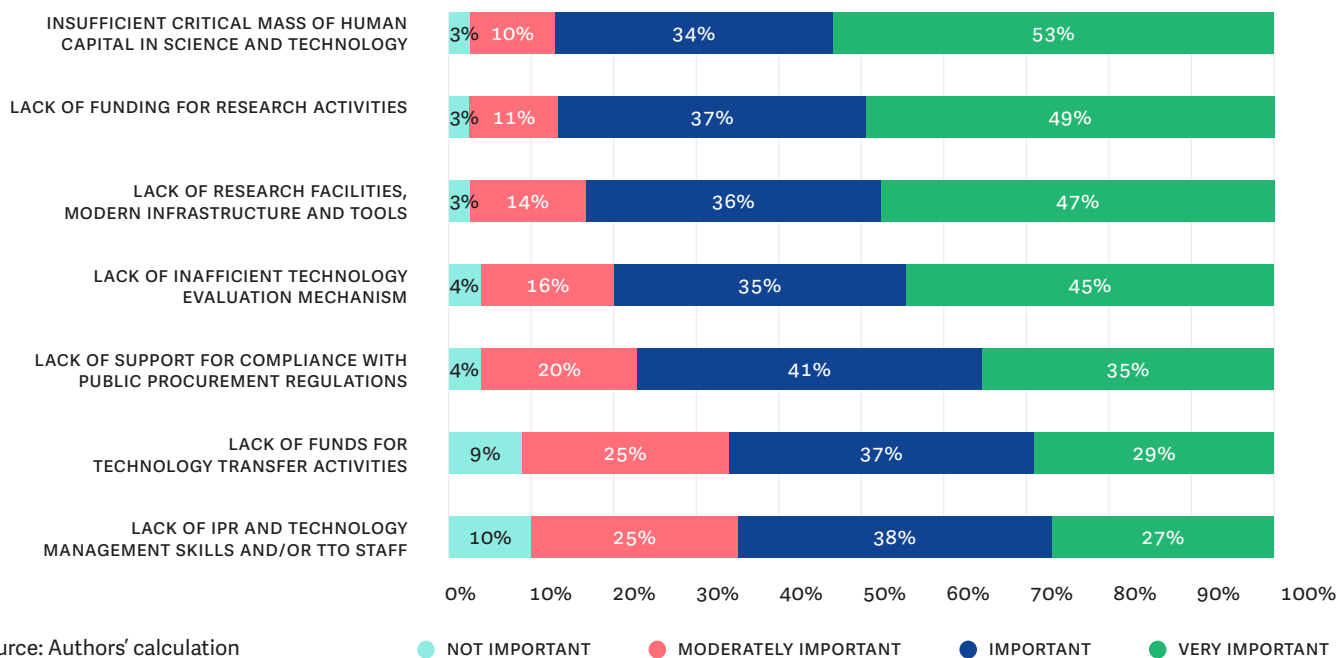


Figure A4.4. Research and technology transfer capacity barriers, according to researchers





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