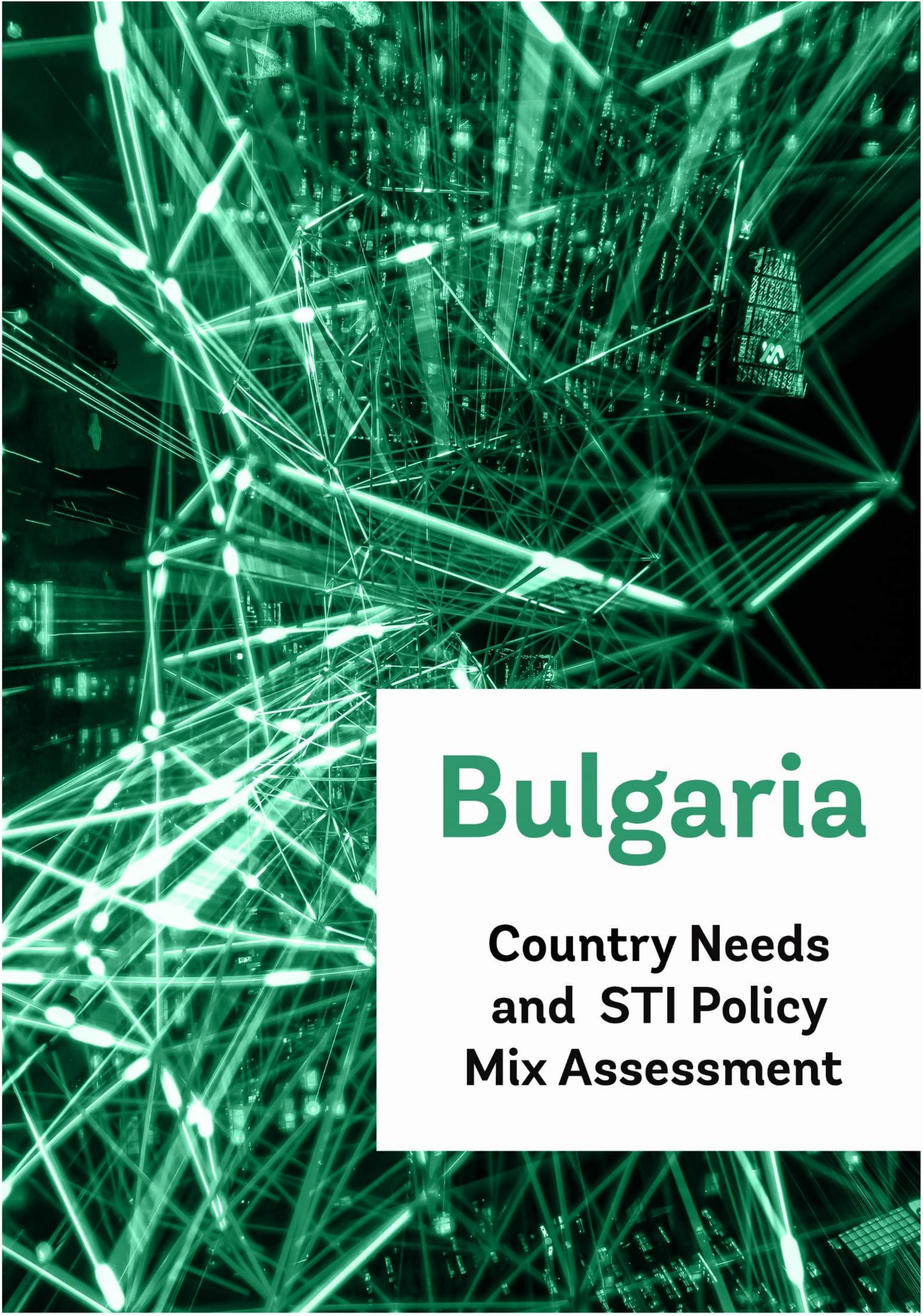

Bulgaria

Country Needs and STI Policy Mix Assessment

THE WORLD BANK
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REPUBLIC OF BULGARIA
Ministry of Education and Science

OPERATIONAL PROGRAMME
SCIENCE AND EDUCATION FOR SMART GROWTH

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September 2020

CONTENTS

ABBREVIATIONS AND ACRONYMS

AA	Agricultural Academy
AR/VR	Augmented Reality/Virtual Reality
BAS	Bulgarian Academy of Science
CEE	Central and Eastern Europe
CEFTA	Central European Free Trade Agreement
CoC	Centres of Competence
CoE	Centres of Excellence
COSME	Competitiveness of Enterprises and Small and Medium-sized Enterprises
CSA	Coordination Support Actions
DESI	Digital Economy and Society Index
EIB	European Investment Bank
EIF	European Investment Fund
EJP	European Joint Programme Co-fund
EPO	European Patent Office
ERC	European Research Council
EU	European Union
FDI	Foreign Direct Investment
FMFIB	Fund of Funds in Bulgaria
GBARD	Government Budget Appropriations on R&D
GDP	Gross Domestic Product
GERD	Gross Expenditures on Research and Development
HEI	Higher Education Institution
HHI	Herfindahl-Hirschman Product Concentration Index
IA	Innovation Actions
ICT	Information and Communications Technology
IMF	International Monetary Fund
IoT	Internet of Things
IP	Intellectual Property
IPR	Intellectual Property Rights
IS3	Innovation Strategy for Smart Specialization
ME	Ministry of Economy

MoES	Ministry of Education and Science
MRDPW	Ministry of Regional Development and Public Works
MSCA	Marie Sklodowska Curie Actions
MTITC	Ministry of Transportation, Information Technologies, and Communication
NEAA	National Evaluation and Accreditation Agency
NEET	Not in Employment, Education, or Training
NIF	National Innovation Fund
NSF	National Science Fund
OECD	Organization for Economic Co-operation and Development
OPIC	Operational Programme "Innovation and Competitiveness"
OPSESG	Operational Programme “Science and Education for Smart Growth”
PMR	Product Market Regulation
PORB	Patent Office of Republic of Bulgaria
PRO	Public Research Organization
R&D	Research and Development
R&I	Research and Innovation
RCA	Revealed Comparative Advantage
RDI	Research, Development and Innovation
REER	Real Effective Exchange Rate
RIA	Research and Innovation Actions
SBA	Small Business Act
SME	Small and Medium Enterprises
SMEPA	SME Promotion Agency
SMEI	SME Initiative 2014-2020
STEM	Science, Technology, Engineering and Mathematics
STI	Science, Technology and Innovation
STP	Sofia Tech Park
TFP	Total Factor Productivity
USPTO	United States Patent and Trademark Office
VC	Venture Capital
WDI	World Development Indicators
WITS	World Integrated Trade Solution
WTO	World Trade Organization

ACKNOWLEDGEMENTS

This report was prepared by a World Bank team led by Anwar Aridi (Senior Private Sector Specialist, Task Team Leader), and comprising Daniel Querejazu (Innovation Policy Specialist), Umut Kilinc (Economist), Teodora Georgieva (Research and Innovation Expert), and Lyubomira Dimitrova (Research and Statistical Expert). The report draws upon two background papers, (a) Bulgaria Firm-level productivity analysis prepared by Umut Kilinc; and (b) Knowledge and Technology Transfer from Bulgarian Public Research Organizations prepared by Teodora Georgieva, Daniel Querejazu, Pluvia Zuñiga (Senior Public Research Expert), and Lyubomira Dimitrova. Vicky Chemutai, Jan Kazimierz Orlowski, and Mirjana Stankovich (World Bank consultants) provided valuable analytical inputs into the report. Paulo Correa (Lead Economist) guided the team and helped structure the narrative and sharpen the messages. William Shaw edited the report.

The report benefited from the guidance of the World Bank management, Fabrizio Zarcone (Country Manager) and Ilias Skamnelos (Practice Manager), and from feedback and comments provided by Asya Akhlaque (Lead Economist), Mariana Iootty (Senior Economist), and Todor Milchevski (Senior Private Sector Specialist).

The team would like to thank the Government of Bulgaria, and in particular the Ministry of Education and Science, the Executive Agency Operational Programme Science and Education for Smart Growth, as well as all other ministries and public agencies which provided input, data, and feedback into the policy mapping exercise. The team also thanks the public research institutions, universities, technology transfer offices, and individual researchers who took part in the researchers and public research organizations survey and questionnaire.

EXECUTIVE SUMMARY

Bulgaria has achieved impressive economic performance over the last two decades. Nevertheless, recent growth of GDP and productivity has slowed since the global financial crisis, and the country faces medium- to long-term labor shortages and skills mismatches driven by an aging population and high emigration rates. Maintaining income growth in the face of these challenges 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. A review of STI policies is critical in preparation for the next EU programing period to ensure that the expected increase in resources to support research and innovation is used effectively.

This report provides a comprehensive assessment of the country's research and innovation needs and an original analysis of the policies devoted to supporting STI in Bulgaria, including nearly all national-level STI-related policy instruments (118 instruments operational from 2013 to 2019 with €843 million in disbursed funding). An analytical framework is used to compare the coherence of the STI policy mix to the country needs, and a set of policy recommendations is presented to reduce misalignment or gaps between policy support and the research and innovation needs of the nation's public and private sectors. The analysis includes three complementary components:

1. A country needs assessment is used to determine the national needs for STI policies. This includes a macro-level analysis of productivity, trade, and investment; a firm-level analysis of productivity across firm sizes and sectors; a review of national level innovation performance, including inputs (research funding and resources), outputs (publications and patents), and outcomes (new firms, products, and services); and an analysis of market and institutional conditions that influence research performance, resource allocation, and firm productivity.
2. A policy mix analysis maps national-level instruments related to STI. This analysis includes a review of relevant STI policy stakeholders, institutions, and their governance; a review of national-level STI strategies; identification of the key characteristics of SME policy instruments (administering agency, mechanism of support, beneficiaries, etc.); and a comparison of the coherence of the STI instrument portfolio to the identified needs of the country.
3. Recommended areas for policy action are developed by matching the country needs assessment and policy mix analysis to identify the areas where the STI instrument mix aligns (or does not align) with the country's STI needs.

The country needs assessment finds that:

- Labor productivity has shown dramatic improvement in the last decade, but despite this growth, Bulgaria still exhibits one of the lowest productivity performances in Europe. Aggregate productivity growth has been driven by the ability of existing firms to become more efficient (through technology upgrading, innovation, and other factors), while productivity growth is dragged down by barriers to the reallocation of resources (preventing more productive firms from growing) and to the creative destruction process (firm entry and exit). Further productivity gains to catch up to European peers will require reforms to the business environment that ease firm entry and exit and allow resources to move more efficiently within the market.
- Bulgaria exhibits one of the lowest innovation performances in Europe, driven by very low levels of research investment compared to peers. Research outputs (publications, patents, etc.) tend to have little impact internationally and there is little transfer of knowledge and technologies from the public to the private sectors. This poor research and innovation (R&I) performance represents a missed opportunity for additional productivity growth driven by innovation and skilled labor. There is a clear need to modernize the national research system, particularly in the public sector, to improve the performance of public research organizations, with a focus on research excellence, market-oriented research agendas, and technology transfer.
- Technology adoption in firms has improved over the last ten years, helping to drive productivity growth, but Bulgaria still lags behind most peers in technology adoption. Bulgarian firms have among the lowest levels of digitization in firms in Europe, for both basic and advanced digital technologies. The findings from the recent World Bank Business Pulse Survey (BPS) survey in the aftermath of the COVID 19 outbreak show that the industry sectors least affected are those with the highest share of firms that have adopted digital solutions, underlining the need for increased digitization to build business resilience and flexibility. Bulgaria should continue to promote and support technology adoption and digitization through targeted instruments and the removal of constraints on the business environment.

The following key findings emerged from the policy mix analysis:

- STI institutions are disconnected from one another and suffer from weak governance structures, which has resulted in fragmented policies and programs and the lack of a coordinated national R&I agenda with clear targets and defined responsibilities. A new R&I Agency has been envisioned to address this issue and consolidate implementation, coordination, and monitoring of the STI portfolio currently spread across different government bodies. However, the mandate, structure, and timeline for establishment of this new agency are yet to be defined.
- Severe lags in the allocation and disbursement of funds for STI indicates serious challenges in the implementation of the STI policy mix, which has likely hindered the effectiveness of existing policy instruments.

- Analysis of the coherence of the policy mix with identified country needs shows gaps in support for technology transfer, Industry 4.0 technology adoption, early-stage company support, improvements to the business environment, and development of digital skills.

By comparing the findings from the country needs assessment and the policy mix analysis, three key areas for policy action emerge, which require attention from the different public sector stakeholders in the short, medium, and long term.

Addressing the coherence of the STI policy mix, which includes:

- Improving STI policy coordination and communication among implementing ministries and agencies through activation of existing coordination channels, bodies, and working groups;
- Increasing national funding for STI, along with clearly defined targets for this spending; and
- Adjusting the policy mix to address identified gaps and improving instrument design and governance to maximize impacts.

Improving the governance of the public research system, which includes:

- Addressing persistent fragmentation and implementation challenges by consolidating the implementation and coordination of the STI policy mix under the planned R&I Agency;
- Enhancing research capabilities and ensuring the economic and societal relevance of research activities by continuing performance-based funding reforms, reorienting public research agendas toward addressing industry and societal needs, and creating channels for industry to provide input into public research agendas;
- Overhauling public researchers' career development and remuneration schemes to attract and retain young talent; and
- Improving the incentive framework and resources for tech transfer and commercialization of public research.

Supporting innovation in firms, which includes:

- Continuing support for firm digitization and tech adoption through identifying firm technology and digitization needs and investing in digital skills through training and retraining programs;
- Introducing targeted support to encourage private sector R&D investments through a mixture of direct and indirect instruments, as well as promotional schemes;

- Promoting innovative entrepreneurship and removing impediments to the growth of new ventures through support for early stage entrepreneurship, investment readiness of startups, and the professionalization of early-stage investors; and
- Easing constraints related to the operating business environment and mobility of resources by addressing challenges related to firm entry and exit and conducting an in-depth assessment of product market regulation.

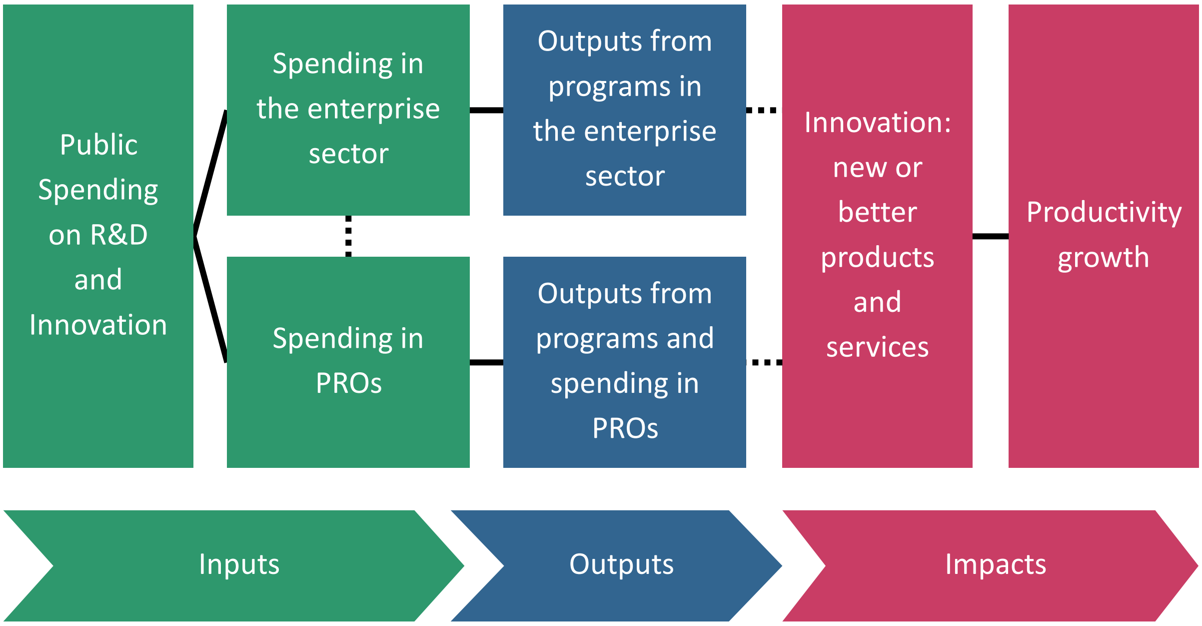
INTRODUCTION

Meeting the coming economic challenges and taking full advantage of increased external resources will require a marked improvement in Bulgaria's policies supporting science, technology and innovation (STI). Recent economic performance has been robust. In the two years before the COVID-19 pandemic hit, GDP growth exceeded 3 percent in the context of declining unemployment rates, a sizable current account surplus, and deepening integration with the EU (e.g., participation in Exchange Rate Mechanism II and the banking union). Nevertheless, growth in GDP remains well below the pace achieved before the 2008 financial crisis, and a rapidly aging population and high emigration rates raise the potential for increasing labor shortages and skills mismatches over the medium term. Increasing productivity will be necessary to maintain growth in the face of these challenges. This will require improvements in Bulgaria's STI performance, which ranks among the worst in the EU across multiple indicators. The increase in financial resources expected with the new EU programming period provides an important opportunity to strengthen STI performance, but obtaining these resources and using them effectively will require greater efficiency in their allocation and management, as well as improved public support for research. Increasing spending requires careful assessment of the functioning, efficiency, and effectiveness of STI programs and instruments before expanding them further. Individual impact evaluations of specific programs or instruments will not be sufficient. A comprehensive and thorough review of the policy mix is needed to achieve the desired STI outcomes.

This report performs a comprehensive assessment of Bulgaria's needs for STI policy and reviews its existing policy mix using the Public Expenditure Review for Science, Technology, and Innovation (PER STI) methodology.[1] The PER STI methodology is a results-based framework to logically link inputs, outputs, outcomes, and impacts of public spending on research and innovation (Figure 1). It proposes that increasing labor productivity and total factor productivity are the ultimate developmental goals for countries' economic growth. The framework first looks at inputs in the form of public spending in both the public sector (funding for R&D at public research organizations and universities) and the private sector (funding for R&D, commercialization, and technology adoption in firms); then outputs (publications, patents, utility models, and other forms of new knowledge); and finally the outcomes (new products and services, new firms) of public spending, which ultimately lead to productivity growth in the economy.

[1] See: Correa, 2014. Public Expenditure Reviews in Science, Technology, and Innovation: A Guidance Note. https://openknowledge.worldbank.org/handle/10986/21064

Figure 1. PER STI framework



Source: Correa, 2014

The objective of this framework is to provide an analytical background for improving the effectiveness of public investments for STI through reallocation of resources and the redesign and rationalization of STI policies and instruments. In the medium term, this report is expected to contribute to increasing the absorption of STI funds in Bulgaria. In the long term, this should lead to improved innovation performance of Bulgaria, as measured by innovation outcomes such as new knowledge-intensive startups, new products and services, firm-level innovation, and ultimately lead to aggregate productivity improvements.

COUNTRY NEEDS ASSESSMENT

This section aims to identify the principal drivers of economic performance in Bulgaria and to indicate where policies may particularly constrain or support research and innovation in the public sector, in the private sector, and the transfer of innovations and technologies from the public to private sectors. This includes analyses of 1) macroeconomic issues, including productivity and trade; 2) productivity differences across firms; 3) innovation, including innovation inputs (R&D funding), outputs (publications and patents), and outcomes (new firms, innovations, and technology adoption); and 4) market and institutional factors that influence resource allocation and firm productivity, such as labor markets, the business environment, and competition policy. The aim of these analyses is to identify key country needs in the areas of science, technology, and innovation, which can then be compared to the national STI policy mix to assess the alignment between country needs and investments in STI.

Macroeconomic Performance

Bulgaria lags behind peers in labor productivity performance but has experienced rapid productivity growth along with a shift from less to more technology-intensive industries:

Bulgarian labor productivity growth in manufacturing from 2002-2016 was higher than that of any European country except Ireland. Nevertheless, the Bulgarian economy still exhibits on average one of the lowest labor productivity levels in Europe, underlining the need for economic policies aimed at improving productivity and innovation.

Employment is growing in more technology-intensive industries, while staying constant or decreasing in lower-technology intensive industries, which implies that there is labor reallocation from lower- to higher-tech industries.

Bulgaria’s economic complexity was relatively low over the 1995-2017 period and breaking away from resource-driven exports will require specialization in more complex activities. Similarly, Bulgaria’s export sophistication (measuring the income content of a country’s export basket) has been increasing but exports are still less sophisticated than comparator countries.

The ICT sector is emerging as a critical driver of future exports of both goods and services, but further growth will require a boost to the innovation economy in order to improve export volumes and diversification.

Bulgaria has undergone a substantial transition from a highly centralized and planned governance system to a market-oriented economy in the last three decades. During the initial phases of the transition, economic growth and restructuring was slow and combined with a low saving rate and high indebtedness. As a result, GDP stagnated at between 10 and 15 billion USD for about a ten-year period from 1990 to 2000. Structural reforms intensified in the late 1990s[2] and the progress in the EU accession process helped the economy to take off and achieve rapid economic growth with improved living standards (World Bank, 2019). From 2000 to 2010, GDP rose from around 13 to 50 billion USD, one of the most remarkable economic growth performances globally during this period. The unemployment rate fell from around 20 percent in 2001 to five percent in 2008 as GDP rose dramatically. At the start of the global financial crisis in 2008, these trends reversed, with GDP falling about 10 percent and the unemployment rate rising from 5 to 11 percent between 2008 and 2010. The unemployment rate continued to rise until 2013 and then declined slowly, returning to its 2008 level only in 2018. GDP, however, stayed rather stable around 55 billion USD after 2008.

Despite the economic growth of the last three decades, Bulgaria still faces an important challenge of raising aggregate productivity, which will be vital for the convergence with the EU as Bulgaria's income per capita is still significantly lower than the EU average. The recent COVID 19 pandemic represents another major ongoing challenge to Bulgarian prosperity and its impacts will need to be mitigated if Bulgaria is to maintain its economic growth trajectory (see Box 1).

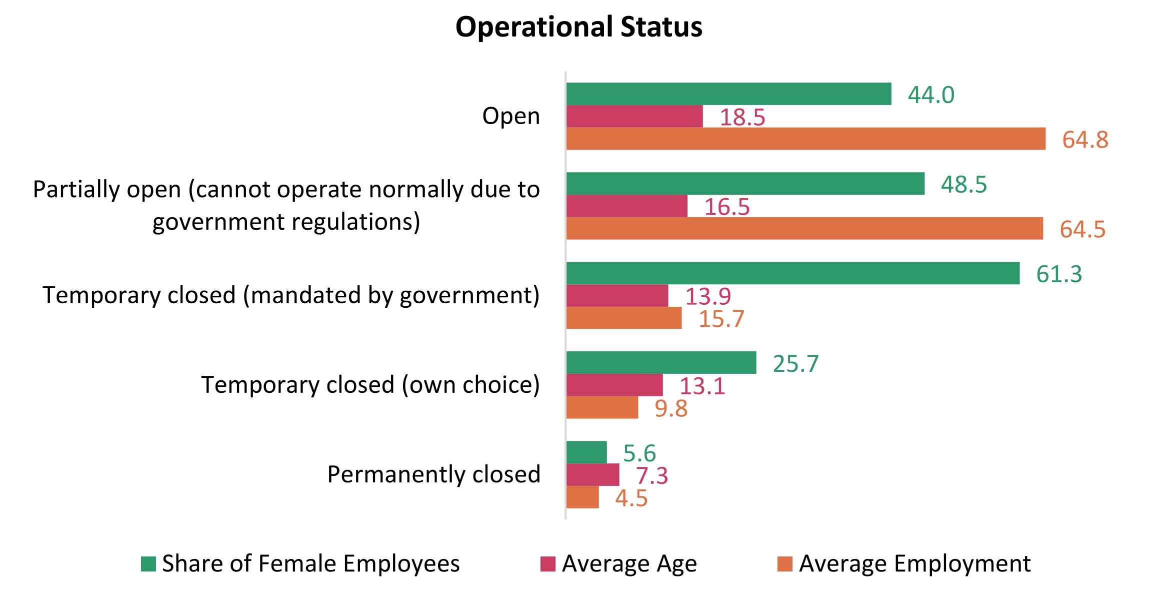
Box 1. Impacts of the COVID-19 Outbreak on Bulgaria's Private Sector

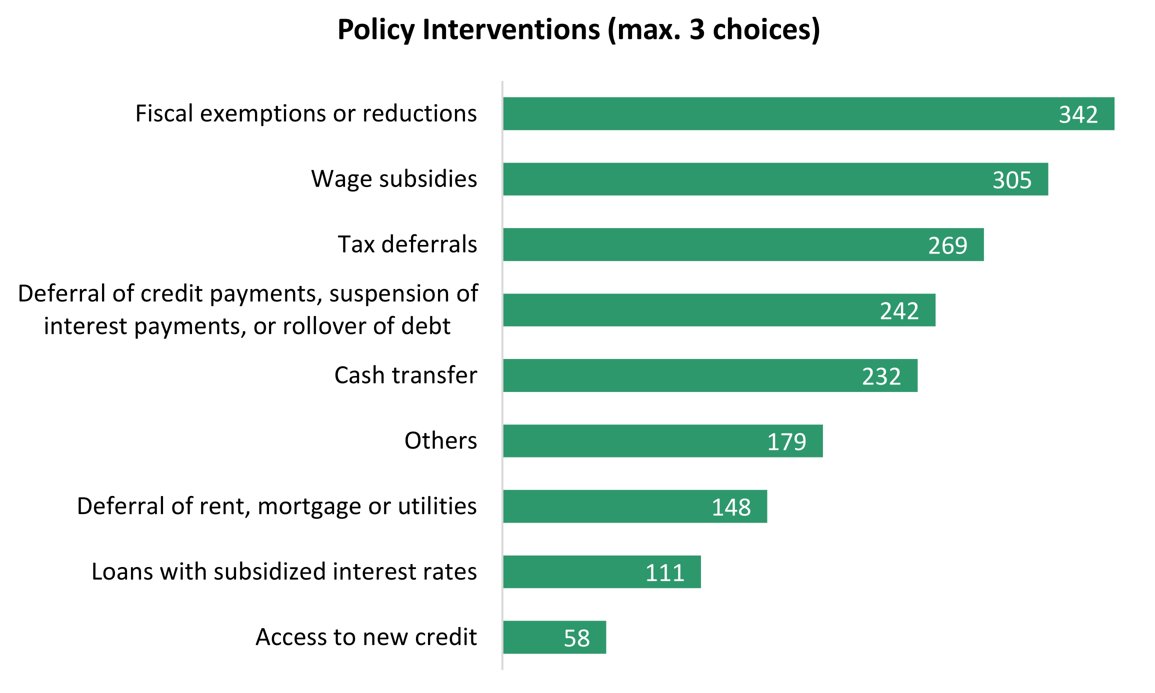
A recent World Bank Business Pulse Survey of over 1,000 establishments in Bulgaria found that the COVID 19 pandemic has disproportionately affected smaller and younger firms in the country. Businesses that have been able to remain open are generally large in size (averaging over 60 employees), while temporary or fully closed firms have on average below 20 employees (see Box Figure 1). Younger firms have also been heavily impacted, where permanently closed firms are on average less than 10 years old.

[2] In particular, privatization was sped up in 1990s in Bulgaria. World Bank (2015) suggests that the state-ownership in Bulgarian sectors was reduced noticeably at the beginning of 2000. The share of state-ownership, however, still remained significant after 2000 in comparison to advanced economies. Although a recent comprehensive assessment of the state-ownership in Bulgaria is not available, in 2008, there were approximately 115 state-owned enterprises. In 2008, the mining sector, the pharmaceutical sector, the energy sector and the transport sector, in particular, railways accommodated largest portion of the state-owned enterprises.

Box 1. Impacts of the COVID-19 Outbreak on Bulgaria's Private Sector

Box Figure 1: Firm Demographics, Operation Status and Most Preferred Policy Actions





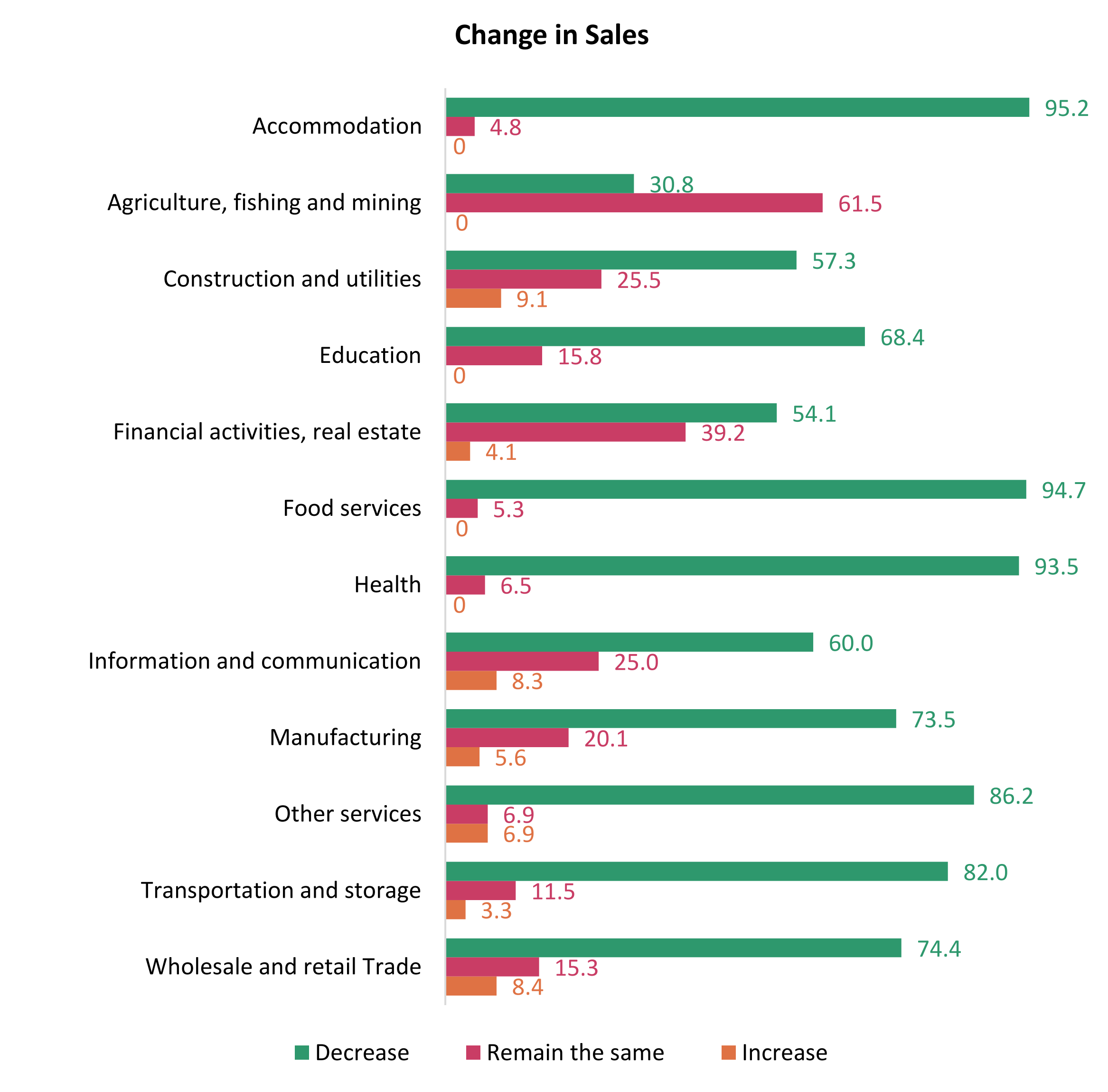
The accommodation, education and food services sectors have the highest ratio of closed to open businesses. Of these three sectors, the share of firms reporting a decrease in sales is the highest in food services and accommodation, while the share of firms reporting layoffs is the highest in food services (see Box Figure 2). Among the least affected sectors, the share of firms reporting loss in sales is the lowest in agriculture, information and

Box 1. Impacts of the COVID-19 Outbreak on Bulgaria's Private Sector

communication, and financial services. In the latter two sectors, the share of firms who increased using digital services, such as internet, online social media, specialized apps or digital platforms, is the highest (see Appendix VII for more details).

Surveyed firms feel that governmental measures to lower fiscal burdens need to be prioritized. Wage subsidizes are among the most preferred policies by Bulgarian firms, while measures to facilitate new borrowing through subsidized loans or better access to credits are the least preferred (Box Figure 1).

Box Figure 2. Share of Firms that reported a change in sales, layoffs, leave without pay and wage reductions in last 30 days (% in sector total)



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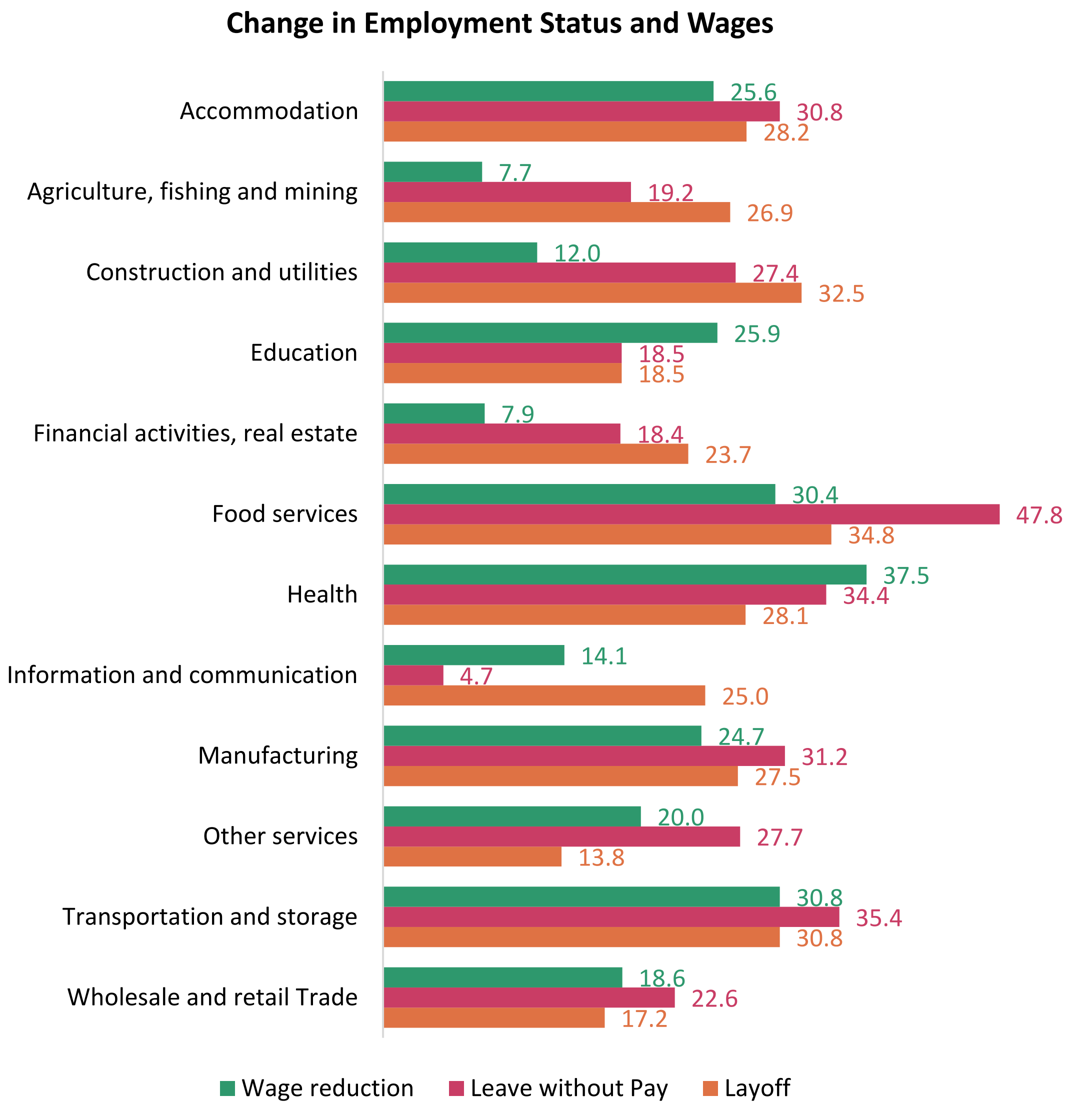
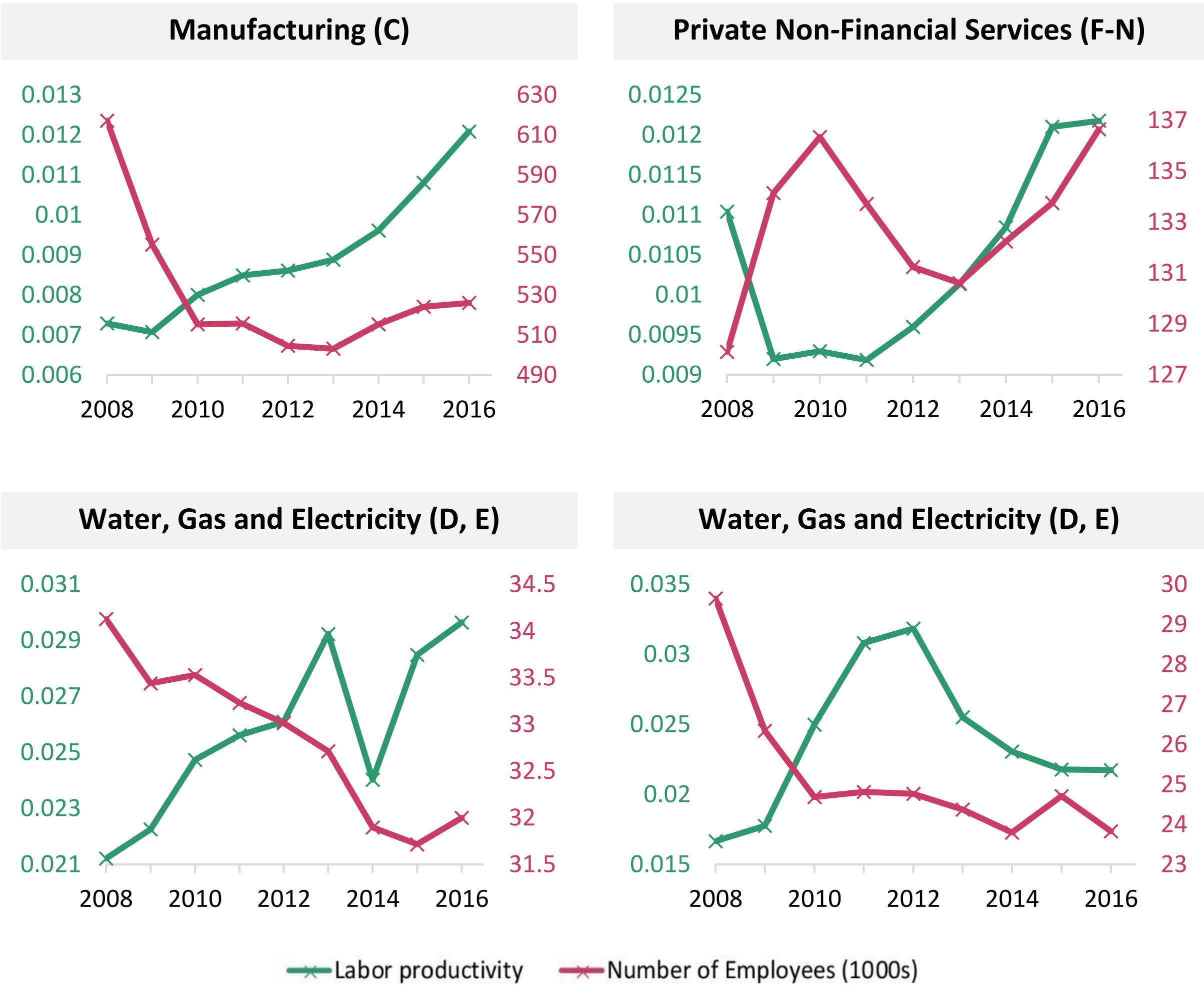


Productivity

Labor productivity and employment trends changed following the economic upheaval of the 2008 global financial crisis. The level of employment in manufacturing, mining and agriculture, and utilities fell dramatically following the crisis, as can be seen in Figure 2, which shows total employment (in thousands of employees) and labor productivity (the ratio of deflated value-added to the number of employees) in the main sectors of the economy. The decrease in employment in these traditional sectors occurred simultaneously with employment gains in non-financial private business services, which may have been due to a reallocation of labor towards services in the global recession period. In sectors where employment fell, labor productivity increased instantaneously. This implies that the global crisis cleared the market of inefficient production units or jobs during the downturn. Labor productivity in services decreased around 20 percent in 2009 following the noticeable increase in employment. Employment in services, however, began to decline after 2010, while labor productivity in the sector simultaneously rose. In the last four years of the sample period, employment and labor productivity increased jointly in the manufacturing and private service sectors, indicating that the economy entered into a period of expansion.

Figure 2. Labor productivity and employment moved in opposite directions at the onset of the global recession, 2008-2016

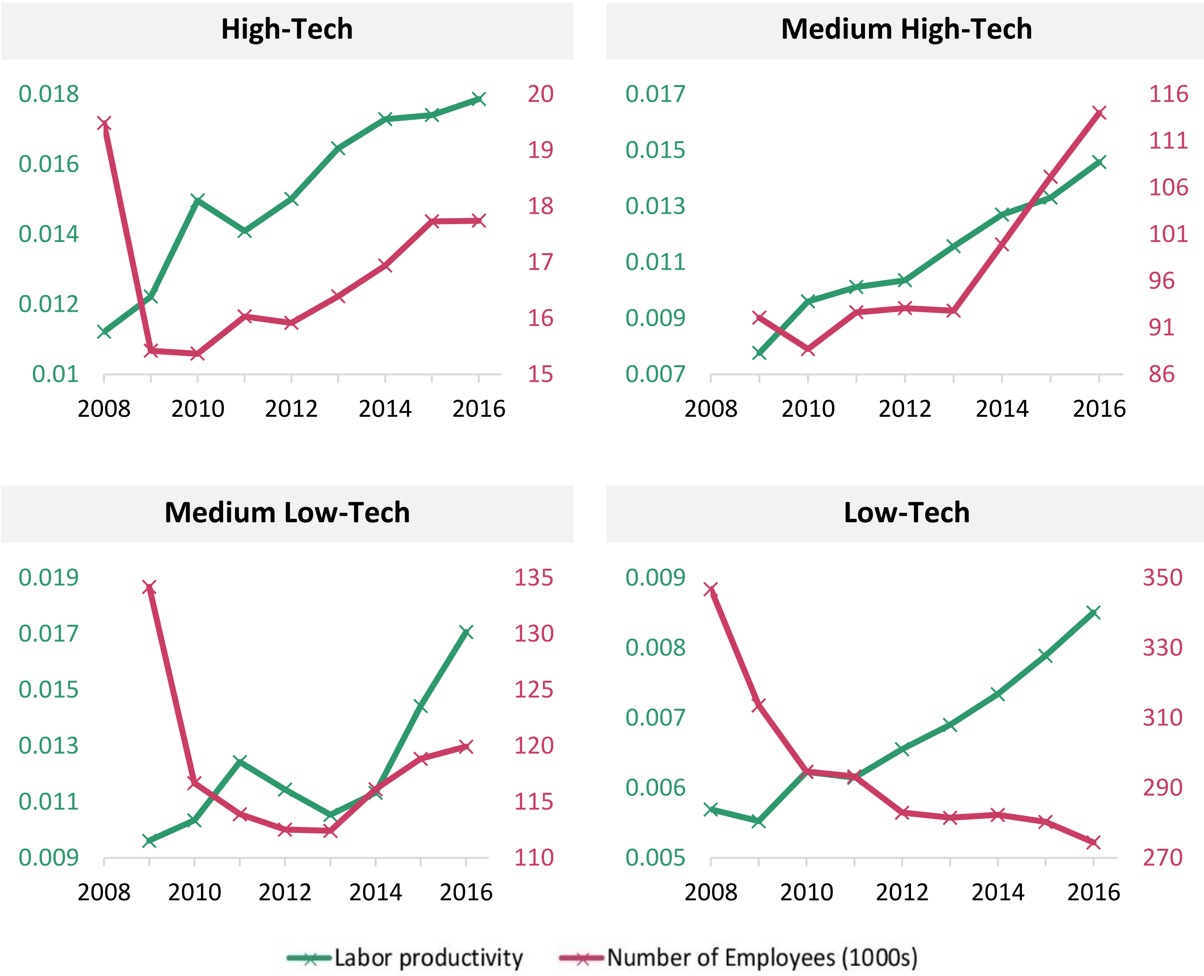


Source: Author's calculation based on Eurostat data

A Closer Look at Manufacturing

The more technology-intensive manufacturing sectors experienced a greater increase in employment and higher levels of productivity than less technology-intensive sectors did following the 2008 crisis.

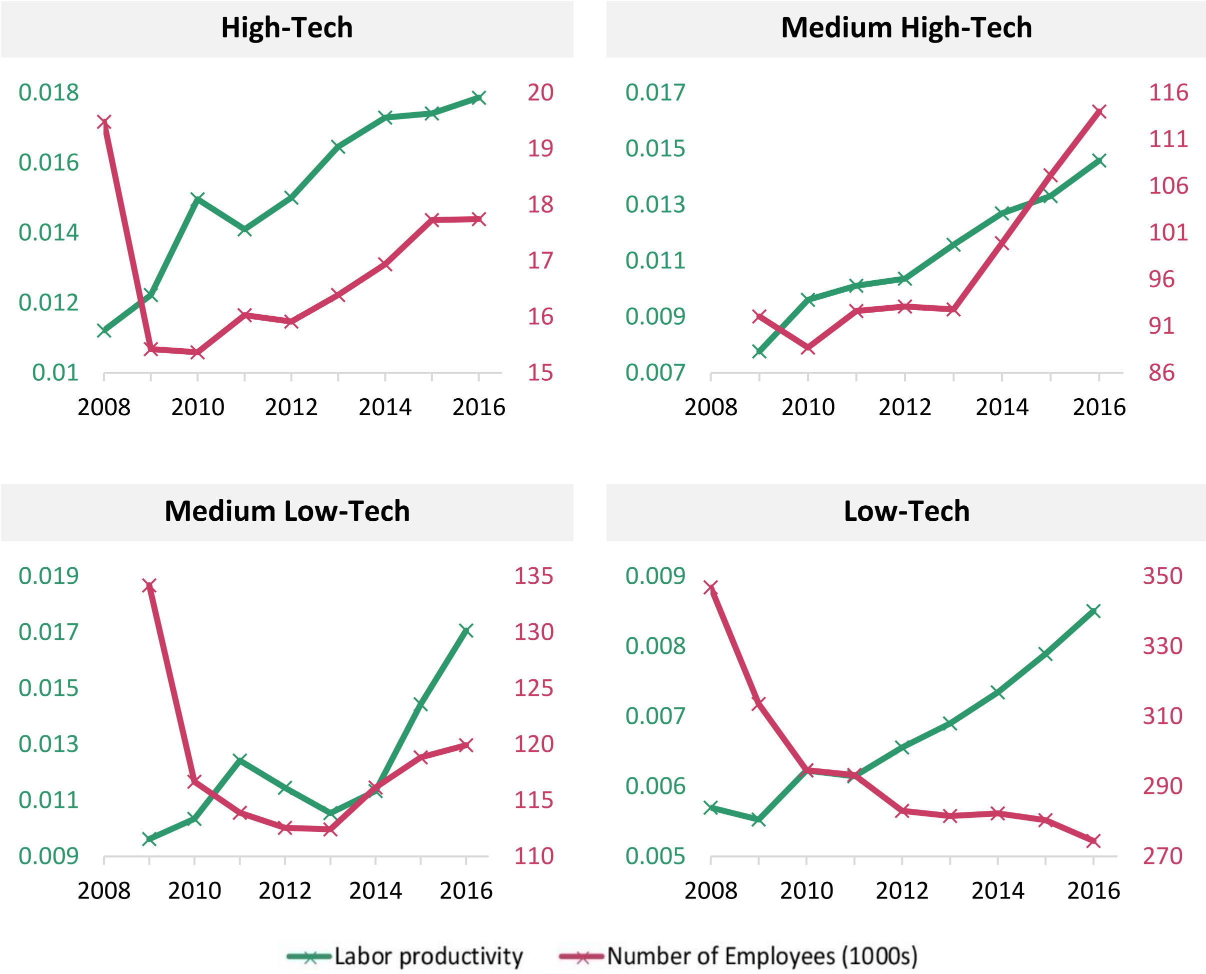
Figure 3. Trends in employment and labor productivity varied by technology intensity in manufacturing



Source: Author's calculation based on Eurostat data

Figure 3 provides a closer look into manufacturing in Bulgaria by breaking the sector into four categories based on the overall intensity of technology used in production at the 2-digit industry level (e.g. Hatzichronoglou, 1997) and displays considerable variation in the employment dynamics.

Figure 3. Trends in employment and labor productivity varied by technology intensity in manufacturing



Source: Author's calculation based on Eurostat data

After the negative shock in 2009 that reduced employment in all four groups, the total number of employees started increasing in more technology-intensive industries (shown in the upper two panels of Figure 3). At the same time, employment either decreased or stayed relatively constant in less technology-intensive industries (lower two panels of Figure 3). The decrease in employment is particularly pronounced in the largest and the least-technology intensive group, which implies a degree of labor reallocation from lower- to higher-tech industries. Labor productivity, however, increased in all 4 groups throughout the sample period. Average labor productivity is the highest in the high-tech industries and the lowest in the low-tech industries, which can be interpreted as an evidence that the technology intensity of production is among the drivers of productivity growth in Bulgarian manufacturing.

Figure 4. Labor productivity growth was particularly high in high- and medium-high-tech manufacturing industries

Source: Author's calculation based on Eurostat data

While nearly all Bulgarian manufacturing industries (at the 2-digit level)[3] experienced a rise in productivity from 2008 to 2016, labor productivity growth was particularly rapid in high- and medium-high-tech industries, such as the manufacturing of chemicals, computer, electronic and optical products, motor vehicles, trailers and semi-trailers and other transport equipment (Figure 4). High levels of productivity growth may explain why employment growth was faster in these more technology-intensive industries, as firms with more rapid increases in output per worker could offer higher wages to workers from other firms. The level of labor productivity was the lowest in low- or medium-tech industries such as leather, wearing apparel, furniture, wood, textiles and food manufacturing. This, however, may be

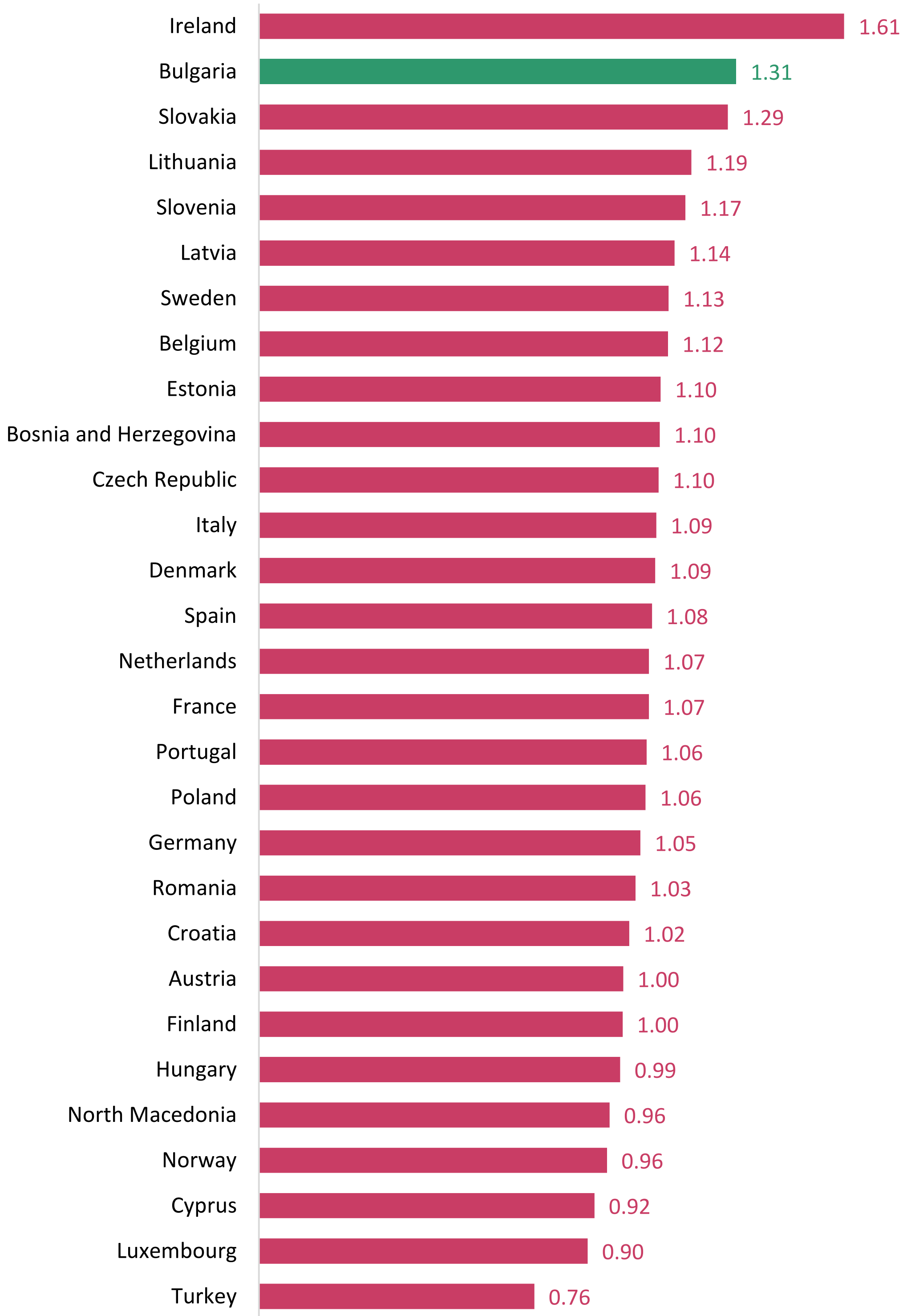
[3] The exception is the manufacture of coke and refined petroleum products, where the calculated labor productivity growth rate was -101 percent, possibly due to the prevalence of state-ownership or data measurement issues. The data for this sector, and for basic metals (growth rate in productivity of 60 percent) are omitted from the graph to preserve visual clarity.

because production is more labor intensive in these industries, rather than because firms lack the technology required to produce efficiently. In fact, the level of labor productivity is not necessarily higher in some of the high-tech industries, such as the manufacturing of motor vehicles, trailers and semi-trailers. This indicates that to understand the extent of efficiency gains, it is necessary to analyze firms' total factor productivity (TFP) performance. TFP performance, along with the direction and patterns of factor reallocation, will be evaluated in the following sections where firm-level data is introduced into the analysis.

Manufacturing Productivity from a Cross-Country Perspective

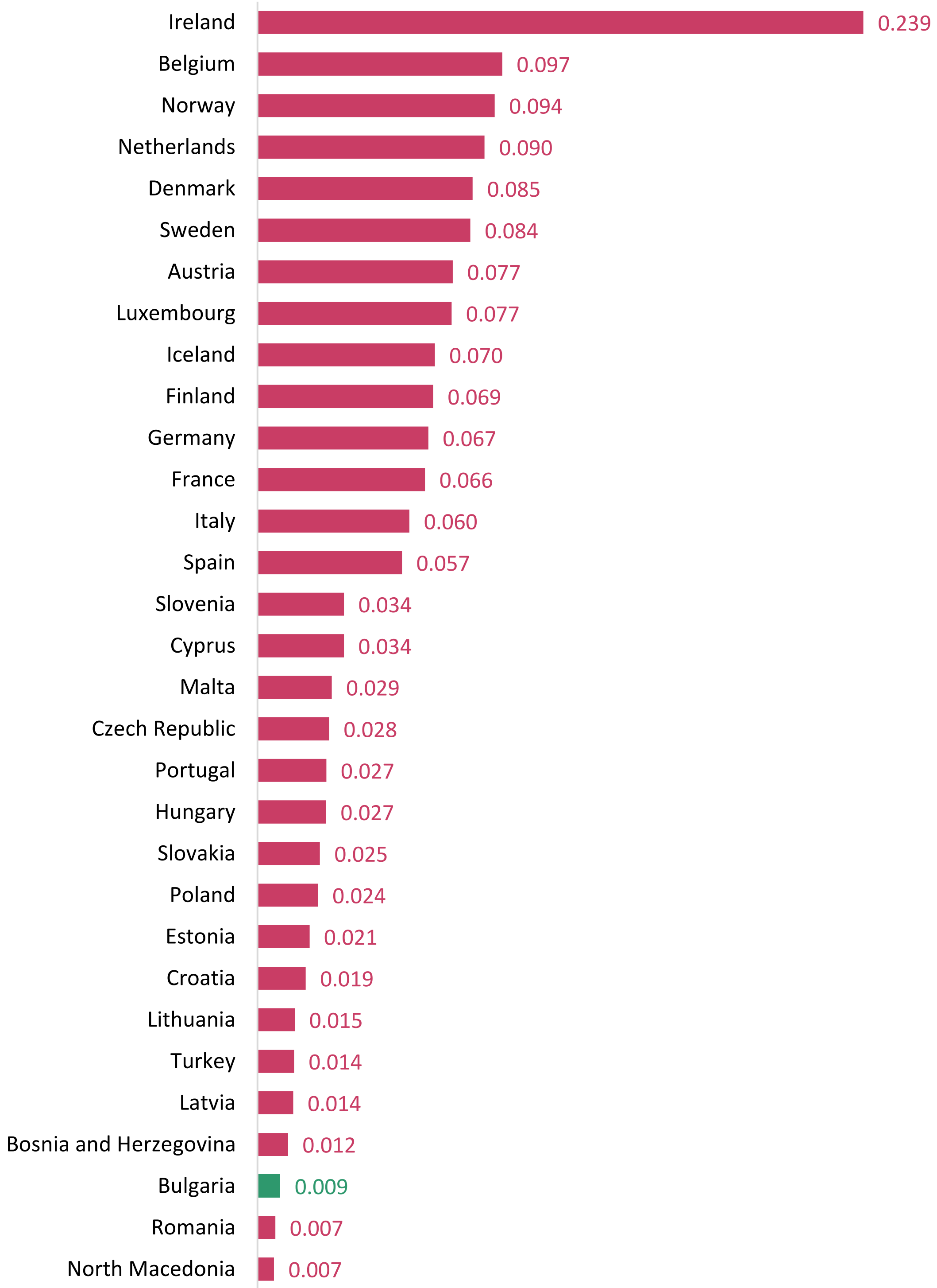
Once the adverse effects of the 2008 global financial crisis dissipated, the Bulgarian economy exhibited remarkable productivity growth performance. Indeed, the increase in labor productivity in manufacturing from 2008-12 to 2013-16 exceeded that of all countries included in the Eurostat database, except for Ireland (Figure 5). However, despite this remarkable *growth* performance, the average *level* of productivity in Bulgarian manufacturing remained near the bottom of European countries (Figure 6). This underlines the importance of accelerating changes in economic policies aimed at improving productivity and innovation, to speed up economic catch-up with the more advanced economies of the EU. The next section delves into the sources of productivity growth using micro data, which will be later used to derive policy suggestions to accelerate productivity growth in the main sectors.

Figure 5. The growth rate of Bulgarian manufacturing labor productivity was extremely high… (Average labor productivity ratio of 2013-2016 over 2008-2012)



Source: Author's calculation based on Eurostat data

Figure 6. But the level of Bulgarian manufacturing labor productivity was extremely low

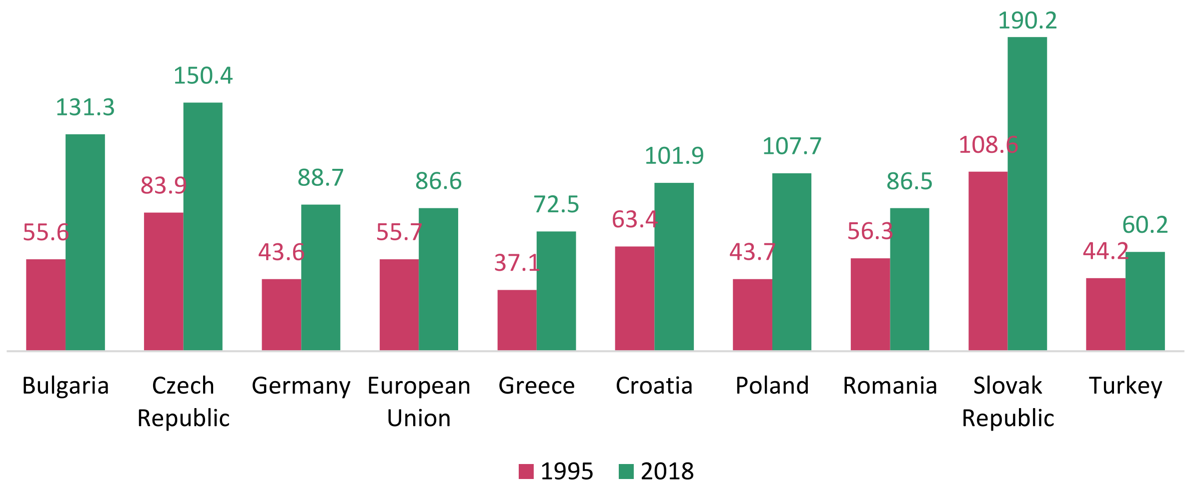


Source: Author's calculation based on Eurostat data

Trade and Investment

Bulgaria is a fairly liberalized economy and has almost doubled its participation in international trade since 1995. Bulgaria has become more integrated into the global economy, as the trade/GDP ratio rose from 55.6 percent in 1995 to 131.3 percent in 2018 (Figure 7). Rapid integration into the global economy in part reflected Bulgaria's accession to several trade agreements. Joining the World Trade Organization (WTO) in 1996 increased Bulgarian firms' access to international markets. Joining the WTO also contributed to domestic productivity through increasing import competition that forced firms to adopt innovations and improvements in product quality, and by strengthening intellectual property (IP) protections (Global Trade and Innovation Policy Alliance 2019). Access to markets was further extended through joining the Central European Free Trade Agreement in 1999 and the EU in 2007. Bulgaria also entered into a series of bilateral trade agreements from 1995 to 2004; trade has thrived under these agreements, with the EU[4], China, Turkey, and Serbia representing the country's top trading partners.

Figure 7. Bulgaria's trade to GDP ratio increased sharply, 1995 to 2018



Source: WDI

Note: The openness to trade indicator provides a snapshot of a country's total trade using the trade/GDP ratio. The measure is computed by summing the total value of exports and imports of the country and dividing this by the country's GDP.

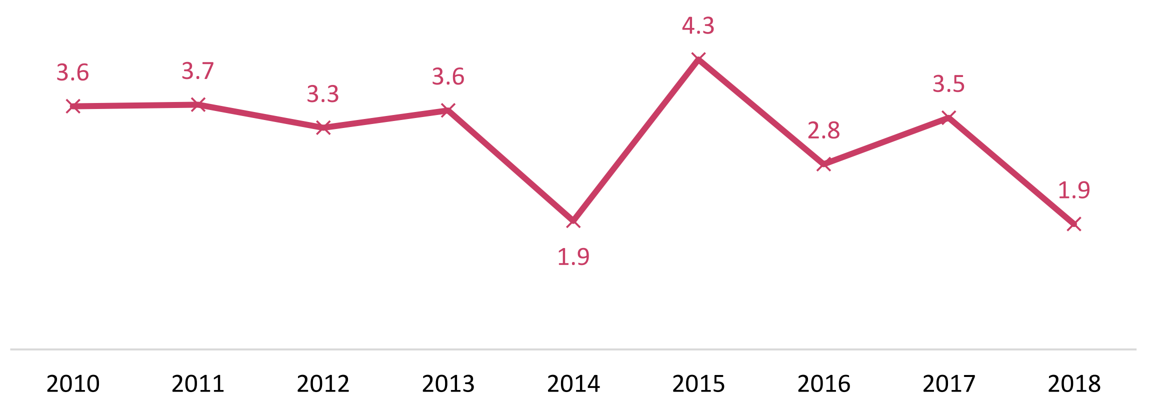
Net FDI inflows as a percent of GDP in Bulgaria became more volatile after the 2010-2012 period, and fell from 2015 to 2018, while inflows increased in CEE peers like Slovak Republic, Czech Republic, Romania, and Croatia. The stock of FDI in Bulgaria as a share of GDP fell from

[4] Almost 72 percent of Bulgaria's total trade is with the EU-28 membership.

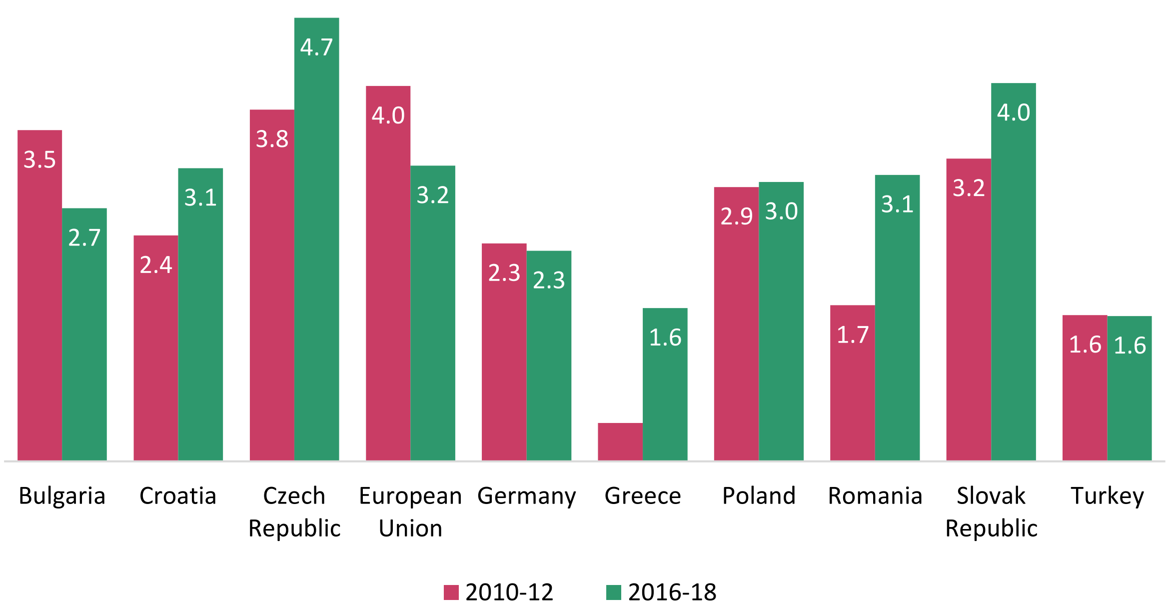
3.5 percent in 2010-12 to 2.7 percent in 2016-18 (Figure 8). A recent IMF study estimates that closing gaps with respect to European leaders in skills shortages, institutional quality, and public infrastructure could result in additional gains in FDI of 5-7 percentage points of GDP (La-Bhus Fah and Rhaman 2018).

Figure 8. Net FDI Inflows were volatile (top) and the stock of FDI fell relative to GDP (bottom), 2010-2018

Net FDI Inflows, 2010-2018 (Percent of GDP)



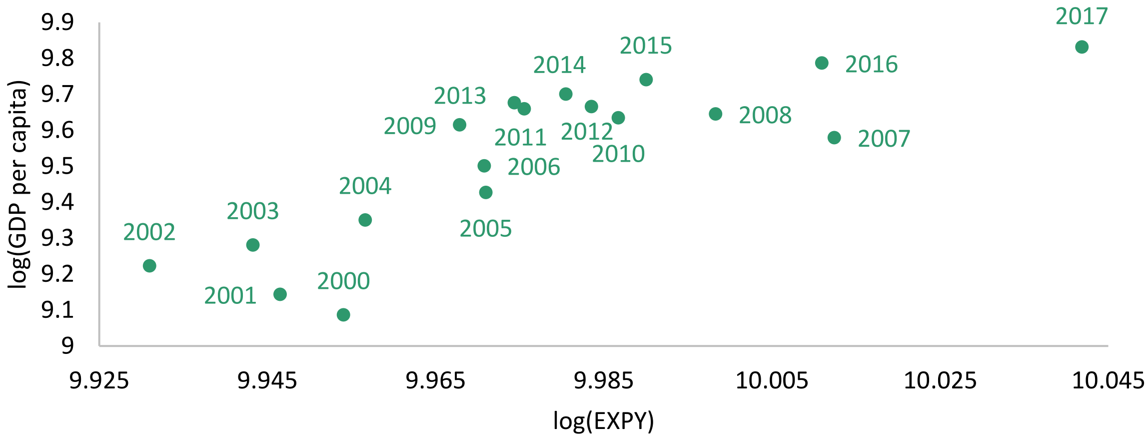
Net FDI inflows, 2010-12 vs. 2016-18 (Percent of GDP)



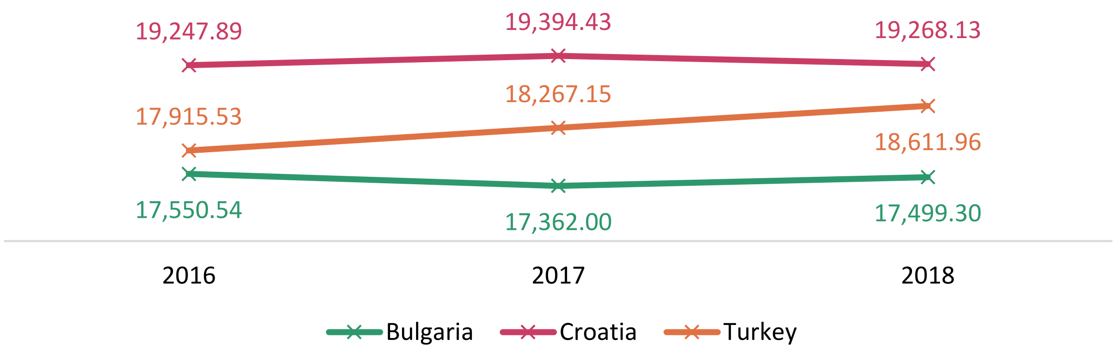
Source: World Bank World Development Indicators

Figure 9. Bulgaria's export sophistication index shows increased with growth from 2000 – 2017 (top) but remains below that of key competitors (bottom)

Export sophistication



Product Sophistication (EXPY)



Source: WITS

Note: Export sophistication index (EXPY) uses a methodology introduced by Hausman et al. to estimate the level of technological sophistication embodied in a country's export portfolio. A high EXPY indicates a more sophisticated export portfolio. EXPY does not account for quality and thus may overestimate the importance of sophisticated products from low-income products.

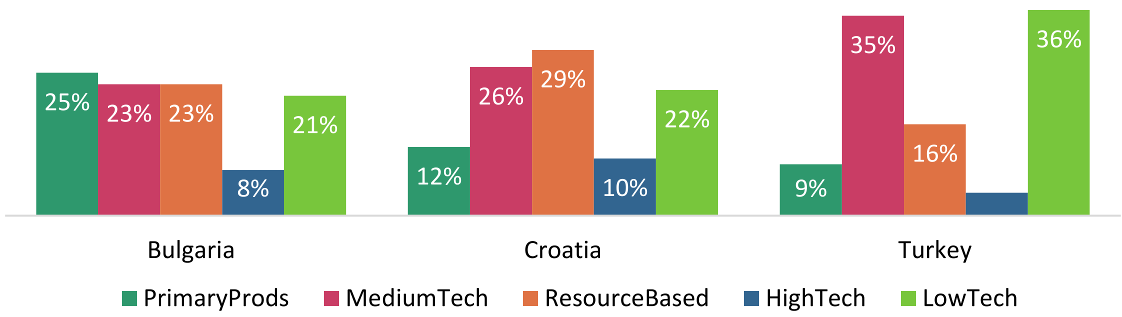
Bulgaria's export sophistication[5] has been increasing since 2000, but the country has not been performing as well as some peers, such as Croatia and Turkey, in recent years (see Figure 9).

[5] As high-income countries' exports tend to have higher technological content, export sophistication is also related to "income potential". It is regarded as a more inclusive measure of sophistication than intensity in technology or R&D, as it also captures the wages supported by production of a good. For more information on product sophistication, see Hausmann, Hwang, and Rodrik (2006), who estimate the sophistication of products on the basis of the income levels of countries that produce them. If a product, say, an internal combustion

The export sophistication index measures the extent to which a country's export basket reflects exports from high-income or low-income countries. Hausmann, Hwang, and Rodrik (2006) show that countries with high product sophistication tend to have higher growth rates in the future, as countries tend to "become" what they export by converging to the income level implied by their export baskets (Reis and Farole, 2012).

Bulgaria largely exports primary, low- to medium-tech, and resource-based products that are at low levels of the value chain, reflecting its upper middle-income status. High-technology products accounted for only eight percent of total exports in 2018 (Figure 10). By continuing to increase exports of higher-tech products, such as new types of ICT products, the country has a path to advance to higher income levels.

Figure 10. Bulgaria exported few high-tech products, 2018 (% of total exports)

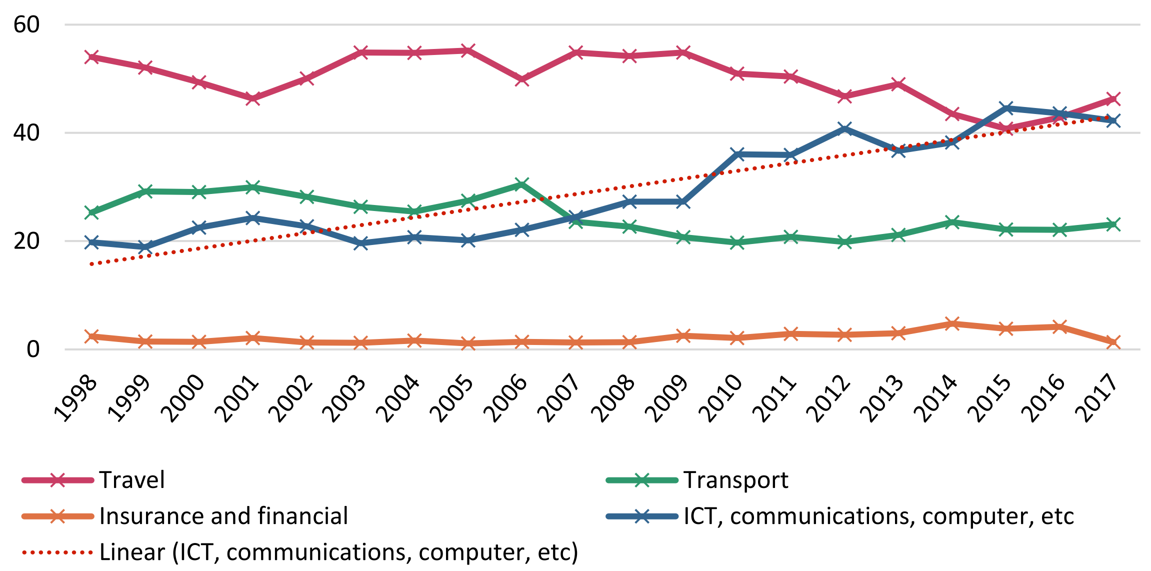


Source: WITS COMTRADE

From 1995 to 2018 period, Bulgaria's total exports maintained an average growth rate of 5.9 percent, performing below the EU average. The country's top exports and imports are in manufacturing, at 57.6 percent and 66.7 percent, respectively. Looking more closely at exports of services, ICT services have been increasing steadily since 1998, constituting 42 percent of services exports in 2018, growing from 27 percent of exports in 2008 (Eurostat, 2018). Bulgaria is home to approximately 10,000 ICT companies, 70 percent of which are only exporting. Turnover in the ICT sector in Bulgaria has increased by 300 percent over the past 7 years and has reached 2.5 billion euros, up by 45 percent from 2017. The main attraction for companies is the low corporate tax rate of 10 percent, compared to top rates equal to, or above, 30 percent in Belgium, France, Italy and Malta.

engine, is largely produced by rich countries, that product would be revealed to be "rich" and sophisticated. This outcome-based measure of sophistication for each product, called PRODY, is a weighted average of the per capita GDP of countries producing that good, with weights derived from RCA. Similarly, the PRODY of coffee beans would be much lower because the countries that dominate its production are generally low income.

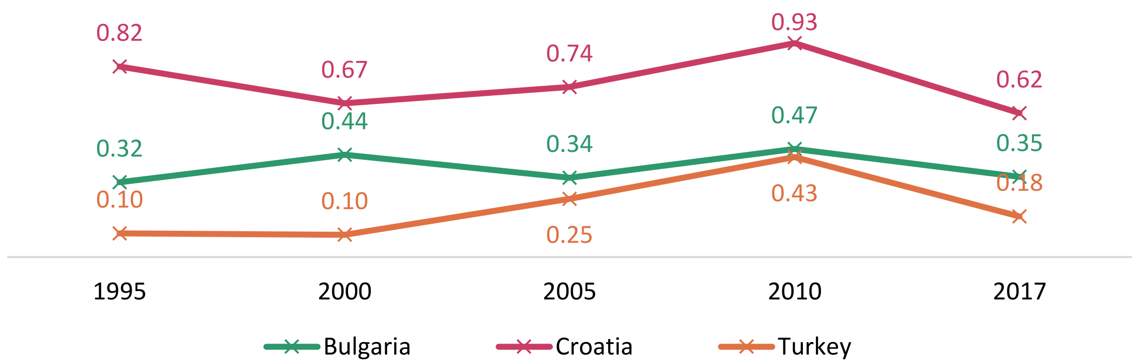
Figure 11. The share of ICT in Bulgaria's services exports increased sharply, 1998-2017



Source: World Bank Indicators

Bulgaria's economic complexity, a holistic measure of the production characteristics of an economy, has fluctuated between 0.3 and 0.5 over the 1995-2017 period.[6] These levels are lower than Croatia's but above Turkey's (Figure 12). The dips could be attributed to the increase in commodity prices and the high share of fuel products in exports. Breaking away from resource-driven exports will require specialization in more complex activities that involve higher levels of processing.

Figure 12. Bulgaria's economic complexity index fluctuated, 1995-2017

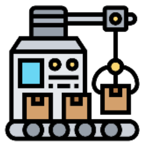


Source: ECI

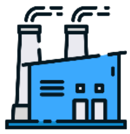
[6] The Economic Complexity Index (ECI) of Hidalgo et al. (2009, 2012) provides a holistic measure of the production characteristics of an economy. The assumption behind the ECI is that the knowledge accumulated in a country is expressed in the country's industrial composition.

Firm-Level Productivity Performance

Aggregate productivity growth is being held back by barriers to resource reallocation between firms and to the entry of new firms:



Microeconomic analysis shows divergent patterns in labor productivity and TFP, driven by a transformation from more to less labor-intensive production technologies.



Aggregate growth in productivity in the manufacturing sector is largely driven by the ability of existing firms to become more efficient, while barriers to resource reallocation and to firm entry and exit drag down productivity growth in the sector. This indicates that regulations aimed at increasing the mobility of production factors across firms should take priority in the economic policy agenda. This includes facilitating firm exit, because the survival of inefficient, large firms inhibits resource allocation by keeping productive resources away from more efficient firms.

Bulgarian service and construction sectors exhibit more dynamic patterns than manufacturing in terms of productivity and resource reallocation performances. The within productivity performance, however, is lower in services and construction, which emphasizes the need for policies to motivate R&D and innovation in this segment of the economy.

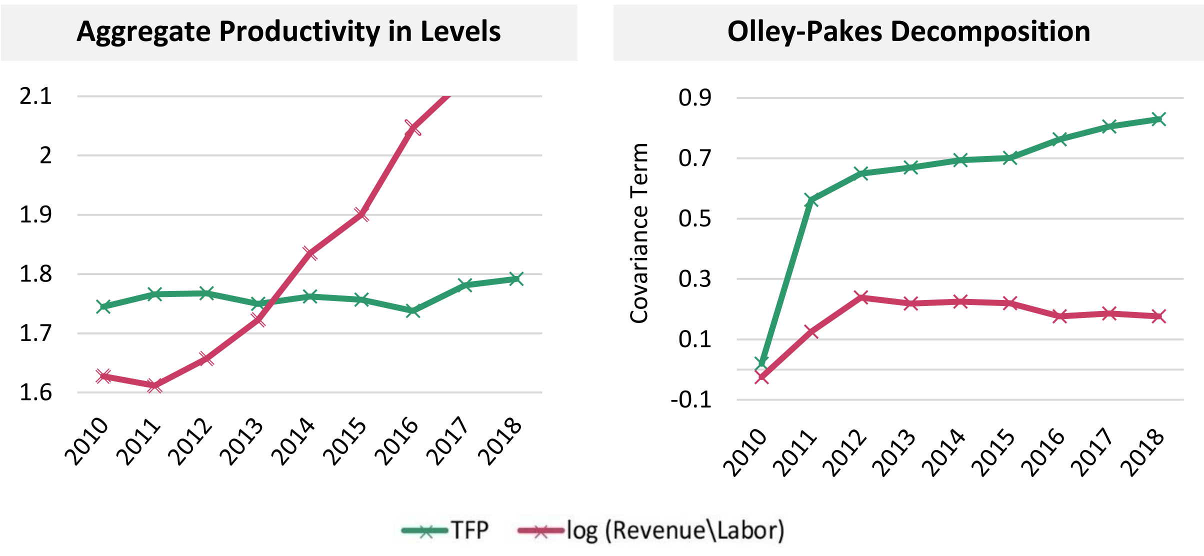
In the Bulgarian economy in general, the contribution of entering firms to aggregate productivity growth is negligible or negative, even 3 to 5 years after entry into the market. Improving the post-entry conditions by lowering barriers to firm growth in all sectors of the economy would further boost the aggregate productivity performance.

R&D is effective in accelerating within-firm productivity performance regardless of the firms' main sector of operation. Policies that incentivize firms' R&D investments, therefore, are expected to have high success rates and economic returns.

This section employs firm-level data to explore the microeconomic dynamics of productivity in key sectors of the Bulgarian economy, using a sample of firms (drawn from Orbis) covering a nine-year period ending in 2018. The description of the variables and methodology for this analysis can be found in Appendix II.

Manufacturing labor productivity[7] fell from 2010 to 2012 (the sample size was increased during this period to cover more small firms with low levels of labor productivity, which may account for at least part of this decline) and then increased monotonically from 2012 to 2018 (left-hand panel of Figure 13). TFP[8] seems not to have been dramatically affected by the increase in the sample coverage and is rather stable until 2016. TFP also shows an increasing trend after 2016, but the rate of the increase is lower than that of the labor productivity.

Figure 13. Labor productivity increased much more rapidly than TFP did in manufacturing, 2010-2018



Source: Authors' calculations based on Orbis database.

After 2012, larger manufacturing firms saw a greater increase in their labor productivity than their TFP. This could have been due to the introduction of more capital- but less labor-intensive technologies into production, which would have increased the larger firms' output per worker but not necessarily TFP (due to the increased intensity of the usage of production factors other than labor).

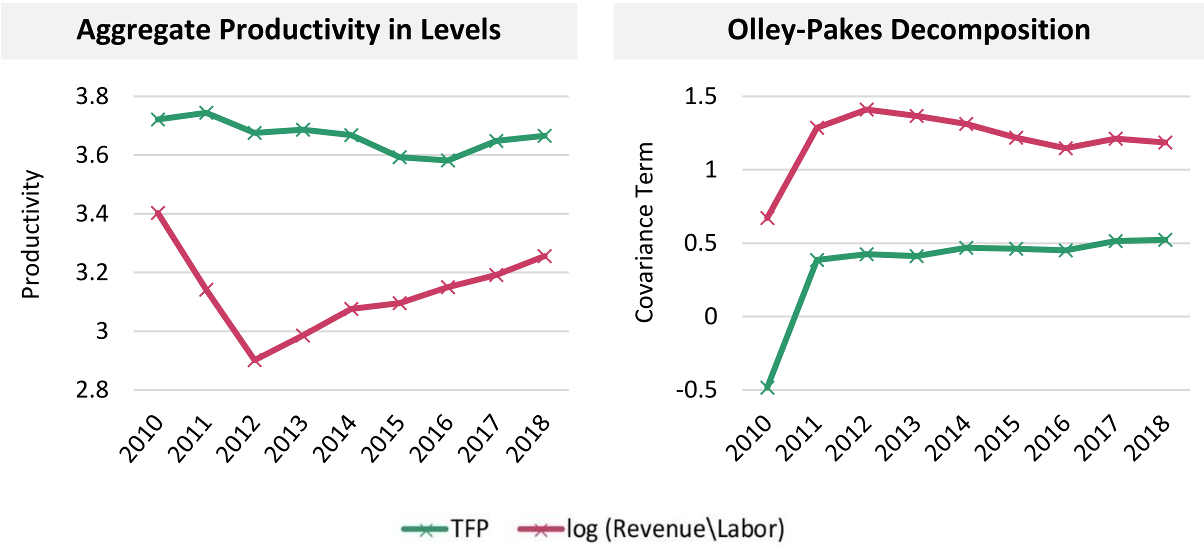
[7] The data for firm-level value-added is missing for a large portion of firms (around 30%). Thus, this report makes use of the ratio of deflated revenues to number of employees as the measure of labor productivity.

[8] The analysis of total factor productivity is based on an estimation of Cobb-Douglas type production function in the following format: $y_{it} = \beta_{0,it} + \beta_m m_{it} + \beta_l l_{it} + \beta_k k_{it} + e_{it}$

In the above equation, y, m, l and k represent the output, intermediate inputs, labor and capital of firm i in time t respectively. β's are the coefficients of interest where $\beta_{0,t}$ is the vector of dummies that includes the intercept and time dummies. e_{it} is the error term. Production functions are estimated for each 2-digit manufacturing and services industries separately using Ackerberg et al. (2015). The estimation sample covers the 6-year period from 2010 to 2018.

From 2012-2018, changes in allocative efficiency based on TFP and labor productivity differ from each other in the manufacturing sector. The right-hand side of Figure 13 displays the covariance between productivity and market share, which represents static efficiency in the allocation of resources across producers at a given point in time. Allocative efficiency rises rapidly in the first two years of the sample, again mostly due to the increase in the sample coverage. After 2012, however, the allocative efficiency measures calculated based on TFP and labor productivity diverge from each other, which can partially explain different patterns observed in aggregate TFP and labor productivity.

Figure 14. Trends in labor productivity and TFP diverged in services and construction, 2010-2018



Source: Authors' calculations based on Orbis database.

In services and construction,[9] the patterns observed in productivity and allocative efficiency are similar to those in manufacturing. Figure 14 shows that after 2012, labor productivity in services and construction increases until the end of sample period. The increase in labor productivity is driven partially by the improvement in the efficiency of labor allocation. TFP, however, starts increasing only after 2016 and there is no significant improvement in the overall resource allocation after 2012. The divergent patterns observed in labor productivity and TFP in Bulgaria are in line with IMF (2019), which shows that the labor productivity and TFP dynamics differ in Bulgaria especially after 2014.[10]

[9] The sectors that are included in the group of services and construction are selected based on data availability and are given in Appendix II.
[10] IMF (2019) computed average annual labor productivity growth for the median firm about 4% for 2013-2015, while the TFP exhibits negative growth at the same period.

Firm Size and Productivity

Firms tend to be smaller in Bulgarian services and construction sectors than in manufacturing. In Bulgarian manufacturing, 71 percent of all firms are micro firms that have at most 20 employees. Small manufacturing firms make up 17 percent of the sector, while the share of large firms (more than 250 employees) is around two percent. In services and construction, however, micro firms account for about 91 percent of all firms in the sector. The main difference between the manufacturing and services and construction sectors, however, is observed in the group of small and medium-size establishments (between 20 and 250 employees), which make up 27 percent of manufacturing but only 9 percent of services and construction. The average age and size in each size group is generally higher in the manufacturing sector, as shown in Table 1.

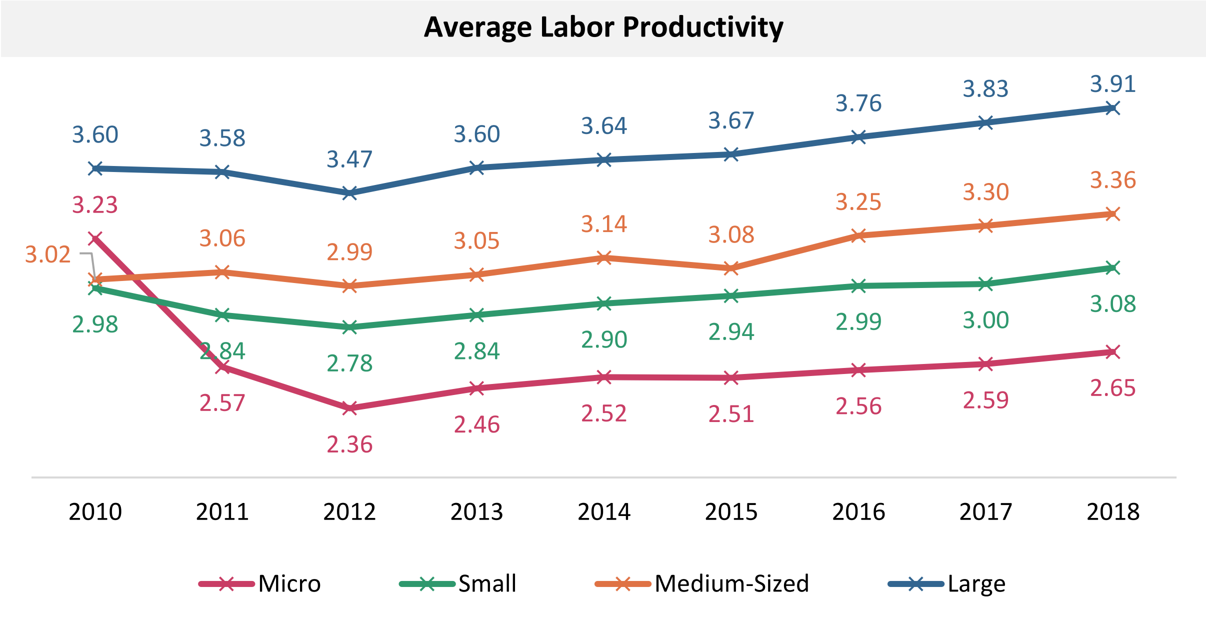
Table 1. Description of Size Classes

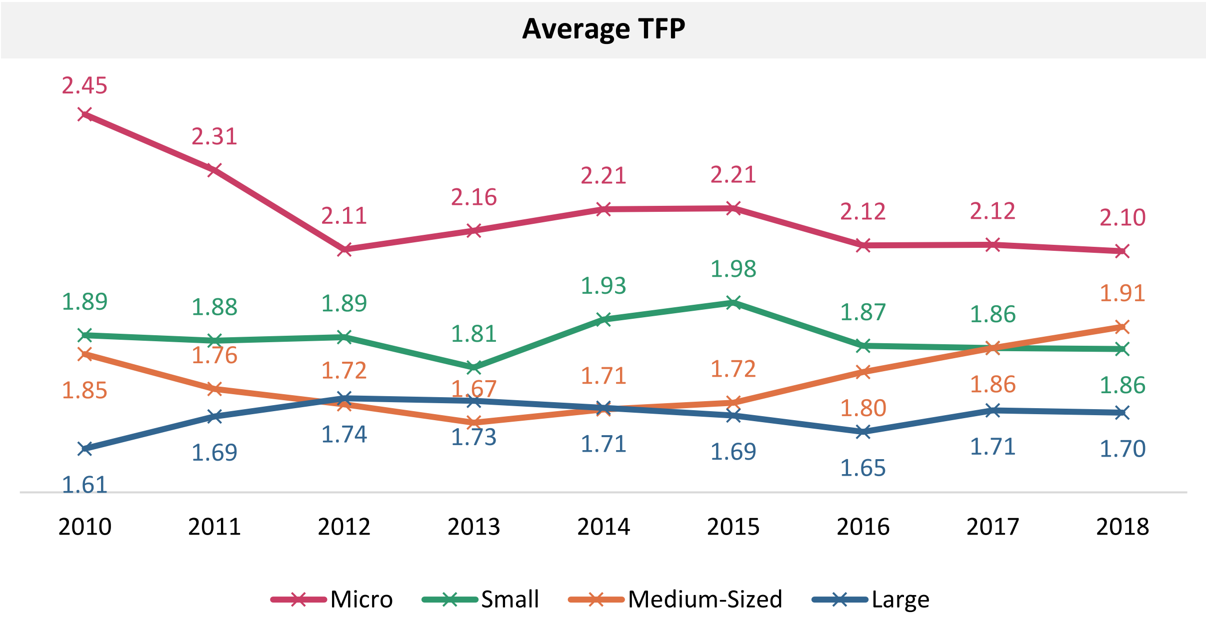
Size Class	Average Age	Average #Employees	#Firms
Manufacturing			
Micro [0, 20]	9	6	18457
Small (20, 50]	12	32	4538
Medium-Sized (50, 250]	16	96	2617
Large 250+	27	548	427
Services and Construction			
Micro [0, 20]	7	4	184409
Small (20, 50]	10	30	13384
Medium-Sized (50, 250]	12	89	5100
Large 250+	19	629	659

Source: Authors' calculations based on Orbis database.
Note: The size thresholds for small (50), medium (250) and large firms (250+) are in line with the Eurostat classification, but not for the micro firms. Micro firms were mostly excluded from the sample in the early years. Size class borders were extended (from 9 to 20) to cover more firms in this group to allow for monitoring and discussion of their performance.

In Bulgarian manufacturing, firm size and the intensity of labor used in production are strongly negatively correlated, which has important implications for measurements of productivity. Large firms are likely to benefit from capital-intensive technologies, which boosts their labor productivity in comparison to other firm size groups. Figure 15 shows the time paths of the weighted average for labor productivity and TFP for each size class. The largest firms have the highest labor productivity, and average labor productivity diminishes as the size of the firm group declines. By contrast, micro firms show the highest levels of TFP, and the largest firms the lowest.

Figure 15. Large firms in manufacturing have high labor productivity but low TFP, 2010-2018

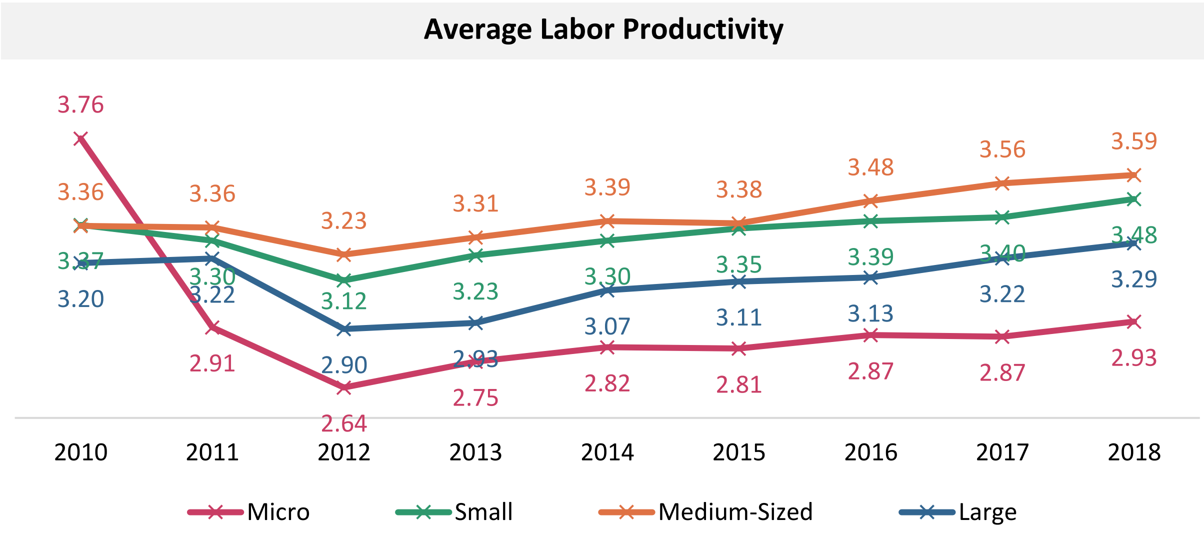


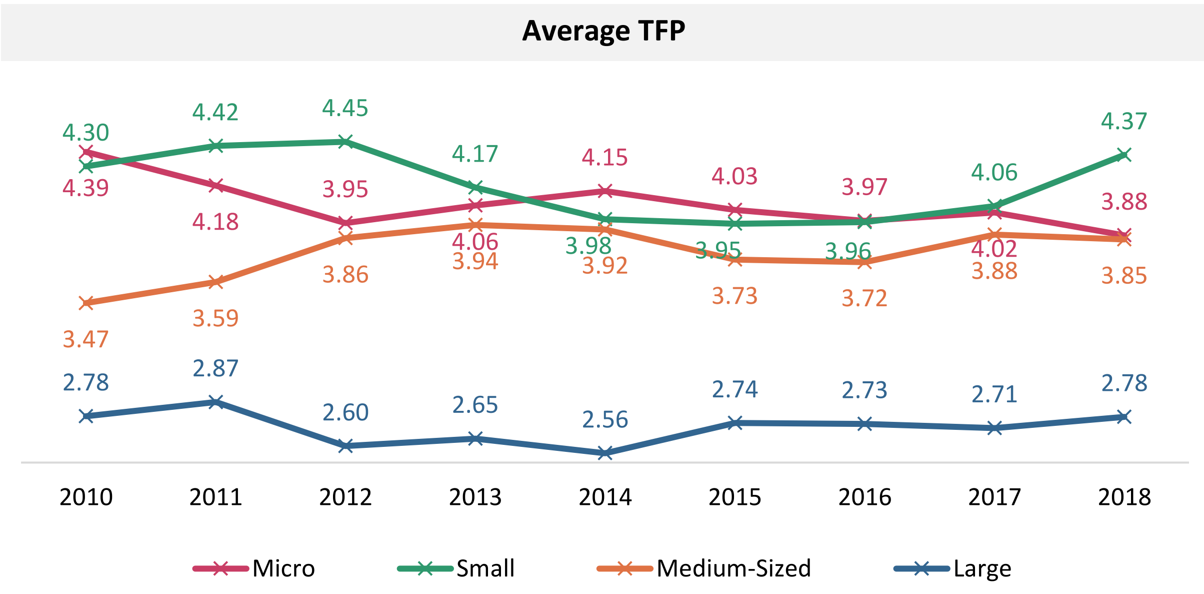


Source: Authors' calculations based on Orbis database.

Medium-sized firms are the engines of TFP growth in Bulgarian manufacturing – labor productivity increases simultaneously for every firm size group after 2012 (the observed decrease in labor productivity from 2010 to 2012 is due to the expansion of firm sample towards less productive firms), but only the medium-sized firms exhibit a noticeable increase in TFP performance after 2013, with particularly strong growth in the last three years of the sample period. For the size groups other than the medium-sized firms, the TFP levels in 2018 are lower than those in 2012, while the medium-sized firms experienced a TFP growth of approximately 20 percent during this 6-year period.

Figure 16. Large firms in services and construction had low levels of productivity, 2010-2018





Source: Authors' calculations based on Orbis database.

In Bulgarian service and construction sectors, large firms exhibit relatively poor productivity performance. As for manufacturing, micro firms' labor productivity performance is the lowest, while large firms' average labor productivity is higher than that of the micro firms but lower than that of small and medium-sized firms (Figure 16)Error! Reference source not found.. Micro firms, however, have significantly higher TFP, indicating that micro firms have more labor-intensive production technologies in services and construction. Large service and construction firms' TFP levels are the lowest among the size groups, and their productivity distance from other size groups is large and persistent throughout the sample period.

The analysis of the economic performance of different firm size classes can provide valuable insights for understanding the sources of and barriers to productivity. For instance, if large firms have poor productivity performance, this indicates allocative inefficiencies. More specifically, low productivity in large firms implies that an important portion of productive resources is held inefficiently by a small group of unproductive firms. Looking at averages within size classes, however, is not sufficient to argue that resources are allocated inefficiently. In the case of Bulgarian service and construction sectors, only 0.3 percent of firms are large. Moreover, these large firms may be concentrated in sectors where productivity is on average low, but large firms in those sectors may have productivity levels well above the specific sectors' averages. In order to achieve a more comprehensive measure of allocative efficiency that, for instance, does not suffer from sector-specific fixed effects, the next section presents an aggregate productivity decomposition analysis.

Assessing the Efficiency of Resource Allocation

Efficiency in the allocation of resources constitutes an important source of aggregate productivity growth.[11] Productivity gains from allocative efficiency can be restricted by frictions due to excessive or badly designed regulations, or poor-quality institutions responsible for their enforcement. The potential gains from allocative efficiency, therefore, are higher in developing countries where the quality of institutions and regulations is relatively low. For instance, Bartelsman et al. (2013) find that market-oriented reforms in the Eastern European countries led to an improvement in allocative efficiency equal to about 30-50 log points increase in labor productivity. This section implements a productivity decomposition exercise, described in Box 2, to capture productivity gains from improvements in allocative efficiency, as well as from entry and exit of firms.

[11] An emerging body of empirical evidence shows that much of the differences in economic performance across countries can be explained by the efficiency in the allocation of production factors. An incomplete list of studies in this direction includes Banerjee and Duflo (2005), Jeong and Townsend (2007), Alfaro et al. (2008), and Hsieh and Klenow (2009).

Box 2. Melitz-Polanec Decomposition

The Melitz-Polanec decomposition, also known as the dynamic Olley-Pakes decomposition, breaks down productivity growth into its components and provides insights into to the drivers of the change in productivity between two points in time. For more information, see Appendix II.

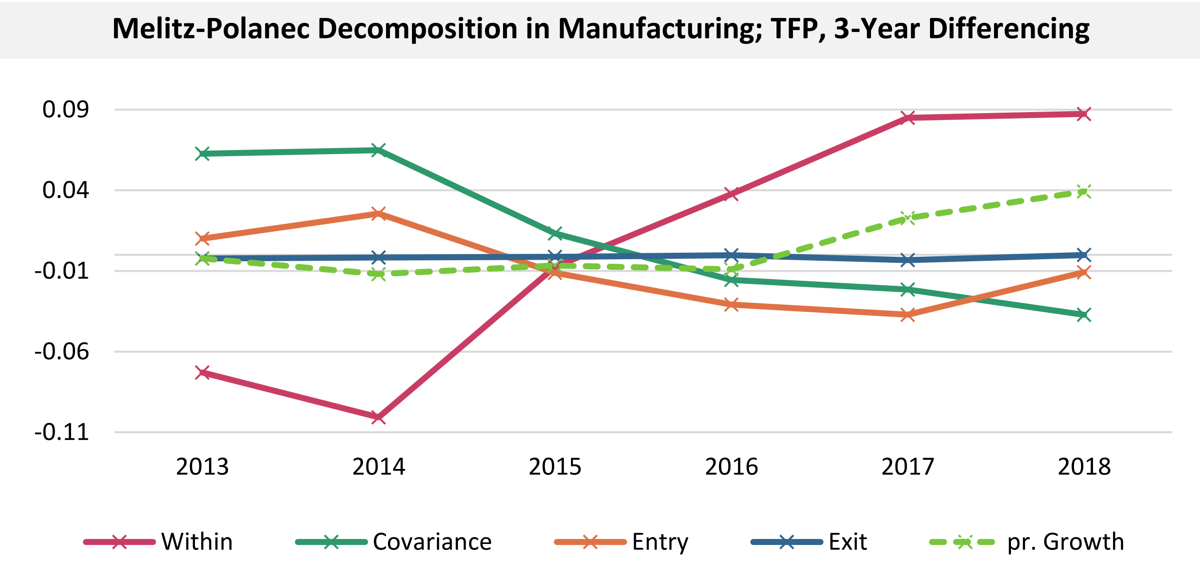
Melitz and Polanec (2015) decompose aggregate productivity growth into four components:

- Within – growth in the mean level of productivity due to changes in firms' productivity performance, holding their market shares constant
- Covariance – productivity gains due to improved allocative efficiency of resources between firms
- Entry – productivity gains due to the entry of new firms
- Exit – productivity gains due to the exit of existing firms

The decomposition shows some diverging trends in the sources of TFP growth in Bulgarian manufacturing, although this is in part due to data issues. The decline in firms' own productivity (within component) in the early years of the sample is due to the increase in the sample size to include more small, low-productivity firms. The within component increases strongly after 2014, and measured aggregate productivity rises after 2016 (Figure 17). By contrast, the efficiency of resource allocation (covariance component) appears to worsen over time, in line with the previous results derived from the static allocative efficiency measure. While the trends observed in the early years of the sample are mostly distorted due to the change in the sample coverage, in the later period, the within and covariance components move in opposite directions. More specifically, the covariance term is negative after 2015 and is the lowest in the most recent year. This indicates that the firms experiencing productivity improvements, which pushes the within component up, are not those that initially had the larger market shares in the sector. In the more recent years, the presence of smaller and more productive firms, which implies that large firms become relatively less productive, pulls down the measurement of allocative efficiency. This indicates that in the manufacturing sector, policies to increase the mobility of production factors across firms would help reallocate resources towards more productive establishments.

In the manufacturing sector, the productivity contribution of exiting firms is negligible, and the entrants' contribution is mostly negative. An exit of a firm raises aggregate productivity if the exiting firms have lower productivity levels than the industry average. If a low-productivity firm that exits the market is large, the observed positive impact on aggregate productivity is also large. The blue line given in Figure 17 is barely different from zero, which implies that firm exit is not an important source of productivity in the manufacturing sector. The entry component, however, is negative after 2015. This is mainly because of entrant manufacturers' slow start-up performance, so that new firms are not on average more productive than the incumbents even 3 years after their date of entry into the market. While better initial productivity performance would be beneficial in terms of economic growth, in manufacturing industries, start-up performances can be low due to the nature of the production process. Manufacturing firms generally require large amounts of sunk investments in their start-up period, which temporarily lowers their post entry performance in comparison to entrants in other sectors that do not require large amounts of initial capital. Thus, manufacturing firms usually have lower productivity in their first years, and their productivity tends to rise over time.

Figure 17. Manufacturing firms' average TFP increased after 2014, but the efficiency of resource allocation fell, 2010-2018

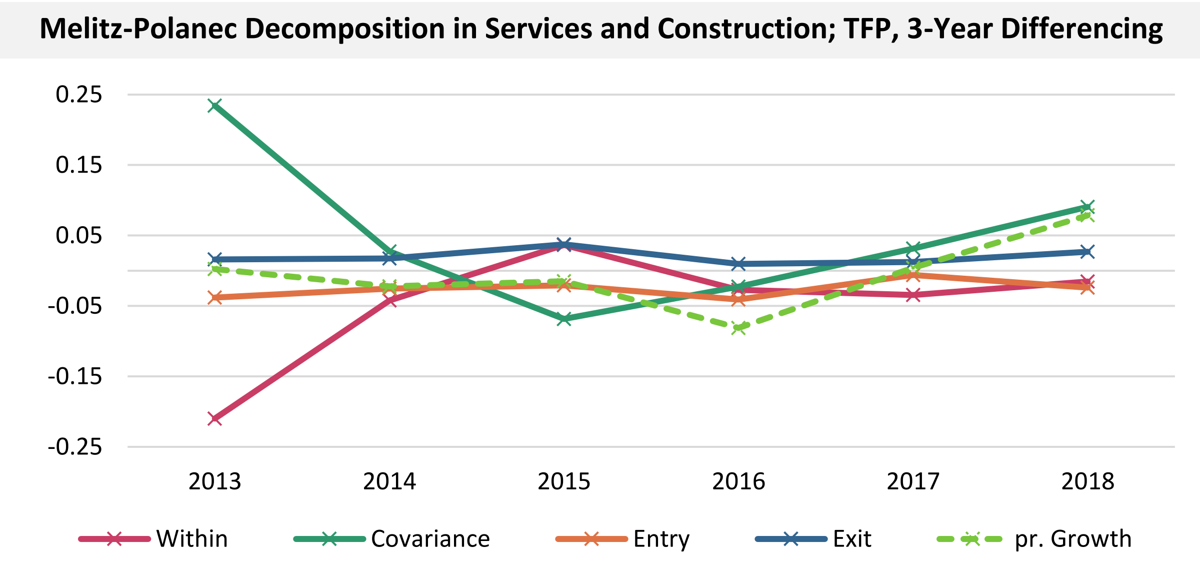


Source: Authors' calculations based on Orbis database.

In Bulgarian services and construction, the recent growth in TFP is mainly driven by more efficient allocation of resources and only secondarily by the exit of low-productivity firms. In the initial years of the sample period, the within component is negative and the covariance is positive, and aggregate productivity growth is stable and close to zero (Figure 18). As described for manufacturing, this is likely because of the change in the sample coverage until 2012, which is reflected in the productivity growth rate through 2014 since the growth is calculated as a 3-year moving average. After 2015, the within component is mostly negative and close to zero. Aggregate productivity, however, starts increasing after 2016, mainly due to the reallocation of resources towards more productive firms. The exit component is slightly positive in services and construction and rising in the last year of the sample, which implies that aggregate productivity increases partially due to the exit of inefficient establishments. The entry contribution, however, is negative throughout the sample period.

The sluggish start-up productivity performance in both manufacturing and services and construction sectors requires particular attention in the phase of policy design; facilitation of post-entry conditions would help the economy to benefit from the dynamism of new firms in these sectors.[12]

Figure 18. After 2015, more efficient allocation of resources drove TFP gains in services and construction, 2010-2018



Source: Authors' calculations based on Orbis database.

Manufacturing industries exhibit a great deal of heterogeneity in terms of the main contribution to aggregate productivity growth. Figure 19 displays the productivity decomposition at the 2-digit industry-level for the manufacturing sector.[13] The figure orders the industries according to their average productivity growth rates over the sample period. In

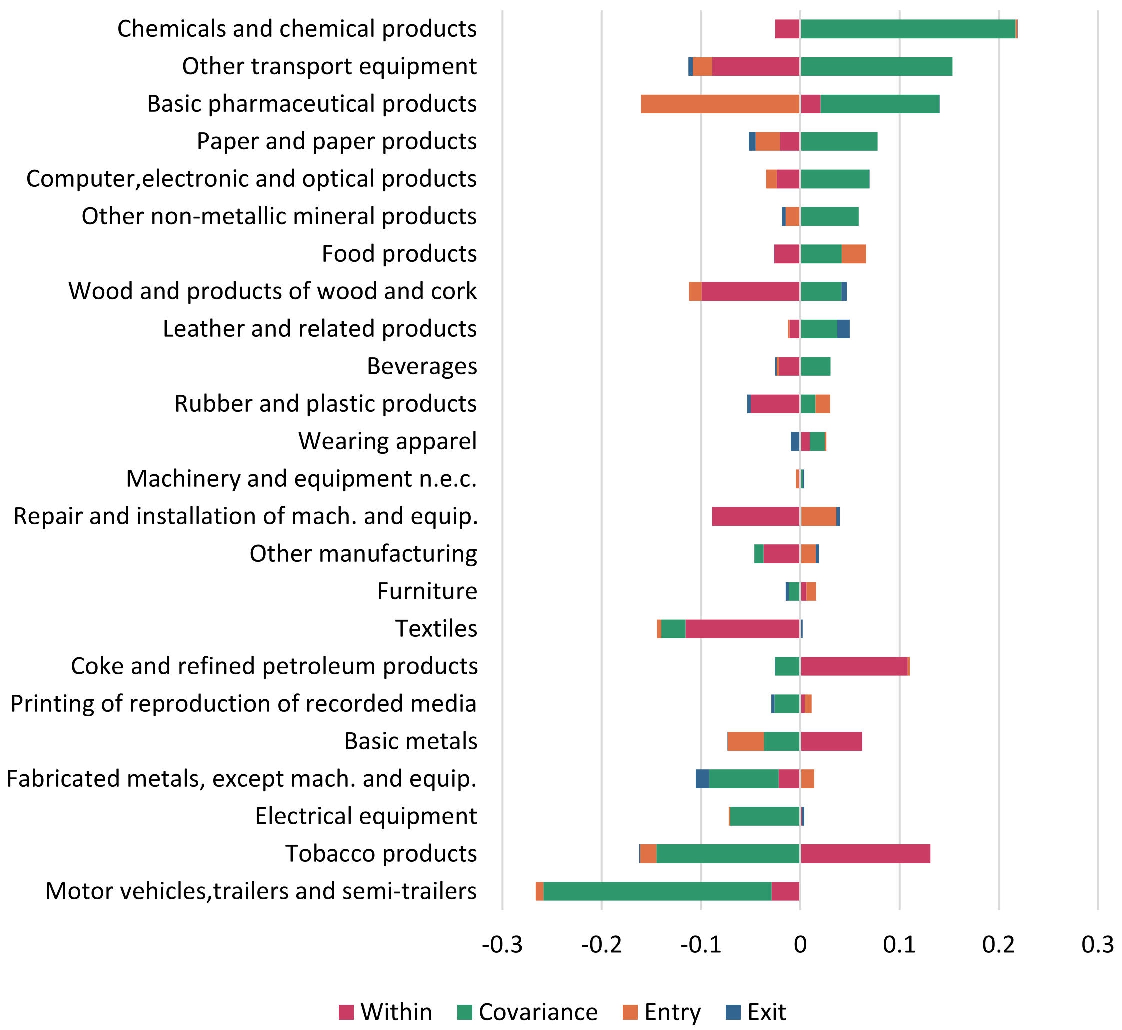
[12] To capture the entrants' productivity contribution from a wider time window, the decomposition exercise also is applied for 5-year productivity growth rates. The results, however, do not significantly differ from those based on the 3-yearly growth decomposition.

[13] While analyzing the time-varying decomposition results for the entire manufacturing sector, the main finding was the importance of the within component for the last years of the sample period. In Figure 19, however, the within component is not significantly higher than the covariance term in most of the industries. This is mainly because of averaging each component over time. Namely, the within component is generally negative in the early years and positive in the later years of the sample, so that the average over the entire period is small.

the fast-growing industries (upper part of the figure), allocative efficiency generally makes an important contribution to productivity growth, with the exception of coke and refined petroleum manufacturing. In many of the sectors where productivity growth is slow or negative, such as the manufacture of rubber and plastic, wood and textiles, firms' own productivity performance is negative and has the greatest influence on average productivity. The contribution of firm exit to productivity is generally small in all industries. The entrants' contribution, however, is more heterogenous. In particular, in manufacturing industries like basic metals, basic pharmaceuticals and paper, the entry contribution is largely negative, while in food products and the repair and installation of machinery and equipment, the contribution of entering firms to productivity is positive and relatively high.

Figure 19. The sources of TFP growth differed across manufacturing subsectors

Melitz-Polanec Decomposition in Manufacturing; TFP, 3-Year Differencing



Source: Authors' calculations based on Orbis database.

In designing policies to improve the performance of start-ups, it might be useful to target industries where the entrants' productivity contribution is large and negative. This would not only improve the contribution from entrants to aggregate productivity, but also intensify competition in the market. Competition can motivate other firms to perform better and push inefficient units out of the market. This would raise the share of the contribution of exit component and speed up the microeconomic restructuring of Bulgarian industries.

The services and construction sectors (again, measured at the 2-digit level) also exhibit a great deal of heterogeneity in productivity growth, mainly driven by the differences in allocative efficiency gains. In the services and construction sectors that exhibit high productivity growth, the productivity gains from allocative efficiency (the covariance term) dominate (Figure 20), where the sectors are shown in descending order according to average productivity growth). In the sectors that exhibit negative productivity growth, however, it is also allocative efficiency that mostly determines the overall trends in aggregate productivity. The exit component is generally positive, and larger than its size in manufacturing industries. In particular, the exit component generates most of the productivity growth in financial services, except insurance. The entry component, however, is generally negative and large in absolute value for the sectors that have on average lower productivity growth rates. This may be because of industry-specific slowdowns in productivity performance, which make it easier for new firms that have relatively low initial productivity levels to enter.

Overall, Bulgarian service and construction sectors seem to be more dynamic than manufacturing sectors. Average productivity growth rates, the speed of reallocation of production factors, and the productivity contribution from entrants and especially from exiting firms are larger in services and construction sectors. This is partially because firms producing services often do not require large amounts of fixed capital stock, so that limitations such as the lack of easy access to finance, difficulties in the liquidation phase due to specificity of production factors or regulatory inefficiencies are most likely less binding for services firms. Services firms in Bulgaria are generally smaller than manufacturing establishments, which gives services firms some degree of flexibility in responding to changes in market conditions. Manufacturing firms, however, operate in larger sizes, which can make the fortunes of individual firms critical in reducing unemployment. Manufacturing firms also can be more resistant to external negative shocks and can be countercyclical in times of recession, which amplifies their importance for macroeconomic policy making.

Figure 20. Differences in allocative efficiency gains drove differences in TFP growth across services and construction subsectors

Melitz-Polanec Decomposition in Services and Construction; TFP, 3-Year Differencing

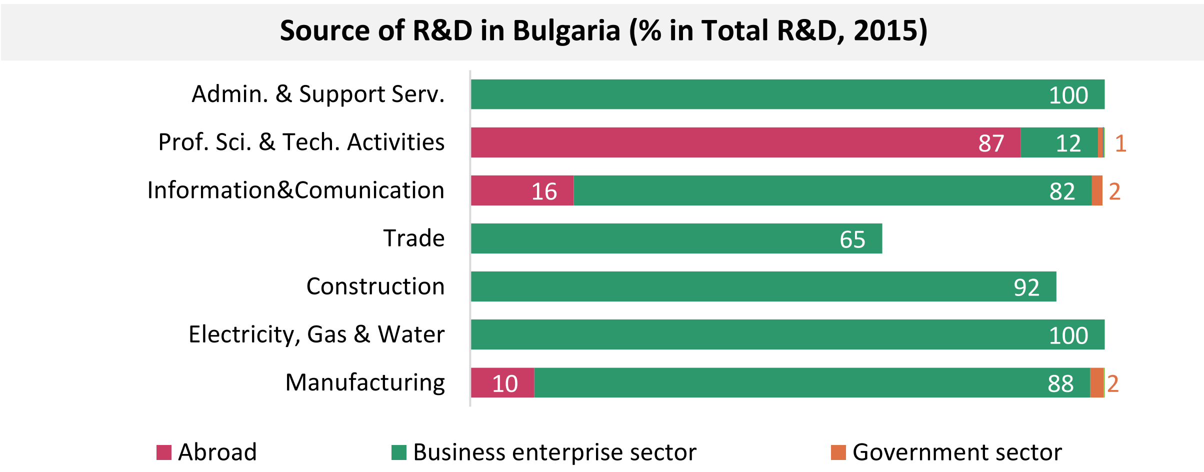
Source: Authors' calculations based on Orbis database.

R&D contribution to productivity

In Bulgaria, R&D activities are concentrated in three sectors – manufacturing, information and communication, and professional, scientific and technical activities – and R&D investments are generally financed by private firms. According to the Eurostat aggregate database, the domestic private sector is responsible for the largest share of R&D investments, with the exception of the professional, scientific and technical activities sector, where the bulk of R&D is sourced from abroad (top side of Figure 21).[14] External sources and the government have somewhat larger shares of R&D in manufacturing and information and communication than in the other sectors. In the trade sector, which constitutes the largest sector in terms of employment in Bulgaria, the R&D sourced by the business enterprise sector has the second lowest share; the other sources of R&D in this sector are unknown due to omitted observations to preserve confidentiality. The shares of R&D from higher education and private non-profit organizations are negligible.

Labor costs account for the largest share in total R&D expenditures in all sectors where all or most of the data are available (Figure 22). The share of capital expenditures in R&D in manufacturing is larger than in other sectors, except in transportation where total R&D expenditures are negligible (bottom panel of Figure 21). This is in line with findings in the previous section that many manufacturing firms (especially the largest firms) are shifting from labor-intensive to capital-intensive technologies. In the other two sectors where R&D expenditures are significant, information and communication and professional, scientific and technical activities, the share of other current expenditures is much larger than that of capital expenditures. In these sectors, a large portion of expenditures are made for purchases of technical equipment that are not classified as capital goods.

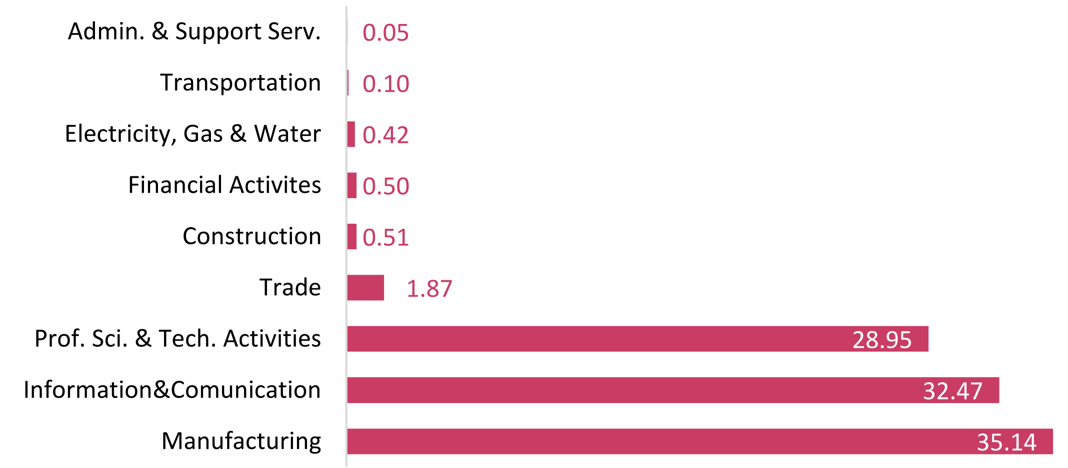
Figure 21. Domestic firms were the source of most R&D in Bulgaria (2015) and R&D activities were concentrated (2016)



[14] The amount of R&D sourced from abroad refers to the intramural expenditures on R&D performed during a specific reference period financed by sources from abroad.

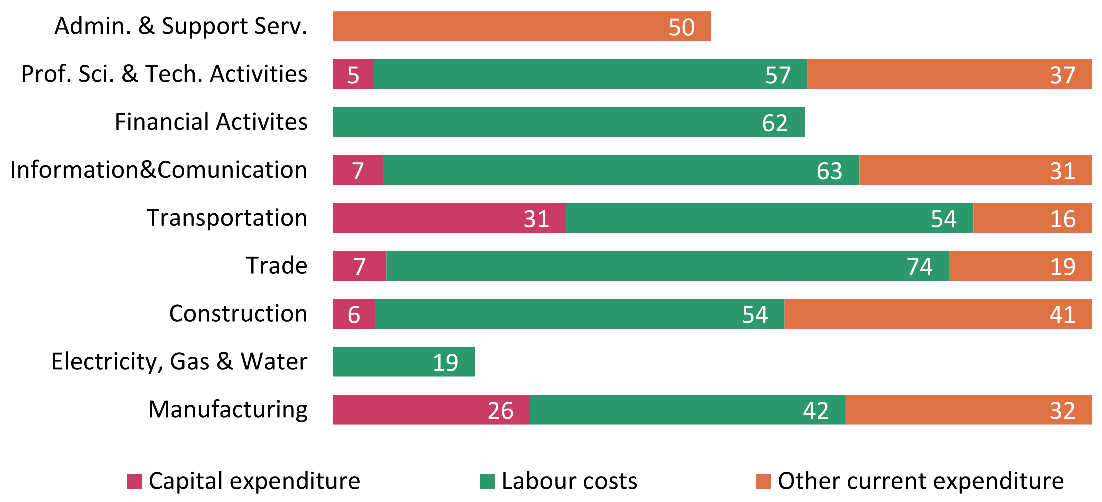
Figure 21. Domestic firms were the source of most R&D in Bulgaria (2015) and R&D activities were concentrated (2016)

Sectors' % in total R&D in Bulgaria, 2016



Source: Eurostat Science, Innovation and Technology Database
Note: Some observations in the source dataset are missing due to confidentiality criteria. The year 2015 or 2016 is selected, because the observations for each sector is most complete in this year.

Figure 22. Labor costs had the largest share of R&D expenditures (% in total R&D, 2016)



Source: Eurostat Science, Innovation and Technology Database
Note: Some observations in the source dataset are missing due to confidentiality criteria. The year 2016 is selected, because the observations for each sector is most complete in this year.

Firms' R&D activities have a significantly positive impact on the within component, which measures aggregate productivity gains from firms' productivity improvements. Regression analysis of the Melitz-Polanec Decomposition Components on R&D (shown in Table 10), shows that when the within component, which stands for pure firm-level productivity improvements, is regressed on the previous period's R&D intensity, the resulting coefficient is positive and significant. This implies that in the industries where producers are engaging in more intense R&D activities, there are significant improvements in average productivity performance.

Innovation Performance

Bulgaria exhibits one of the lowest innovation performances in the EU:

Investments in R&D are very low when compared to peers – with Romania, Bulgaria had the lowest levels of gross expenditures on research and development (GERD) as a percentage of GDP among peers (and well below the country's new 2030 target of three percent of GDP), as well as the lowest level of government budget appropriations on R&D (GBARD) per capita among peers. Bulgaria's public research institutions are poorly funded and perform a smaller share of national R&D than observed in peer countries.

Research outputs are relatively small and have limited impact, which indicates a need for policies and programs aimed at improving research excellence. Beyond the Bulgarian Academy of Sciences, there are very few national institutions that meaningfully contribute to the international scientific literature, and Bulgarian publications in general tend to have a limited impact. Internationally registered IP outputs are low and have been decreasing since 2015.

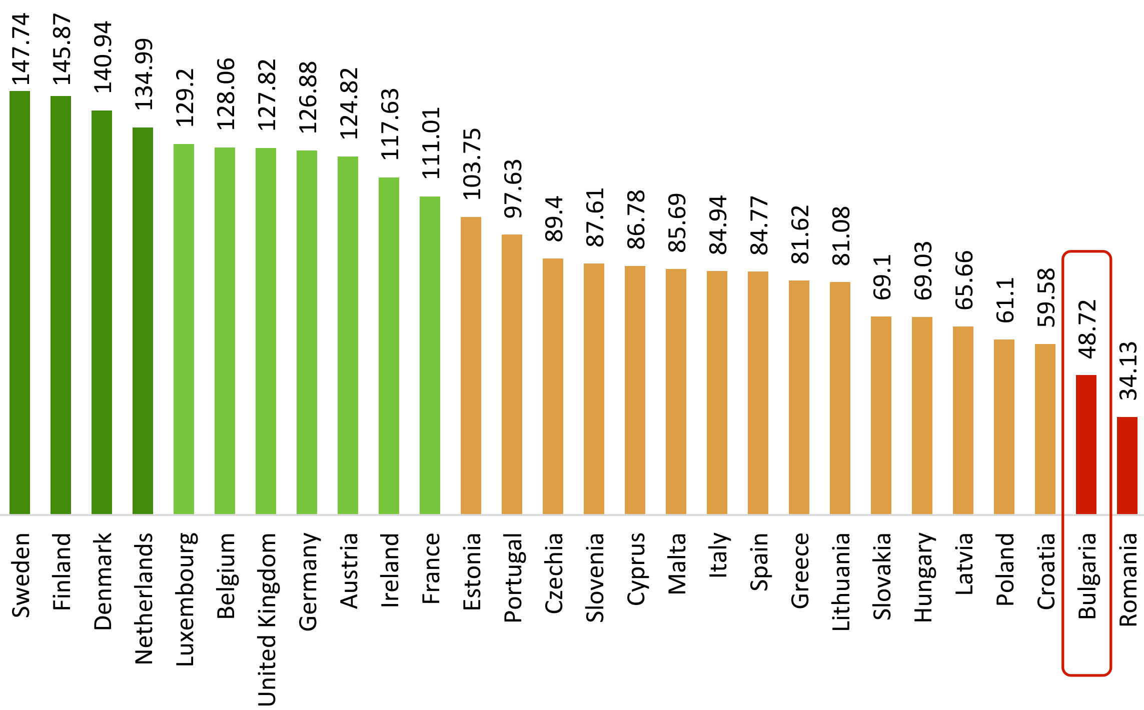
The transfer of innovation outputs (publications and patents) from the public sector into private sector outcomes (new firms and new innovations in firms) is limited by a lack of clear legislation governing who owns IP generated by public research institutions, insufficient incentives for public researchers to commercialize their work, and a lack of resources for IP protection and commercialization in public institutions.

Bulgaria generates a relatively high number of new businesses and startups, though few of these startups are knowledge-based or develop new products or services.

Technology adoption in firms has improved over the last ten years, helping to drive productivity growth, but Bulgaria still lags behind most peers in technology adoption. Bulgarian firms also have among the lowest levels of digitization in firms in Europe, for both basic and advanced digital technologies.

Bulgaria lags behind many of its peers across many indicators related to science, technology, and innovation. The European Innovation Scoreboard, which provides a comparative analysis of the innovation performance in EU countries, ranked Bulgaria as the second lowest performer in the EU ahead of only Romania in 2019, with a performance level of only 49 percent of the EU average (Figure 23). Bulgaria scored highest, and higher than the EU average, in “employment in fast-growing enterprises of innovative sectors”, “design applications”, and “trademark applications”. The country’s lowest indicator scores were on “R&D expenditure in the public sector”, “most cited publications”, and “lifelong learning”, all of which were less than 15 percent of the EU average.

Figure 23. Bulgaria scores poorly on the European Innovation Scoreboard rankings, 2019

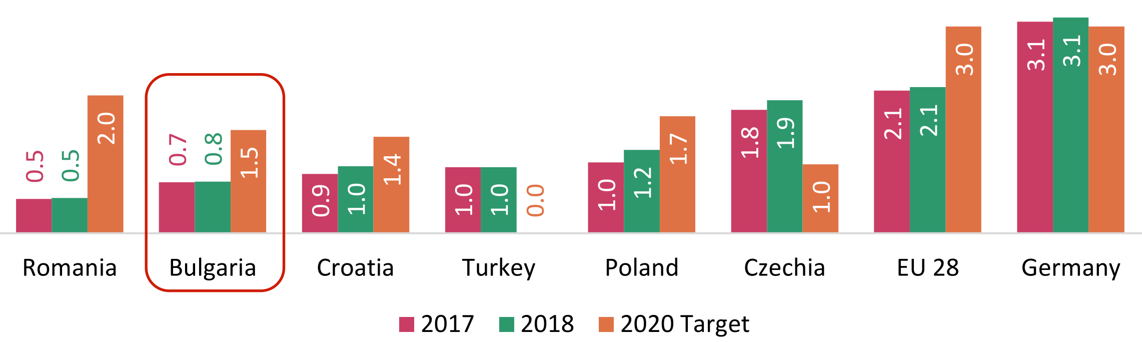


Source: European Innovation Scoreboard (2019)

Innovation Inputs

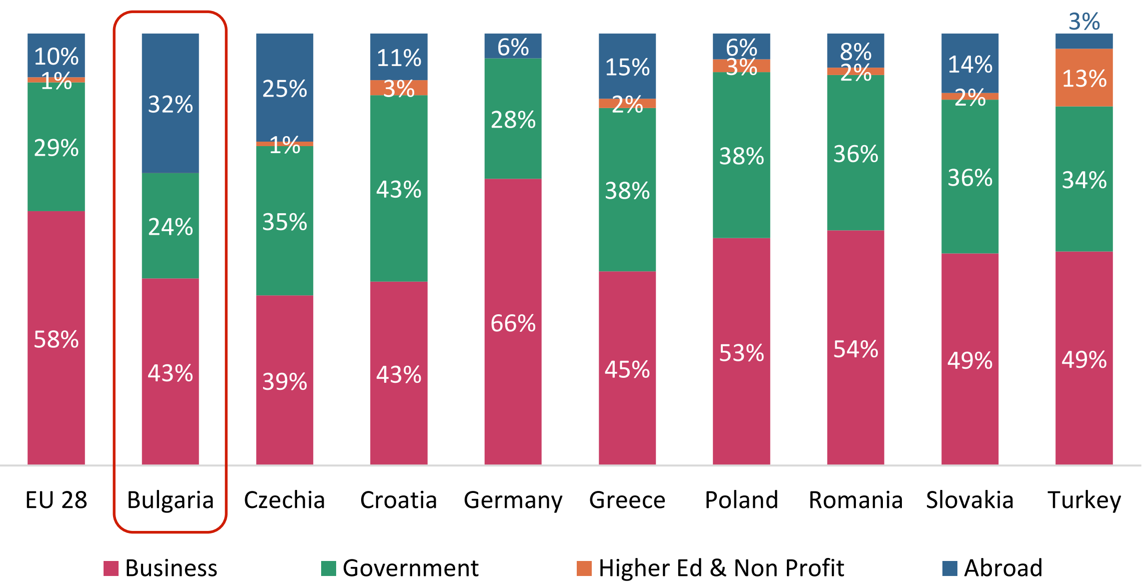
Bulgaria lags behind all of its peers except Romania in investments in R&D in terms of gross expenditure on research and development (GERD) as a percentage of GDP (Figure 24). GERD as a percentage of R&D has been trending down since 2015, reaching 0.7 percent in 2018. This share would need to more than double to reach Bulgaria's 2020 target and more than quadruple in order to reach its ambitious new 2030 target of three percent of GDP.

Figure 24. Bulgaria's gross expenditure on R&D is low, percentage of GDP, 2017-2018, and 2020 target



Source: Eurostat

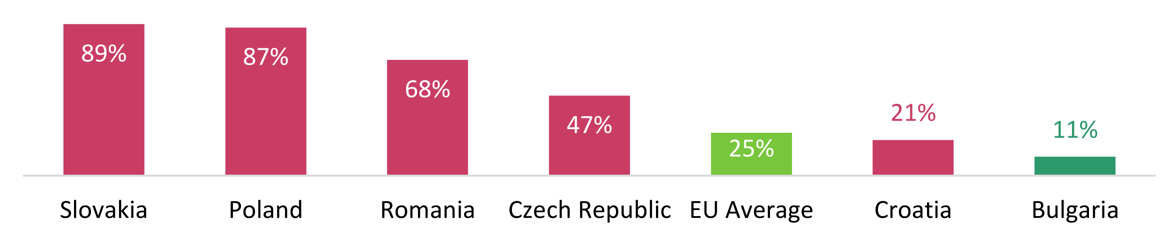
Figure 25. The government accounts for only a small share of Bulgaria's gross expenditures on R&D, 2017



Source: Eurostat

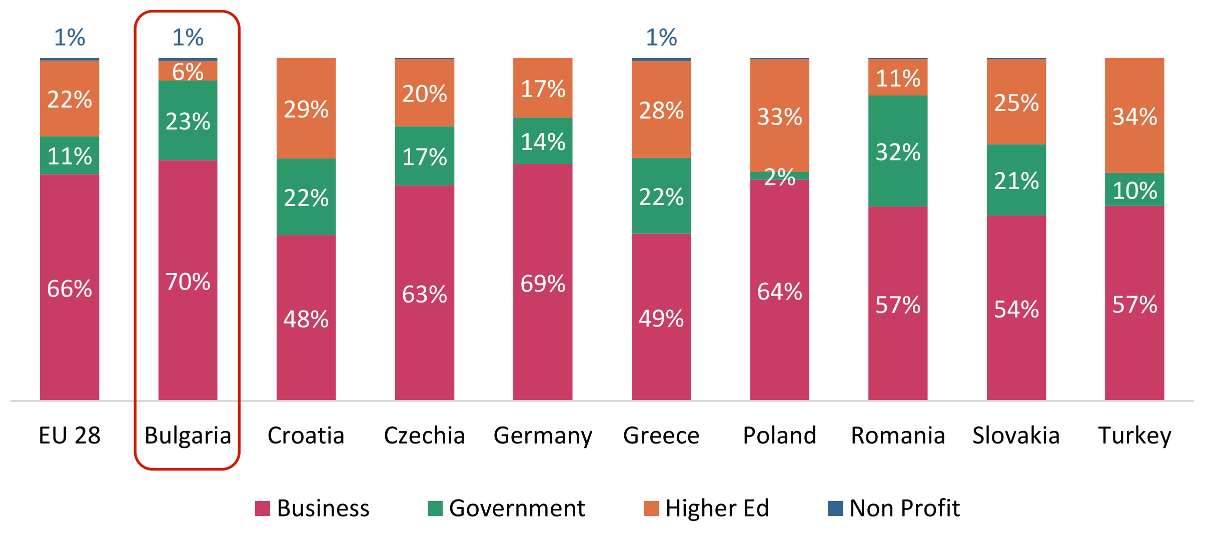
Breaking down the sources of R&D investments, Bulgaria had the lowest share of GERD financed by the national government among peers (Figure 25). Bulgaria also had the highest share of GERD financed from abroad among peers, over three times the EU average share. Closer inspection of GERD financed from abroad reveals that funding from European Structural and Investment Funds only constituted 11 percent of external R&D funding, the lowest share among peers and less than half of the EU average (Figure 26). This low share of funding from European Structural and Investment Funds indicates challenges that Bulgaria has experienced in absorbing and implementing EU funding programs in STI. For example, the allocation and implementation of funds for two large, key instruments for the current programming period's Operational Programme Science and Education for Smart Growth only began in 2019. These challenges point to potential national-level STI governance issues and to a lack of capacity on the part of researchers within the system.

Figure 26. The European Commission accounts for only a small share of Bulgaria's externally funded R&D expenditure, 2015



Source: European Commission - DG Research and Innovation, Eurostat

Figure 27. Institutions of higher education financed the lowest share of gross expenditures on R&D among peers, 2017

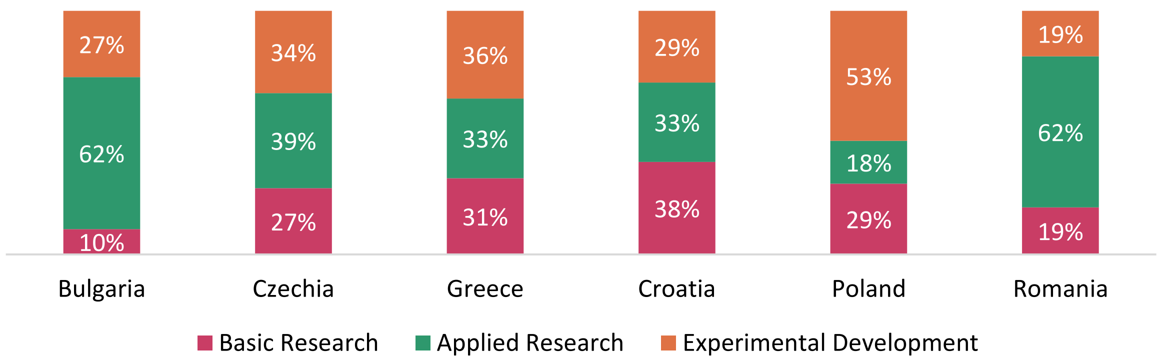


Source: Eurostat

Bulgaria's public research institutions perform a very small share of R&D nationally. In particular, institutions of higher education only accounted for six percent of GERD in 2017, the lowest rate among peers by far and less than a third of the EU average. Because of the low contribution of Bulgaria's public research institutions to R&D performance, the business sector accounted for 70 percent of GERD in 2017, the highest share among peers and above the EU average of 66 percent (Figure 27).

Basic research only accounted for 10 percent of GERD in 2017, by far the lowest among peers, while applied research accounted for 62 percent of GERD, tied with Romania for the highest rate among peers (Figure 28). This is primarily due to the very low contribution of public research institutions (HEIs and PROs) to national R&D and a correspondingly high share of GERD from the business sector. Given Bulgaria's relatively low per capita income and scant resources for R&D, this focus on applied research over basic research appears appropriate.

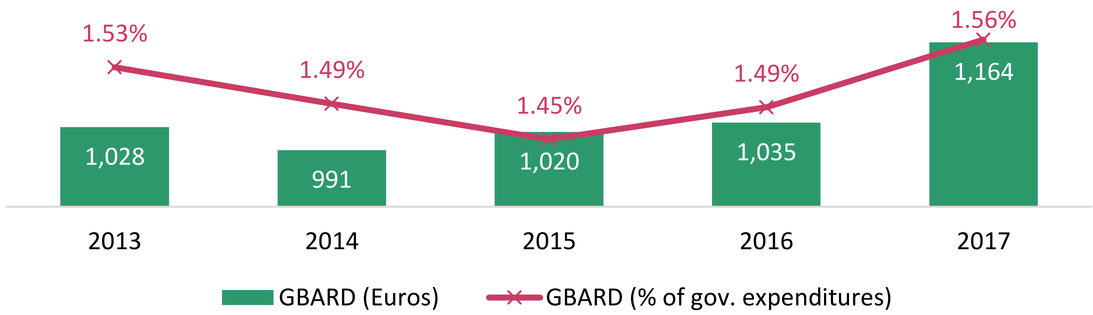
Figure 28. Basic research accounted for only a small share of Bulgaria's gross expenditures on R&D, 2017



Source: Eurostat

Note: Data not available for EU 28 average, Germany, or Turkey

Figure 29. The Bulgarian government's budgeted appropriations for R&D (GBARD) increased, 2013-2017

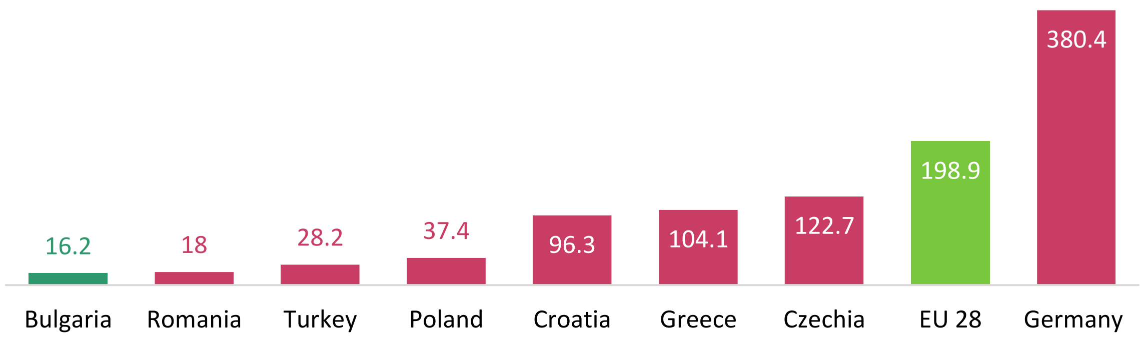


Source: Eurostat, authors' calculations

Government budget appropriations on R&D (GBARD) increased in both total funding and as a percentage of total government expenditures from 2014 to 2017 (Figure 29). However, despite these increases, Bulgaria still ranked last among its peers in GBARD per capita and less than ten percent of the EU 28 average in 2017 (Figure 30).

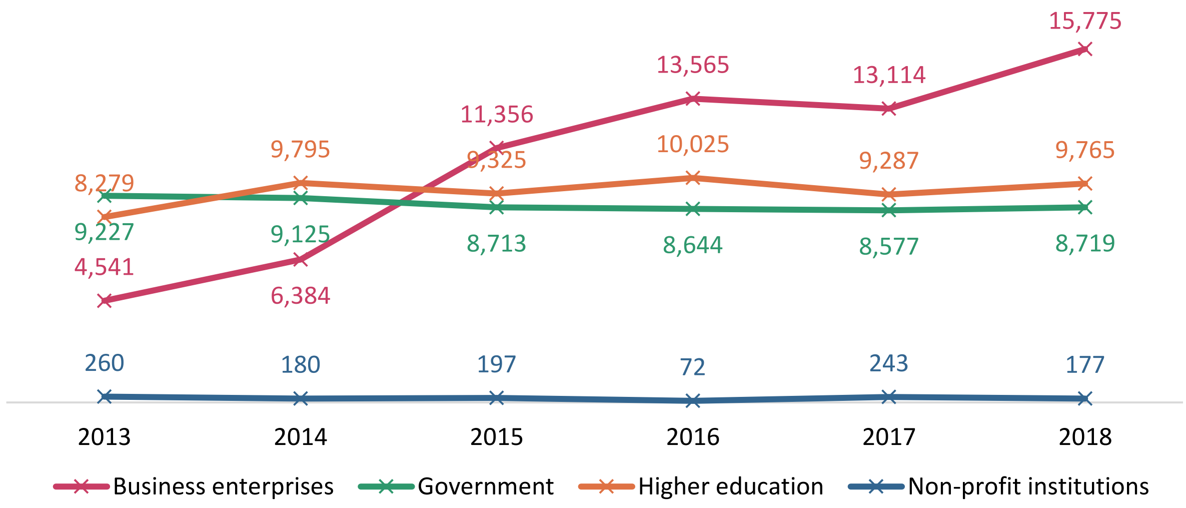
While public resources for R&D are relatively low and the public R&D workforce has remained largely static, the private sector R&D workforce has grown tremendously in recent years, with the number of researchers growing from 4,500 in 2013 to almost 16,000 in 2018 (Figure 31). The private sector now employs 51.5 percent of all researchers nationally.

Figure 30. But government budgeted appropriations on R&D per capita remained very low, 2017 (Euros per inhabitant)



Source: Eurostat

Figure 31. The number of researchers working in business enterprises increased sharply, 2013-2018



Source: Infostat

The rapid growth of the private sector research, in terms of R&D expenditures and personnel, is likely due to several factors. In the current EU programming period, the amount of financial resources available for R&D has risen and are provided through a more diversified portfolio of national and international instruments, which has had a leveraging effect on private investment of Bulgarian companies and has also made Bulgaria more attractive to foreign investments – not only in traditional sectors and outsourcing but also in high-technology sectors and research-driven services. Increased funding for R&D has motivated companies to hire more researchers, some of whom are drawn from public research organizations. However, some of this growth is also likely due to changes in how companies classify their activities and personnel in annual financial reports as a means to improve their applications for funding from national and EU innovation programs.[15]

Bulgaria's performance relative to its peers in attracting centrally-managed, competitive EU funding for innovation, described in Box 3, is relatively modest. Within its peer countries, Bulgaria is in a group with Croatia, Slovak Republic, Romania, and Greece that attracts relatively small amounts of funding and projects from competitive EU R&D funding programs, lagging behind regional leaders Germany, Poland, Turkey, and the Czech Republic.

Box 3. Overview of Competitive EU R&D Funding Programs

Horizon 2020

Horizon 2020 is the financial instrument implementing the Innovation Union, a Europe 2020 flagship initiative aimed at securing Europe's global competitiveness. With an overall budget of EUR 80 billion, it is the largest and most competitive RDI funding program in Europe. Participation is open to both public and private sector participants, and project proposals undergo a rigorous review and evaluation, with only 12 percent of eligible proposals succeeding. The program is delivered through several funding schemes, including European Research Council grants, SME Instruments, Fast Track to Innovation, Innovation Actions, Research and Innovation Actions, Coordination Support Actions, and Marie Sklodowska Curie Actions.

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

[15] Under some STI programs targeting innovation the private sector, companies can improve their application scores if they show evidence of past innovation activities. Firms do this by submitting reports with information on R&D expenses, R&D personal, IPR generation, and other innovation activities.

Box 3. Overview of Competitive EU R&D Funding Programs

Competitiveness of Enterprises and Small and Medium-sized Enterprises (COSME)

COSME is a program for SME support through grants and financial instruments with a total budget of EUR 2.3 billion for years 2014–2020. COSME focuses on projects that strengthen the competitiveness and sustainability of the EU's enterprises, particularly SMEs, encourage entrepreneurial culture, and promote the creation and growth of SMEs. Grants are provided to public and private entities to deliver SME support projects, particularly in the areas of entrepreneurial culture and SME growth. Financial instruments are delivered through two main facilities: a Loan Guarantee Facility, which supports guarantees and counter-guarantees to financial institutions to help them provide more loans and lease finance to SMEs; and Equity Facility for Growth, which invests in risk capital funds that provide VC and mezzanine finance in the expansion and growth stage of SMEs.

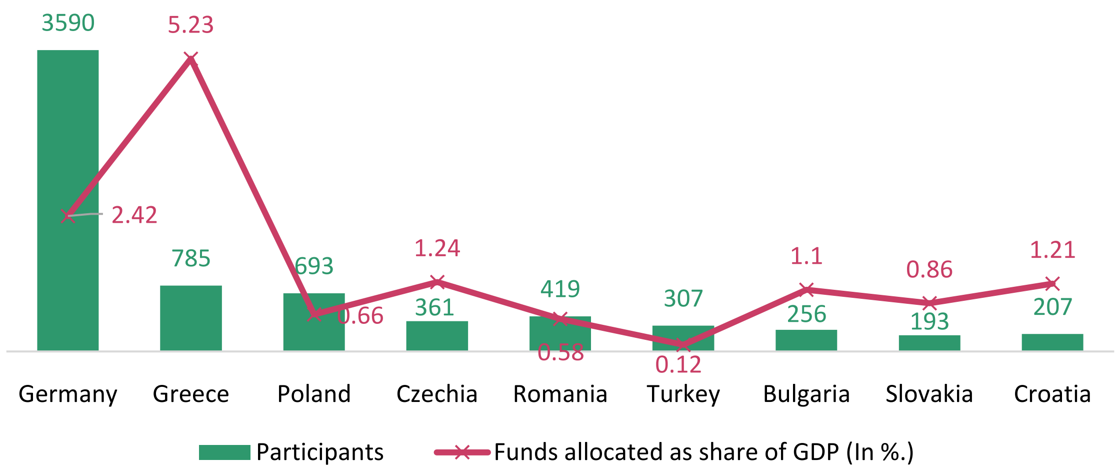
Eureka and Eurostars

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

Bulgaria is in the middle of its peers in H2020 funding awarded as a percentage of GDP (Figure 32), and the country has become increasingly competitive, both in terms of number of awards and share of total funding awarded, since 2015 (Figure 33). Private entities, which includes businesses and non-profits, lead Bulgarians in participation in Horizon 2020 programs both as project coordinators and as project partners[16], followed by public research organizations and universities (Table 2). Only five out of the 57 Bulgarian universities have participated in the Horizon 2020 as a project coordinator.

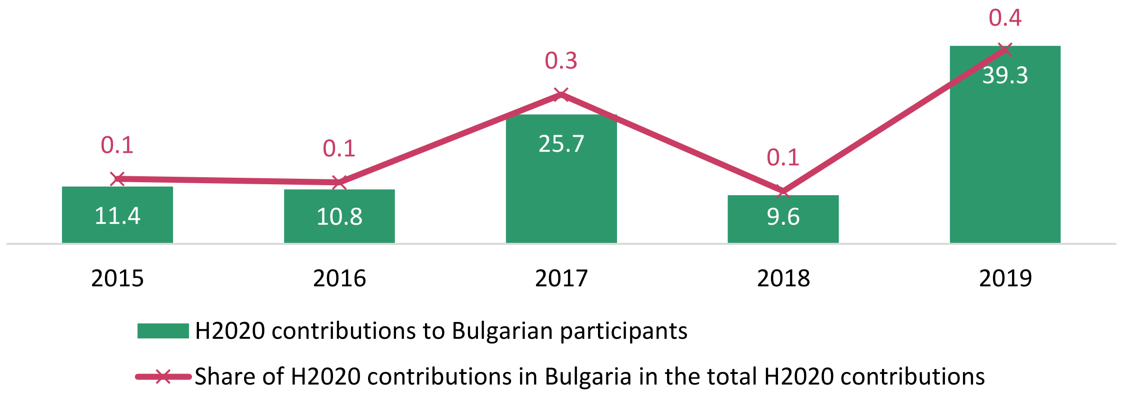
[16] Each Horizon 2020 project consortium consists of a project coordinator and project partners. The coordinator is responsible for communication with the European Commission and also manages quality performance and communication between the participants. The project partners are responsible for parts of the project but not the overall management.

Figure 32. Bulgaria was in the middle of peers in Horizon 2020 participation, 2014-2019



Source: EU Open Data Portal

Figure 33. Bulgaria Horizon 2020 participation increased, 2015-2019



Source: European Open Data Portal

Table 2. Participation of Bulgarian entities in Horizon 2020 programs 2014-2019

	As coordinator	As participant	As partner
Private entities[17]	25	145	3
Public research organization	7	25	
University	5	24	2
Government entity	2	36	

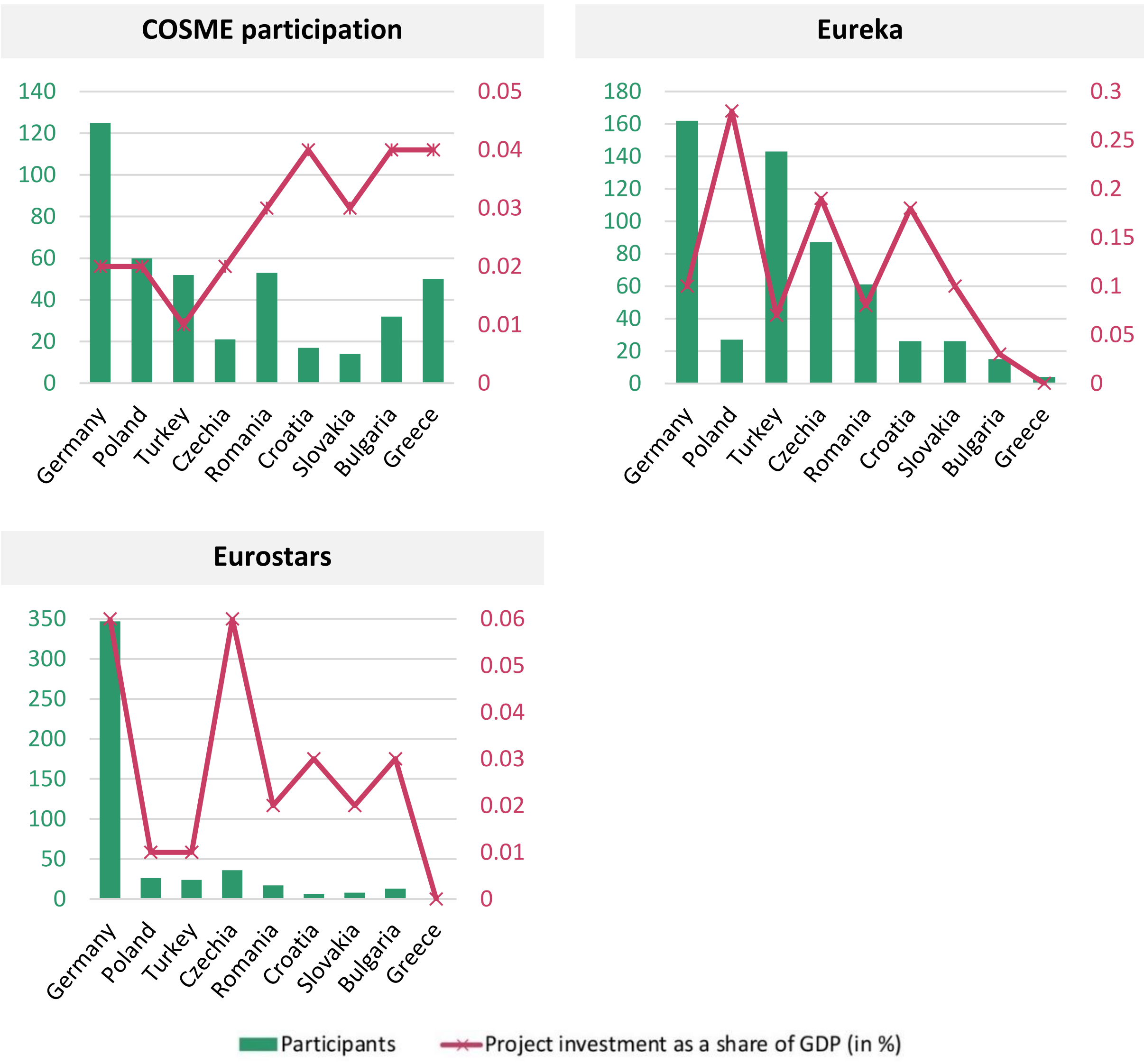
[17] Private entities are both for- and non-profit.

	As coordinator	As participant	As partner
Total	**39**	**230**	**5**

Source: EU Open Data portal

Bulgaria has been relatively successful in attracting COSME projects, ranking first among peers in COSME awards as a share of GDP from 2014 to 2019 (Figure 34). However, it has been less successful in attracting Eureka and Eurostars projects, ranking among the middle of its peers for Eurostars awards as a share of GDP and behind all peers except for Greece in Eureka awards.

Figure 34. Bulgaria's participation was high in COSME projects, but low in Eureka and Eurostars projects, 2014-2019



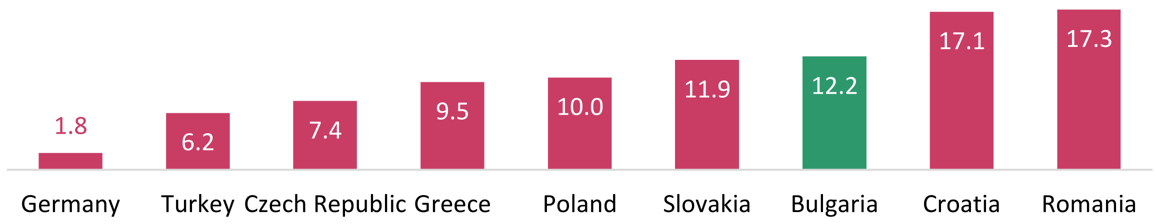
Source: COSME data hub

Innovation Outputs

Bulgaria lags behind most of its peers in generating impactful research outputs, which indicates a need for policies and programs aimed at improving research excellence. Beyond the Bulgarian Academy of Sciences, there are very few national institutions that contribute meaningfully to the international scientific literature, and Bulgarian publications on average do not tend to be well cited or impactful compared to those of peer countries. Bulgaria's outputs in terms of internationally-registered patents also lag behind peers, and patent outputs have been decreasing over time.

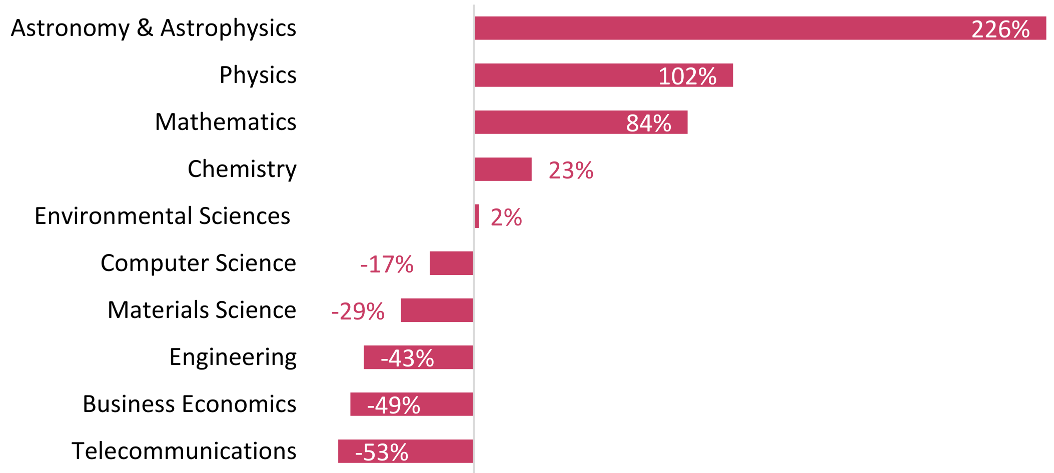
Bulgaria's publication output has increased significantly since 2015, growing at a rate of almost 9 percent per year from 2015 to 2019. Bulgaria's research output in 2018 was relatively productive compared to its peers, below only Croatia and Romania in the number of publications generated per million GERD (Figure 35).

Figure 35. Bulgarian researchers had a lot of publications compared to the level of gross expenditures on R&D, 2018 (Publications per million GERD)



Source: Scimago, Eurostat, authors' calculations

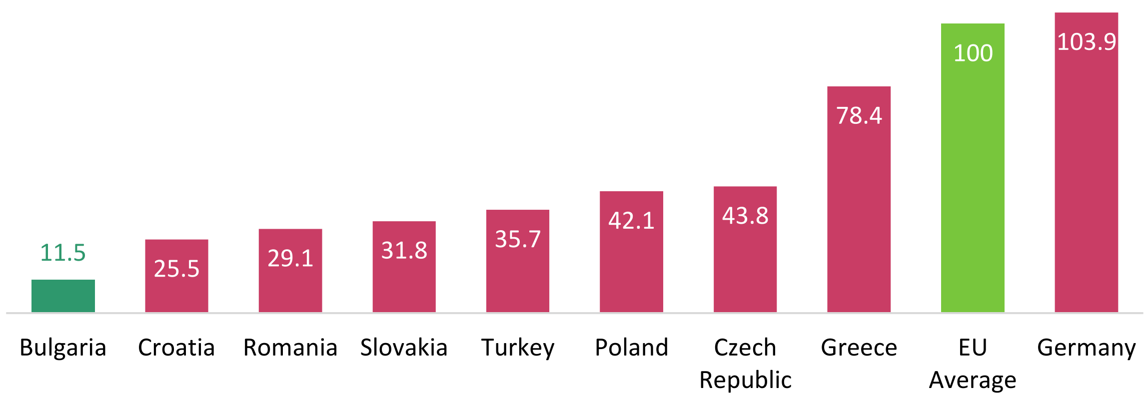
Figure 36. Bulgarian researchers specialize in fields with little relevance to Industry 4.0 and digitization, 2010-2019 (Relative Concentration of Publications)



Source: Web of Science

Bulgaria lacks any specialization or comparative advantage in many of the research areas that are important for Industry 4.0 and digitization. For example, no peer country had a lower relative concentration[18] of publications in the research areas[19] of telecommunications, business economics, and engineering. By contrast, no peer country had a higher relative concentration of publications in the research areas of astronomy and astrophysics, physics, and chemistry (Figure 36). This points to a lack of linkages between Bulgaria's researchers – particularly those in the Academies of Science and universities focused on producing publications – and the needs of the local manufacturing and IT sectors.

Figure 37. Only a small share of Bulgaria's scientific publications was in the top ten percent of most-cited publications, 2019 (Share of top ten percent most cited publications relative to EU average)



Source: European Innovation Scoreboard (2019)

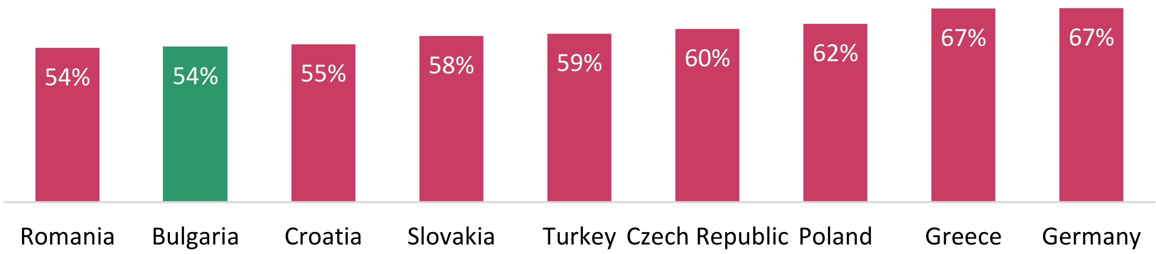
Bulgaria's publications tend to be less cited and less impactful than those of its peers, indicating a lack of quality and/or relevance of research being conducted. Bulgaria ranked last among its peers in scientific publications among the top 10 percent of most cited publications worldwide as a percentage of total publications in the country in 2019 (Figure 37), and with Romania had the lowest share of publications that were cited from 2013-2018 (Figure 38). This indicates that a relatively large share of publications produced nationally may not be relevant to the international (or even domestic) scientific community. While Bulgaria ranked among the middle of its peers in the average number of citations per publication from 1996-

[18] Relative concentration is an analytical statistic that measures a country's research specialization relative to global research activity. It is the share of a country's publication activity in a specific research area divided by the share of global publication activity in that research area.

[19] Research areas are defined here by a subject categorization scheme developed by Web of Science that is shared by all Web of Science product databases. See more information here: http://images.webofknowledge.com//WOKRS534DR1/help/WOS/hp_research_areas_easca.html

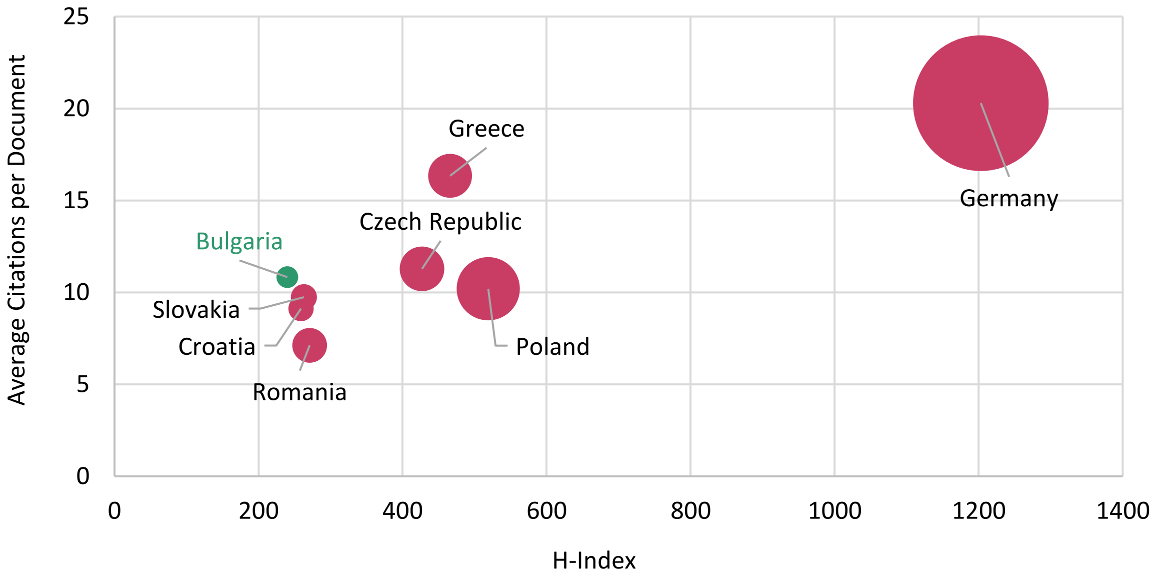
2018, Bulgaria ranked last among peers in h-index[20], a measure of both the productivity and citation impact of a group of publications (Figure 39).

Figure 38. A smaller share of Bulgaria's research publications were cited than in country peers, 2013-2018 (Share of cited publications)



Source: Scimago

Figure 39. Bulgaria ranked last among peers in h-index, a measure of productivity and citation impact of publications, 1996-2018

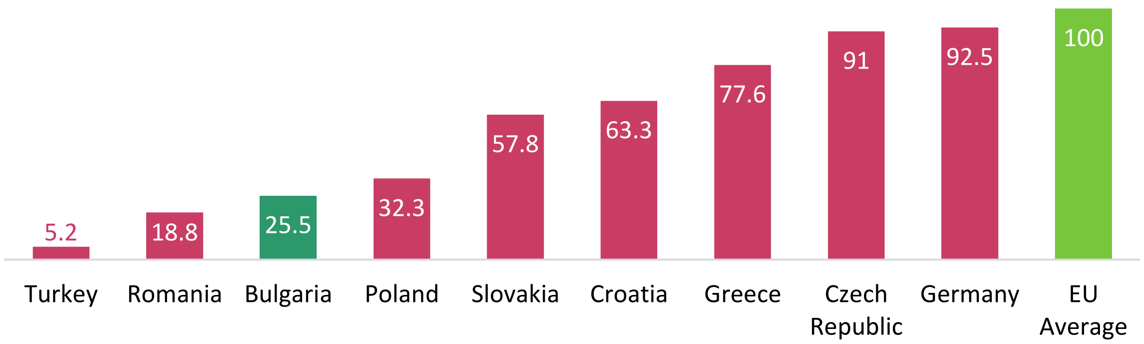


Source: Scimago
Note: The size of the bubble represents that total number of publications.

[20] The h-index is a metric that measures both the productivity and citation impact of a body of publications. Typically used to measure the impact of a given author, but also used to measure the impact of scholarly journals, institutions, or countries, 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 particular publishing and citing frequencies. For more information, see Hirsch 2005.

Information on co-authorship also indicates low quality and limited relevance of Bulgarian research publications. Bulgaria ranks fairly low among its peers in the number of publications with international co-authors (Figure 40), indicating low quality and international relevance,[21] as well as the limited extent of knowledge transfer from the international research community. Similarly, Bulgaria lags behind all peers except Turkey in the number of public-private co-publications per capita (Figure 41), an indicator of public-private linkages and the extent of knowledge transfer from academia to the private sector. The 2020 World Bank Survey of Bulgarian Public Researchers and Research Organizations reported that 30 percent of respondents had been involved in joint research with industry, 28 percent had engaged in a personnel exchange with industry (such as secondment), and 26 percent had performed consulting services for industry.[22]

Figure 40. Bulgaria's scientists publish few papers with international co-authors, per million inhabitants relative to EU average, 2019 (International scientific co-publications relative to EU average)



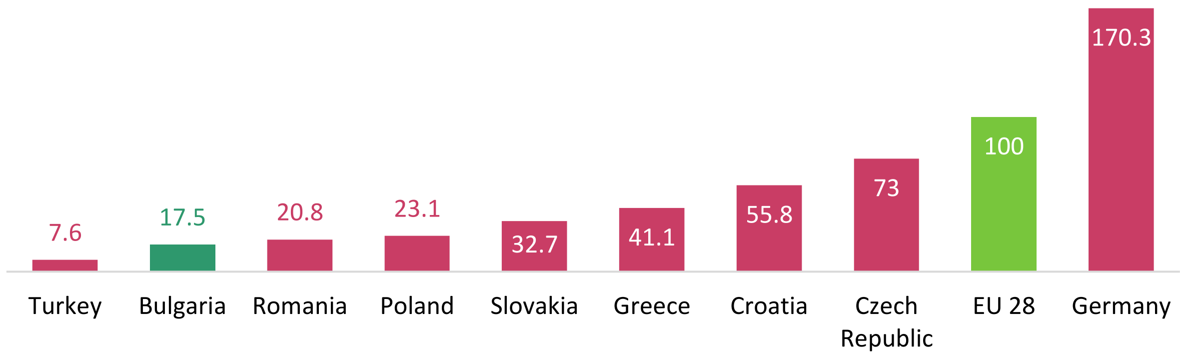
Source: European Innovation Scoreboard

The Bulgarian Academy of Sciences plays a leading role nationally in producing academic publication outputs; researchers from the Academies authored or co-authored 46 percent of the publications in Bulgaria from 2010 to 2019. Beyond the academies, only a small number of universities, largely based in Sofia, meaningfully contribute to the international scientific literature (Table 3). Only BAS, the University of Sofia, and the Medical University of Sofia had an h-index score above 50 from 2010-2019.

[21] Bulgarian publications with international co-authors perform dramatically better than papers without international co-authors in both average citations per publication (14.5 versus 2.6) and h-index (119 versus 32).

[22] In comparison, recent implementation of the World Bank's knowledge and technology transfer survey reported that 80% of Malaysian public research organizations were engaged in joint research with industry (Kuriakose and Tiew, 2020).

Figure 41. Public-private co-publications per capita are low in Bulgaria, relative to EU average, 2019



Source: European Innovation Scoreboard (2019)

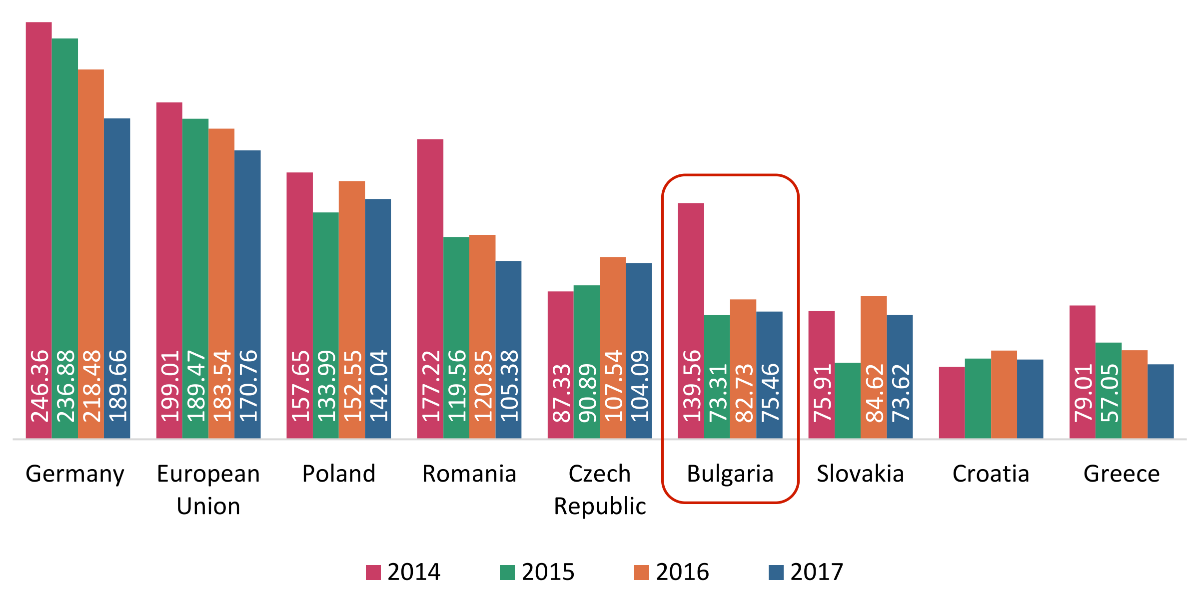
Table 3. Top Bulgarian institutions in publication activity, 2010-2019

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

Bulgaria ranked ahead of only Slovakia, Croatia, and Greece in the number of patent applications to the European Patent Office (EPO) per GERD among its peers in 2017, which shows that the Bulgaria STI system is relatively unproductive in producing valuable IP. Worryingly, patent productivity has declined since 2014 (Figure 42).

Figure 42. Bulgaria had fewer patent applications to the EPO per billion euro of GERD than most peers, 2014-2017



Source: Eurostat

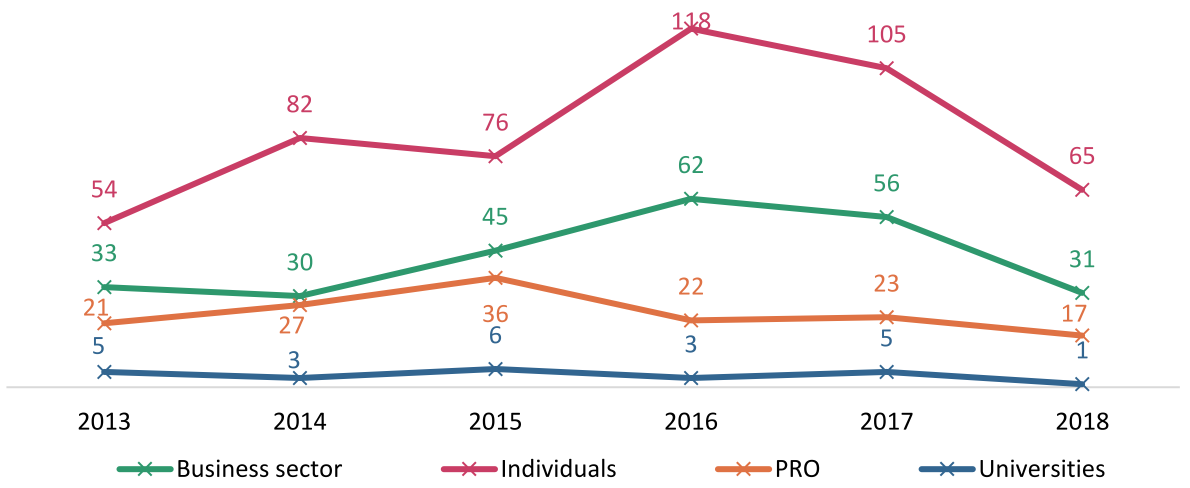
While patenting activity has been declining, utility models[23] are becoming increasingly popular for Bulgarian inventors, with utility model registrations outnumbering patent registrations in the Bulgarian Patent Office each of the last five years, with the exception of 2014. The growth in popularity of utility models may be explained by the fact that utility model registration is a simpler process, taking about a year on average, and less costly compared to patent filling. Bulgarian public research institutions have limited budgets for IPR activities, making protection from utility models more attractive, and utility models and patents are equally weighted as indicators for public research career development. However, utility models are not recognized by EPO, USPTO, and other important international markets, and thus are considerably less valuable than patents. In the recent World Bank Survey of Bulgarian Public Researchers and Research Organizations, only three percent of surveyed researchers had been granted a domestic patent in the last two years, compared to eight percent who had been granted utility models. Of the patents, about half had been done in collaboration with industry.

The Bulgarian private sector is the leading source of patents in Bulgaria (after individuals), while PROs and universities play a minimal role in patent production (Figure 43). Patenting

[23] Utility model systems provide intellectual property protection of so-called "minor inventions" through a system similar to the patent system under some IP regimes. In general, compared with patents, utility model systems have less stringent requirements (for example, lower level of inventive step), have simpler procedures and offer shorter terms of protection.

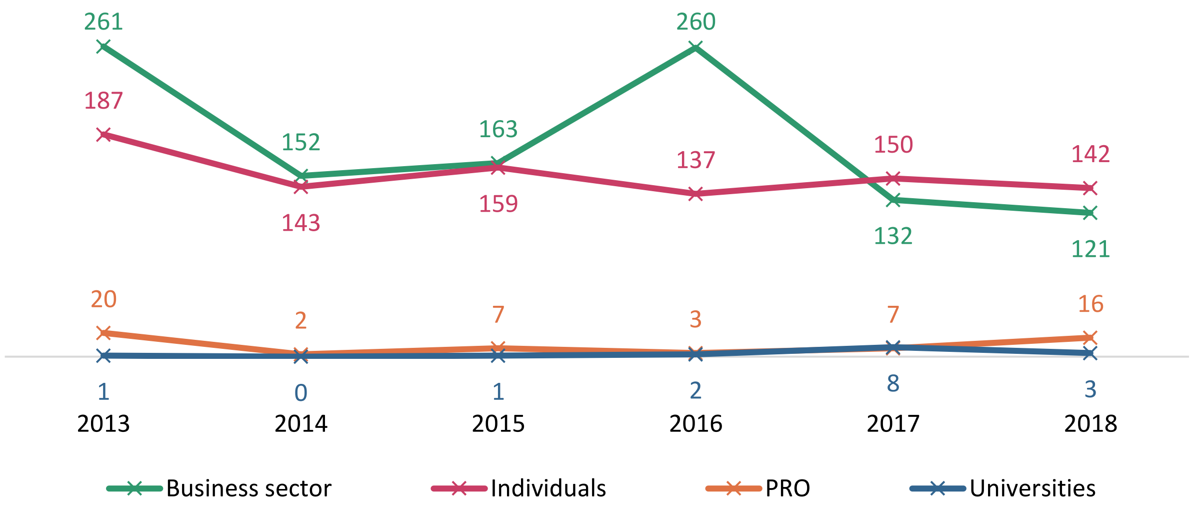
activity has increased among individuals and the private sector since 2013, while it has slightly declined for PROs and universities over the same period. This pattern is likely driven by the lack of budgets for IPR activities in public research institutions, leading public researchers to file as individuals. Similarly, individuals and the private sector were the leading sources of utility models in Bulgaria from 2013-2018 (Figure 44).

Figure 43. The Bulgarian business sector accounts for the largest share of patent activity, 2013-2018



Source: Patent Office of Republic of Bulgaria (PORB)

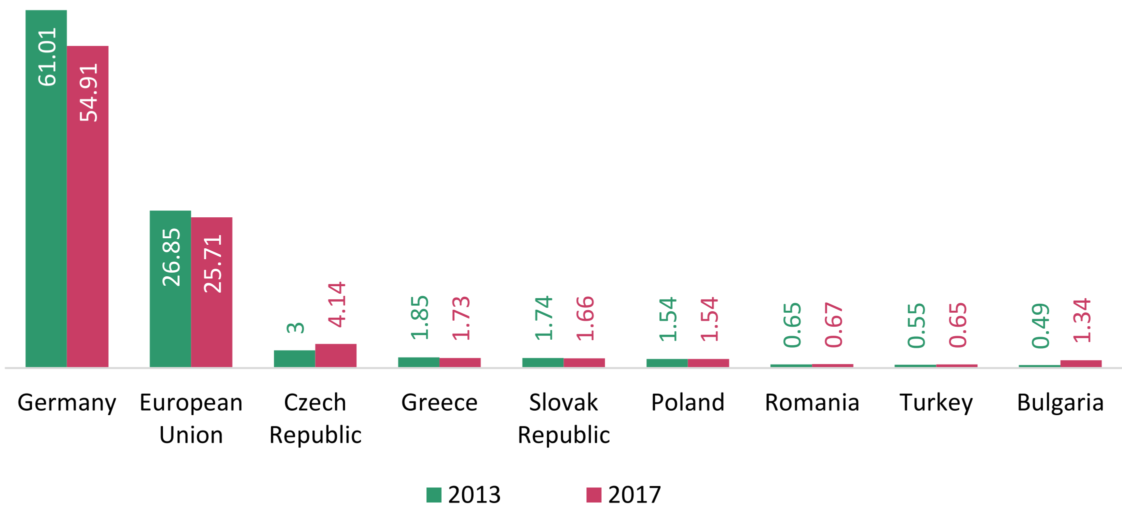
Figure 44. Individuals and firms were the leading sources of utility model activity, 2013-2018



Source: Patent Office of Republic of Bulgaria (PORB)

In terms of patenting abroad, Bulgaria lags behind all peers in the number of triadic patent families per capita (Figure 45).[24] Triadic patents are an indicator of both the value and international relevance of inventions being protected. Bulgaria's public research institutions do not have the resources for costly pre-patent investigations to the EPO or USPTO and therefore largely limit IPR activities to domestic protection, which is reflected in the low numbers of international and triadic patents nationally.

Figure 45. Bulgaria had the lowest number of triadic patent families per million inhabitants, 2013 and 2017



Source: OECD

Framework Conditions for Technology Transfer

This section provides an overview of the framework conditions for technology transfer in Bulgaria, including relevant laws and regulations, incentives, and resources that support (or hinder) technology transfer or collaboration between the public and private sectors. While key elements of intellectual property (IP) law are in place, the Bulgarian IP system appears detached from national policies related to science and technology, innovation, SMEs, and entrepreneurship. This detachment has resulted in a lack of coherent policies and incentives for encouraging the creation of IP and the commercialization of public research (Soete et al, 2015). In Bulgaria, the process of commercialization of scientific results by public research

[24] A triadic patent family is defined as a set of patents registered in three major international patent offices (the European Patent Office (EPO), the Japan Patent Office (JPO) and the United States Patent and Trademark Office (USPTO)) to protect the same invention.

organisations has historically been comprised of largely unofficial arrangements between public researchers and the private sector, ranging from consultancies to research collaborations to start-up creation. These informal arrangements sometimes bypass or even violate regulations, and thus do not appear in official statistics for commercialization and technology transfer (Galev, 2011). Such arrangements are not necessarily harmful or undesirable, as they do aid in technology and knowledge transfer to the private sector, but their informal nature hinders their sustainability and scalability.

Bulgarian IP and technology transfer legislation is generally in line with international norms and standards (WIPO, WTO) and with regional norms (European Union). Bulgaria is a member of the WTO, WIPO, the European Union, and the European Patent Office. IP ownership rules can be found in different acts that regulate various types of intellectual property (see Table 16). Rights for patents, utility models, trademarks, geographical indications, industrial designs and topology of the integrated circuits are registered rights, where the IP holder must complete a registration procedure before the respective Patent Office (e.g. Bulgarian Patent Office for national registration, the European Intellectual Property Office for European registration). The IP rights related to trade secrets are applied through court proceedings.

While the regulations around IP ownership are generally clear, 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 governs the transfer of public research to private applications (Spacic et al, 2019). Further, the researchers at public research institutions suffer from a lack of knowledge about technology transfer practices and procedures, a shortage of funding for IP protection and tech transfer activities, and a lack of incentives to commercialize their work (World Bank Survey of Bulgarian Public Researchers and Research Organizations).

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 state 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 their own internal regulations, so the ownership of IP derived from public research differs from one academic institution to another. Table 17 gives an overview of some of the publicly available IP policies at Bulgarian public institutions.

Incentives and Resources for Commercialization in Public Institutions

The legal framework for public research does not provide adequate incentives for commercialization. The *Law on the development of academic staff* and the corresponding *Rules for the implementation of the Law on the development of academic staff* stipulate the minimum requirements for academic titles, including indicators related to IP generation (for example, number of applications for patents, number of published patents, and number of copyrighted works) and project funding raised at both PROs, such as the academies of science and agriculture, and public HEIs. Importantly, there are no provisions that tie the commercialization of research (such as licenses or spinoffs) to the career development path of academic faculty in HEIs and PROs. These provisions are also not present in the reviewed IP policies of individual institutions. There is also no comprehensive national legislative framework that defines the benefits that should come to inventors if their inventions are commercialized. These issues are regulated by PROs' IP policies and individual contracts between PROs and researchers.

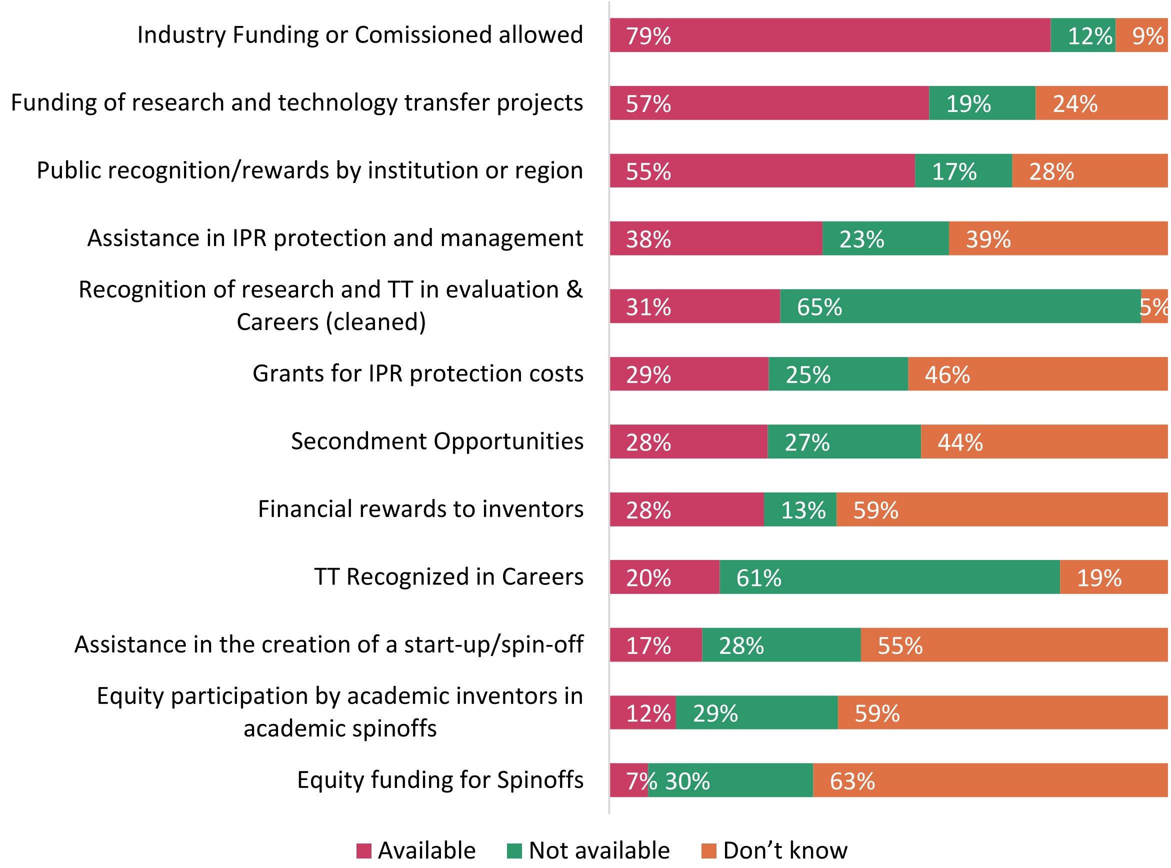
The *Rules* do not distinguish between obtaining patents versus utility models, nor between foreign/international patents (e.g. those granted by the EPO, USPTO, or JPO) versus domestic patents, when allocating points for academic development of HEI/PRO researchers. Patents are generally much more difficult to obtain than utility models, and foreign/international patents are more difficult than domestic patents, so the distinction could serve as an indicator of the quality of the invention/research. Additionally, the IP-related provisions of the *Rules* do not explain what would qualify as "inventions" or "technologies", which can create legal uncertainty in practice.

Public institutions also generally lack sustainable funding and resources for IPR and tech transfer activities. Not all public universities have dedicated TTOs, and some of the TTOs that do exist 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 academies may not have dedicated IPR experts. Public tech transfer offices suffer from a lack of sustainable funding – in recent years, significant investments were made, primarily with EU funding, to develop TTOs at public research institutions, but 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).

Because PROs lack resources for IPR activities (e.g. to cover the costs of pre-patent investigations by the EPO or USPTO), many of these institutions favor protection through utility models, which are easier, faster, and less costly to obtain. However, this type of protection is not recognized by the EPO and many other international patent regimes. In addition, the National Science Fund does not cover costs related to the protection of IP created in the implementation of its projects. The Ministry of Finance does not recognize this expenditure as eligible by claiming that the Fund only finances basic research.

Analysis of domestic patenting patterns shows that public institutions rarely appear as assignees for patents, and many more patents are registered to individual inventors unaffiliated with institutions. Coupled with anecdotal evidence, this suggests a pattern of public researchers patenting their research on their own, without support from their institutions. After being granted a patent, public researchers will often go on and establish their own companies to commercialize the IP (Galev, 2011).

Figure 46. A large share of Bulgarian researchers had little information on incentives for technology transfer engagement, 2020



Source: World Bank Survey of Bulgarian Public Researchers and Research Organizations

The recent World Bank Survey of Bulgarian Public Researchers and Research Organizations showed there was a huge lack of awareness about their institutions' technology transfer policies, with 40-50 percent of researchers unaware about specific policies and incentives of their institutions related to tech transfer (Figure 46).

Establishing Startups and Spinoffs

Bulgaria has made progress in enabling public institutions to use research for business purposes. The 2016 amendments to the *Higher Education Act* removed the not-for-profit status of HEIs and PROs, which would allow public research institutions to establish spin-off companies and to own shares in companies. Additional legislation[25] was introduced in 2020 to allow public HEIs/PROs to establish limited liability companies and joint stock companies in accordance with the Commercial Law, as well as participate in the capital of such companies

[25] The *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

only for the economic realization of the results of the performed research and the created objects of intellectual property.

Nevertheless, public researchers' participation in start-ups and spin-off has been limited, due to a lack of awareness or ambiguity regarding the ownership of IP rights and equity stakes in these ventures, as reported in the World Bank Survey of Bulgarian Public Researchers and Research Organizations. Of the PROs and HEI tech transfer offices interviewed, none of the institutions had generated a start-up in the last three years. Only one percent of researchers surveyed reported that they had created a start-up in 2019 through licensing of intellectual property rights or any other technological assets. There is anecdotal evidence that many public researchers patent their research on their own, without support from their institutions, and after being granted a patent sometimes go on to establish their own startups to commercialize the IP (Galev, 2011). However, the frequency and impact of these spinouts from PROs/HEIs is largely unknown or unaccounted for.

Licensing outcomes from public research are particularly hard to quantify because licensing is not tracked by individual PROs and HEIs, nor is it tracked at the national level by MoES, National Evaluation and Accreditation Agency, or as part of the Ranking System of the HEIs in Bulgaria.

Contract research, consulting, and other knowledge transfer activities

According to the *Law on Higher Education*, HEI/PRO employees are also free to provide consulting and other services related to their subject area, under the conditions and in the order specified in the regulations of their institution. However, publicly availably HEI regulations reviewed for this report have not included any provisions that regulate this activity. The usual practice is that researchers are free to sign any contracts for providing consultancy and other services outside the university. The information pertaining to consultancy contracts of their research staff is gathered by the universities as part of the accreditation procedure provided by the National Evaluation and Accreditation Agency. This information serves as evidence of the academic staff's expertise.

Due to scarcity of public funding for research, Bulgarian PROs enter a pattern of collaboration with industry that is more or less a form of industry-sponsored research, and also engage in various stages of the product development process based on industry requests. Most of the internal IP regulations stipulate that research results under "sponsored" research would be regulated by individual contracts signed by the sponsoring institution and the HEI/PRO.

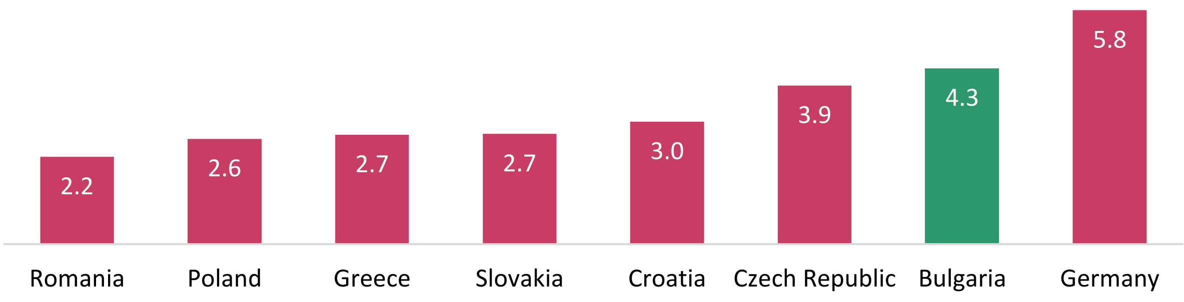
Public institutions also engage in publicly-funded collaborative research projects with industry – typically through programs administered by the OP IC or NIF. However, interviews reveal that this collaborative research is not necessarily collaborative or productive for the public institutions – companies often include a public partner to improve their chances of receiving funding, and there is little monitoring or follow up to check the level of collaboration.

Innovation Outcomes

Bulgaria performs well compared to peers in startup creation, but these startups rarely engage in the creation of new products or services. The country leads all peers but Germany in new business density[26] and in startups and scaleups per capita (Figure 47). However, few new businesses offer new or innovative products and services compared to startups in peer countries (Figure 48), as reported by the 2018 Global Entrepreneurship Monitor Global Report. The sectoral distribution of Bulgarian startups activity does not match much of Europe's, with over half of new ventures started in retail or wholesale, sectors which are extremely vulnerable to economic downturns. Bulgaria has a smaller share of early-stage startups belonging to knowledge-intensive industry sectors than innovation-driven economies; rather, the industry sector distribution of Bulgarian startups is similar to the distribution in factor- and efficiency-driven economies (Global Entrepreneurship Monitor, 2018).

Bulgarian startups also tend to be less productive than established firms; firm-level productivity analysis shows that the contribution of new firms to aggregate productivity growth is negligible or negative, even after five years of entering the market. This indicates a need for post entry support and addressing barriers to firm growth to allow startups to grow and be more competitive.

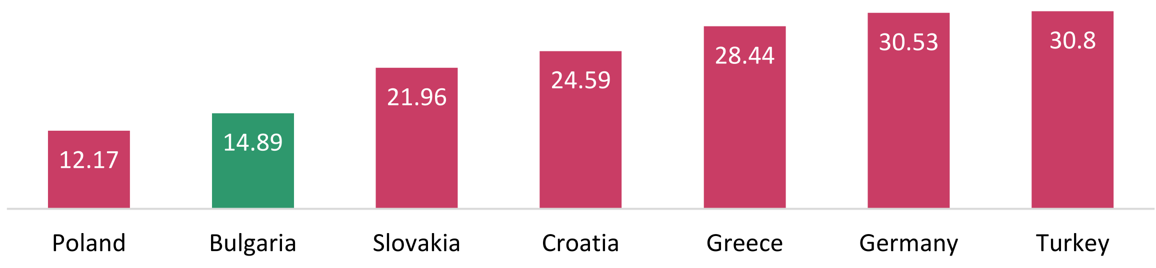
Figure 47. Bulgaria leads most peers in start-ups and scale-ups per 100,000 inhabitants, founded between 2008-2018



Source: Zakhidova et al., 2020
Note: Firms included were those with high growth ambitions as either start-ups or scale-ups depending on their own assessment on which stage best describes the current stage of their business. Base: Firms founded between 2008 – 2018 that are still active

[26] New business density is defined as the number of new business registrations in a year per 1,000 inhabitants.

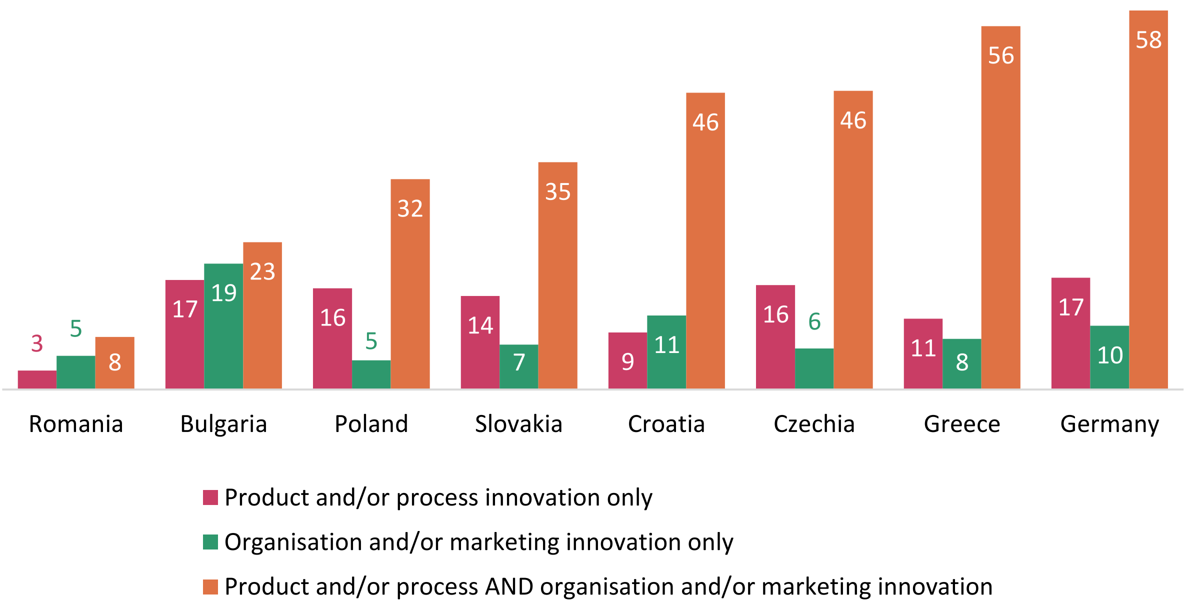
Figure 48. Few Bulgarian entrepreneurs believed that their product was new to all or some customers, 2018



Source: Global Entrepreneurship Monitor (2018)

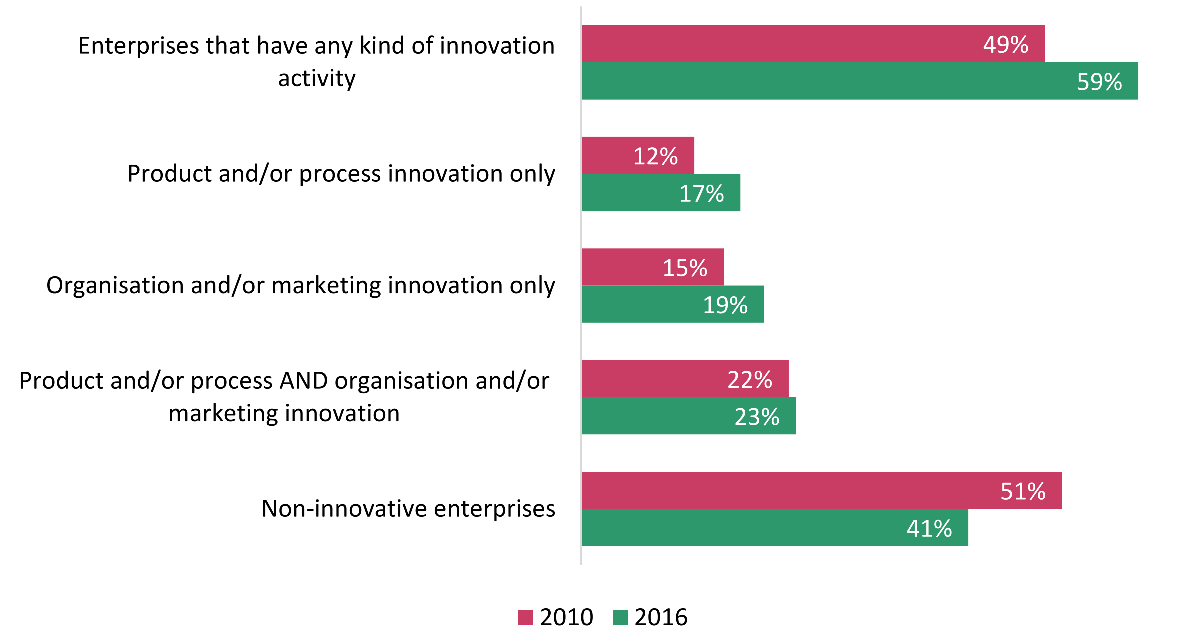
Bulgaria lagged behind all peers except for Romania in the share of firms that introduced an innovation (product, process, marketing, or organizational innovation) in 2016 (Figure 49). However, innovation in Bulgarian firms as measured by employment has grown in both product/process and marketing/organizational innovations, and the share of non-innovators dropped from 51 percent in 2010 to 41 percent in 2016 (Figure 50).

Figure 49. The share of Bulgarian employment in firms that introduced a product, process, marketing, or organizational innovation was low, 2016



Source: Eurostat

Figure 50. The share of Bulgarian employment in firms that engaged in innovation rose, 2010 vs 2016



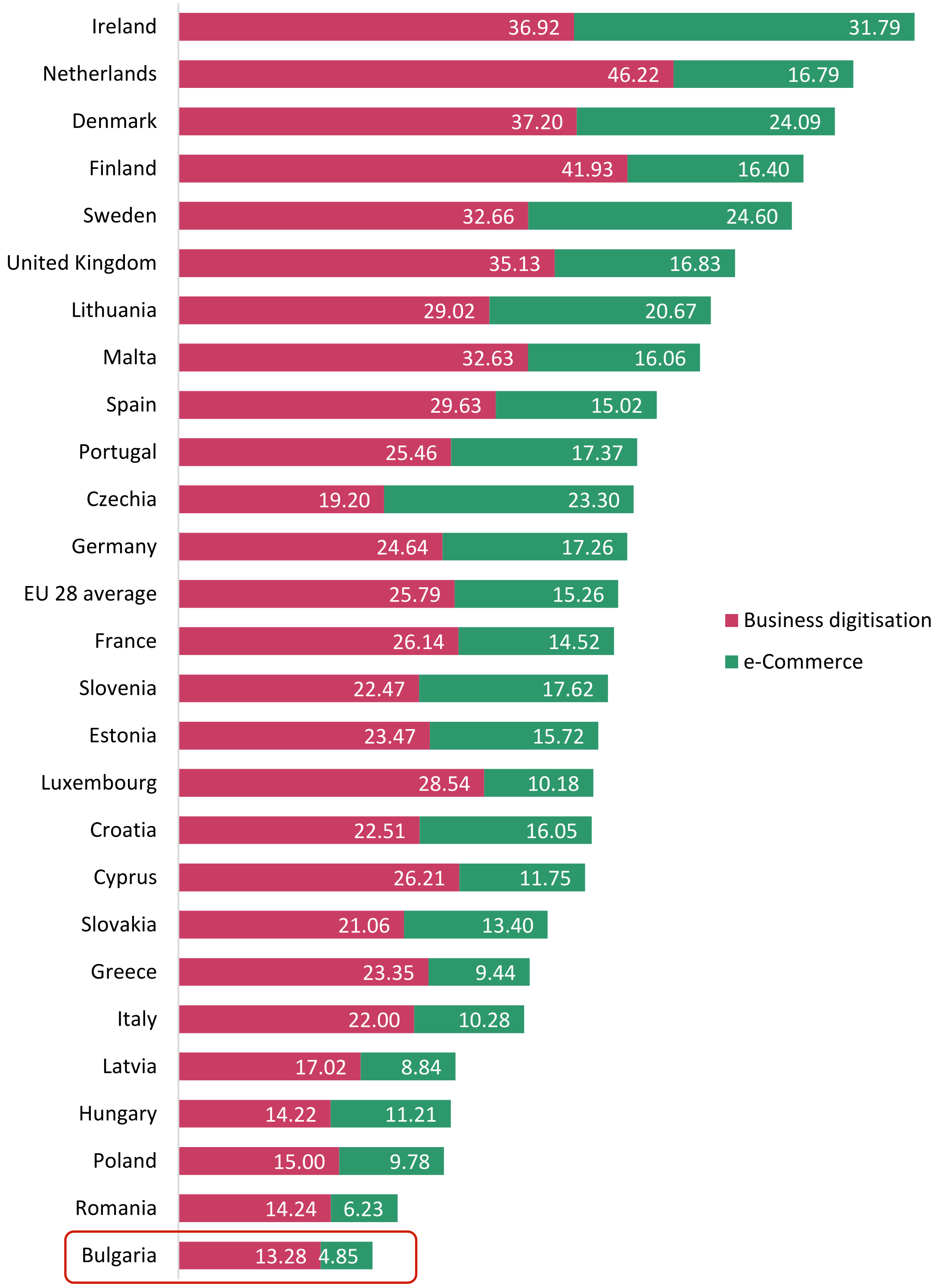
Source: Eurostat

Digitization and Industry 4.0

Bulgaria lags behind all other EU countries in the use of digital technologies. In 2019, Bulgaria ranked last in the EU in the Digital Economy and Society Index (DESI), a composite index that summarizes relevant indicators on European member states' digital performance. Bulgaria also had the lowest score in the EU for the DESI business digitization sub-indicator in 2019, which measures the use of digital technologies (such as cloud computing and big data) and e-commerce in firms (Figures 51 and 52). Increasing digitization in firms not only improves productivity, but also helps to build business resilience and flexibility; evidence from the recent World Bank BPS survey on the COVID 19 pandemic shows that the sectors least affected by COVID are those with the highest share of firms that have adopted digital solutions.

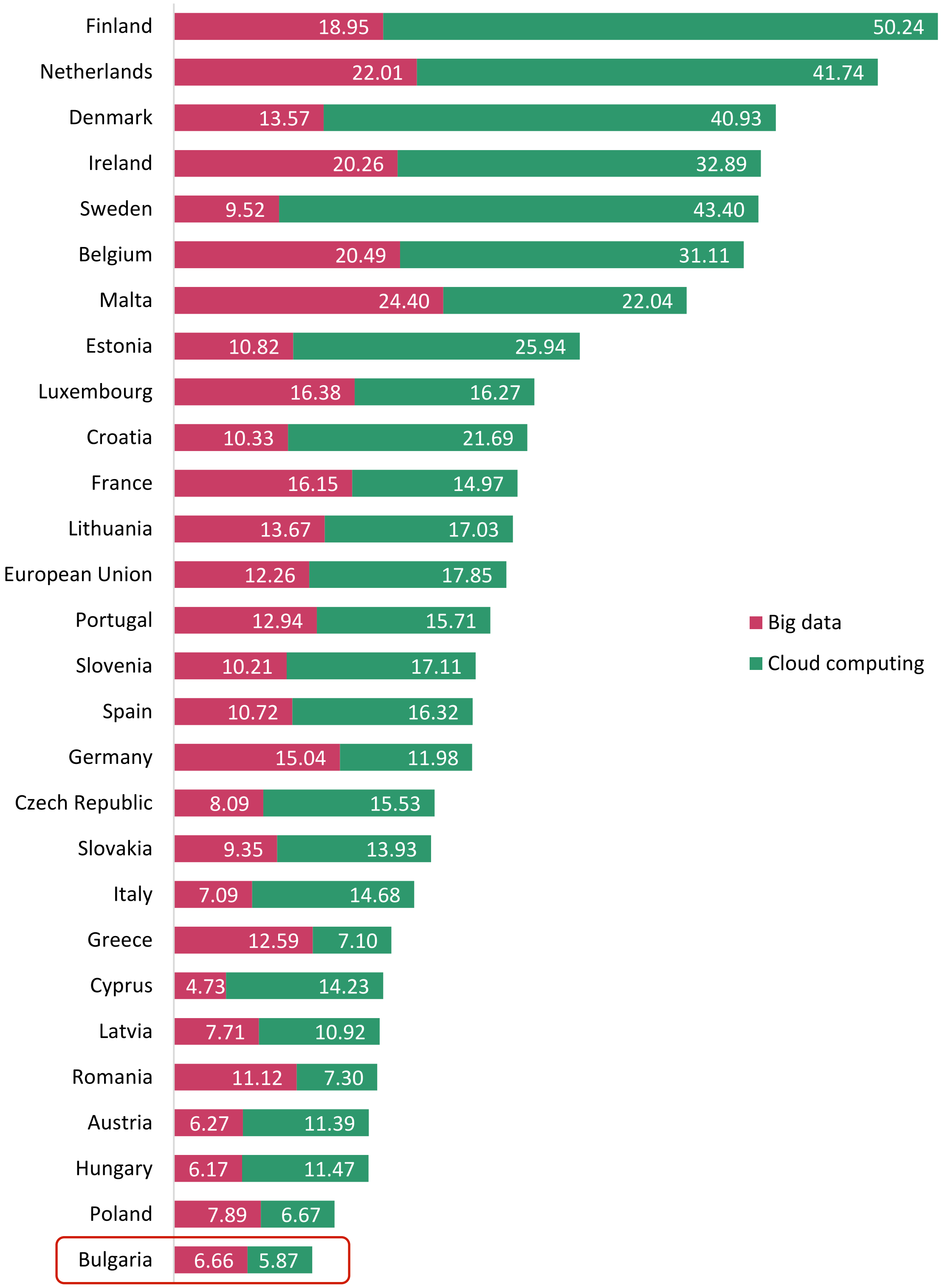
While the use of e-commerce among firms is low, the share of firms buying (as opposed to selling) online has grown rapidly in recent years. E-commerce use by firms could be an important component of Bulgaria’s economic recovery from the fallout of the COVID pandemic, as described in Box 4.

Figure 51. Bulgaria had the lowest score in the EU in DESI's Business Digitization Score, 2019



Source: DESI (2019)

Figure 52. Bulgaria ranked last in DESI's score of the use of big data and cloud computing in firms, 2019



Source: DESI (2019)

Box 4. E-commerce and COVID-19

In the aftermath of the global COVID-19 pandemic, economic activities that require close physical contact have been severely restricted. In this context, e-commerce – defined broadly as the sale of goods or services online – is emerging as a major pillar in economies coping with the COVID-19 crisis. E-commerce can reduce the risk of new infections by minimizing face to face interactions and can help preserve jobs during the crisis.

E-commerce in Bulgaria has thrived in recent years, particularly for firms engaged in buying online (see main text). However, there are still several challenges preventing prolific usage, for example difficulty in setting up and maintaining online stores, particularly for small firms that employ fewer than 50 people. Despite the dynamic development of ICT in Bulgaria, the main problems faced by individuals (2015-2019) when engaging in ecommerce involve delivery mishaps, information gaps concerning guarantees and other legal rights, and technical difficulties when using the website (see Box Table 1).

Box Table 1. Share of individuals encountering problems when buying goods or services online

Type of problems	2015	2016	2017	2018
1. Speed of delivery longer than indicated	11.7%	7.1%	6.9%	8.7%
2. Difficulties in finding information concerning guarantees and other legal rights	9.9%	4.9%	3.4%	5%
3. Wrong or damaged goods/services delivered	3.8%	3.7%	3.5%	4.6%
4. Technical malfunctioning of website during ordering or payment	4.8%	4.1%	1.9%	3.8%
5. Others	3.9%	2.6%	2.3%	3.4%
6. Final costs higher than indicated (e.g. higher delivery costs, credit card transaction fee)	3.0%	1.3%	2.4%	3%
7. Complaints and redress were difficult, or no satisfactory response received after complaint	2.6%	1.3%	1.3%	1.8%
8. Foreign retailer did not sell to my country	1.8%	1.7%	1.4%	1.5%
9. Problems with fraud encountered (e.g. no goods/services received at all, misuse of credit card details, etc.)	1.8%	0.4%	0.3%	0.5%

Source: Republic of Bulgaria – National Statistical Institute

Box 4. E-commerce and COVID-19

A recent World Bank policy note outlines 13 key measures that governments can take in the short term to support e-commerce during the ongoing crisis, including ensuring an enabling regulatory framework for e-commerce; clarifying (and, where appropriate, relaxing) the legal framework surrounding online delivery of professional services, particularly medical and other health services; and maintaining the functioning of the logistics system, including the national postal service. For more information, see Ungerer et al, 2020.

I4.0 technologies, which include technologies such as big data analytics, cloud computing, the Internet of Things, and advanced robotics, hold great promise for increasing the economic competitiveness of regions and nations around the world, including Bulgaria. However, to realize the potential productivity gains of these technologies, lagging regions and firms must be ready and able to adopt them – if not, they risk being left behind by firms in more advanced economies. Yet, Bulgaria lags behind most of Europe in both the creation and adoption of I4.0 technologies, as described in Box 5.

Box 5. Industry 4.0

Several recent studies assessing the Industry 4.0 "readiness" of European countries show that Bulgaria is largely not prepared to participate in the creation or adoption of I4.0 technologies. Naudé et al. (2019) assess I4.0 readiness of CEE countries in three key dimensions of I4.0-readiness – technological, entrepreneurial, and governance competencies – and finds that Bulgaria, Slovakia, Romania and Poland are the least ready of the CEE countries. Castelo-Branco et al. (2019) uses nine indicators to compare EU countries in existing digital infrastructure and their analytical capabilities for big data applications and finds that Bulgaria is one of three European laggards, along with Hungary and Poland. The World Economic Forum's Readiness for the Future of Production Report 2018 analyzes how well positioned countries are to shape and benefit from new industrial technologies and classifies Bulgaria as a "nascent" country, in the group least ready for the future of production.

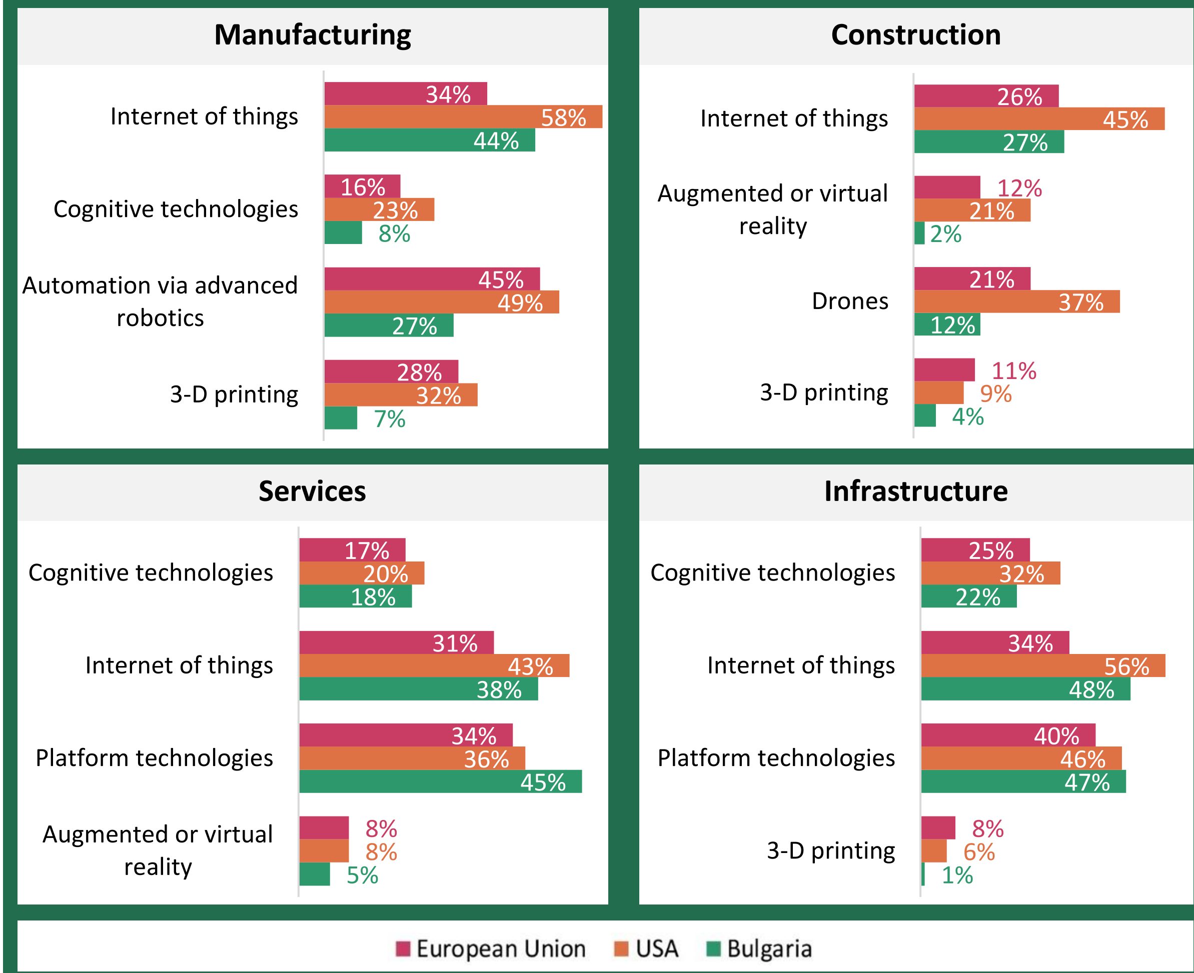
Evidence from Ciffolilli, Muscio, and Reid (2019), based on information extracted from industrial research projects financed by Horizon 2020, shows that Europe can be divided into four categories of I4.0 knowledge producers, of which Bulgaria falls into the laggard group along with other EU states that lack significant capacities in any of the fields of Industry 4.0. However, they find that Bulgaria has a small revealed comparative advantage

Box 5. Industry 4.0

in augmented reality technologies. This finding is reinforced by Balland and Boschma (2019), who uses patent data to calculate European regions' *relatedness density* to Industry 4.0 technologies – in other words, they measure how related a region's patent outputs are to Industry 4.0 technologies – in order to find which regions might develop a relative technological advantage (RTA) in a given Industry 4.0 technology. They find that Bulgaria – specifically the Yugozapaden region around Sofia – has the sixth highest relatedness density score in augmented reality.

Looking at firm adoption of I4.0 technologies (Box Figure 1), Bulgarian firms use internet of things (IoT) technologies at a higher rate than the average European firm across sectors, and use platform technologies and cognitive technologies (i.e., artificial intelligence and machine learning) in the services and infrastructure sectors. However, Bulgarian firms use automation, 3D printing, drones, and AR/VR at lower rates than the average European firm.

Box Figure 1. Industry 4.0 Technology use by sector, 2019



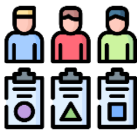
Source: EIB Investment Survey 2019

Market and Institutional Factors

In general, Bulgaria lags behind its peers in the development of a conducive business environment and a competitive market.

In particular, regulations related to starting a business appear to represent a large constraint on market access and consequently on competition in Bulgaria.

Overall access to finance is an area of strength in Bulgaria, although the country lags behind peers in innovation finance investments. This is likely more due to a lack of investment-ready early stage companies than to a lack of investors and capital.



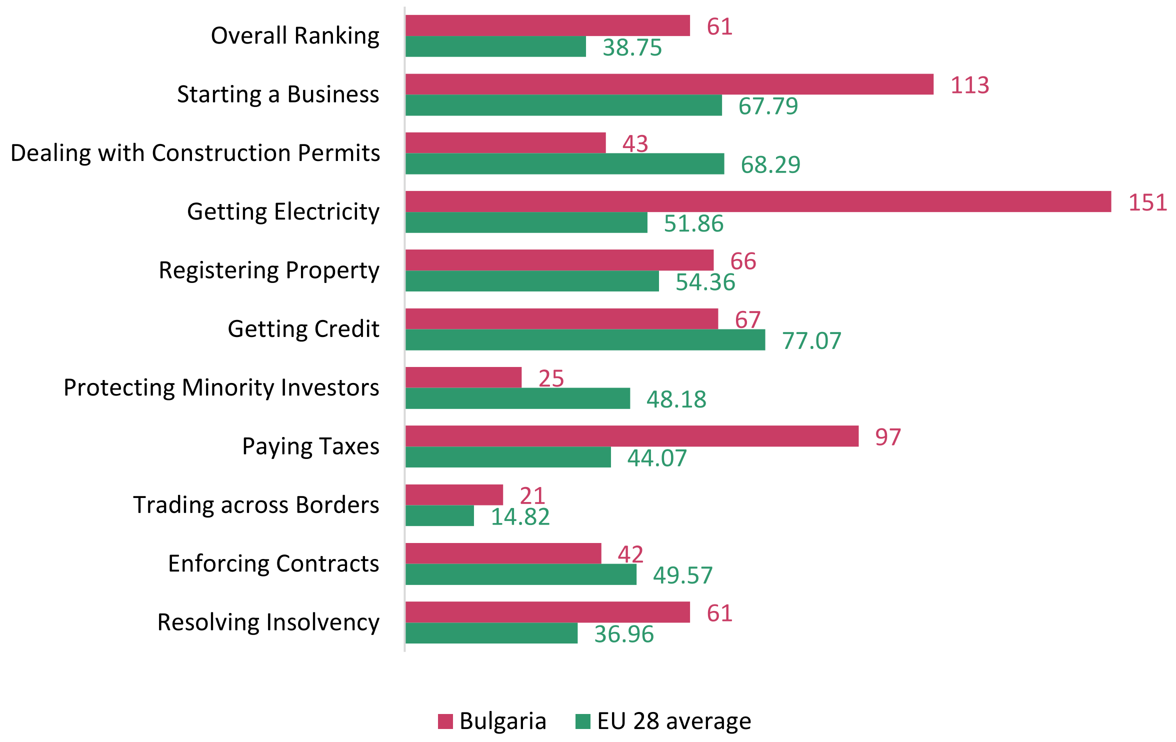
Labor shortages are becoming an issue for employers. Like its European peers, demand for advanced skills is projected to grow in Bulgaria, yet the country lags in terms of the share of the labor force with STEM degrees, advanced degrees, and with other relevant digital skills.

The main framework conditions that govern Bulgaria's national science, technology and innovation performance are the business environment and competition regulations, the availability of innovation finance, and the availability of skilled labor.

Business environment

In general, Bulgaria lags behind its peers in the development of a conducive business environment and a competitive market. The firm-level productivity analysis found a negative contribution from firm entry and exit to aggregate productivity growth, indicating barriers in the business environment in these areas. This is reinforced by Bulgaria's 2020 global Doing Business rankings, which compare poorly to peers (Figure 53). The overall business environment ranked 61st globally, a decrease from 59th the previous year and below all of its peers, with the exception of Greece. While the country performs relatively well in some indicators, ranking among the top 30 countries globally in the "protecting minority investors" and "trading across borders" indicators, Bulgaria ranks poorly in indicators related to firm entry (113 in ease of starting a business) and firm exit (61 in resolving insolvency), as well as other important indicators such as paying taxes (97) and getting electricity (151).

Figure 53. Bulgaria ranked worse than the EU average in several Doing Business rankings, 2020 (lower scores indicate better business conditions)



Source: Doing Business

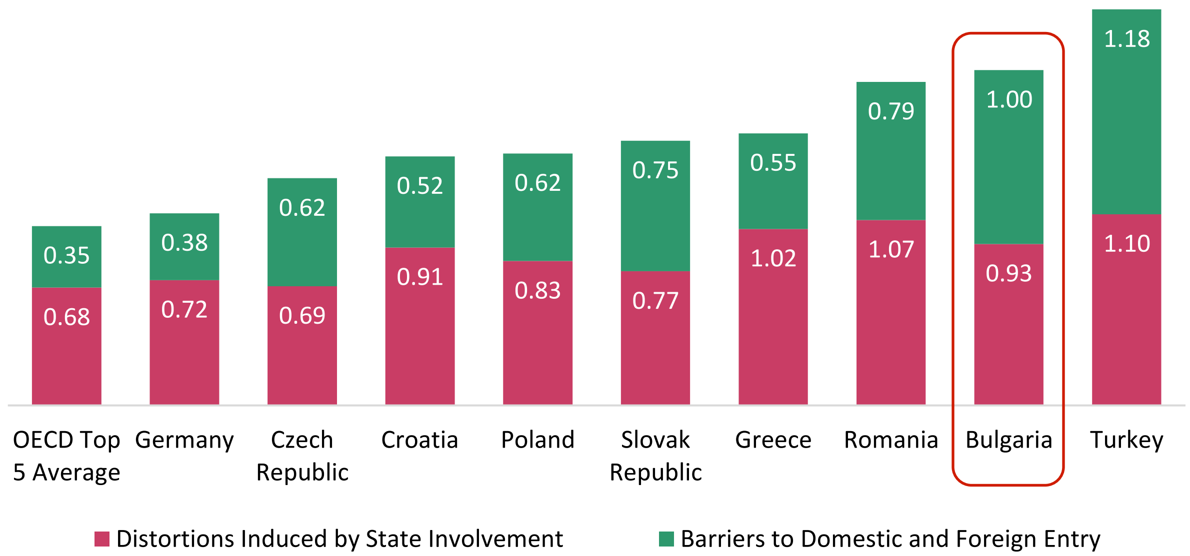
The firm-level analysis also found that more productive firms in Bulgaria are unable to grow due to a lack of available resources, indicating barriers to competition between firms. The World Economic Forum's Global Competitive Index, which measures national competitiveness in terms of the institutions, policies and factors that determine the level of productivity in a country, ranked Bulgaria 49th globally in 2019, below peers Germany, Czech Republic, Poland, and Slovakia. The country's ranking was dragged down by scores in indicators related to "business dynamism" (due to the time it takes to start a business and the insolvency recovery rate), "product market" (due to the distortive effect of taxes and subsidies on competition, complexity of tariffs, and prevalence of non-tariff barriers), and the "financial system" (due to non-performing loans as a percent of gross total loans).

Bulgaria lags behind all of its peers except Turkey in the degree of market restrictions to competition, as measured by product market regulation (PMR) indicators (described in Box 6). These restrictions stem from a roughly equal split between distortions induced by state involvement and barriers to domestic and foreign entry. Distortions related to state involvement in the economy account for 52.5 percent of the overall PMR score, while barriers to domestic and foreign entry account for the remaining 47.5 percent (Figure 54). Looking deeper at the PMR sub indicators, public ownership is the main driver of the burden related to state presence in the economy, while administrative burdens on startups (particularly licenses and permits) are the key driver of restrictions associated with barriers to domestic and foreign entry.

Box 6. Product Market Regulation

Product Market Regulation (PMR) indicators form a comprehensive and internationally-comparable set of indicators that measure the degree to which policies promote or inhibit competition in areas of the product market where competition is viable. PMR data captures: i) laws and regulations at the national level; ii) laws, regulations and market outcomes in key sectors (telecommunications; electricity; gas; rail, road, maritime and air transport; retail; professional services); and iii) economy-wide policies (e.g., price controls, antitrust exemptions, quality standards). The PMR tool is composed of two sub-indicators – "distortions induced by State involvement" and "barriers to domestic and foreign entry" - with various intermediate and low-level indicators. Higher scores reflect more restrictive regulation or a regulatory framework least conducive to competition.

Figure 54. Bulgaria has higher product market restrictions than almost all peers, 2018 (higher scores indicate more restrictions to competition)



Source: OECD PMR database

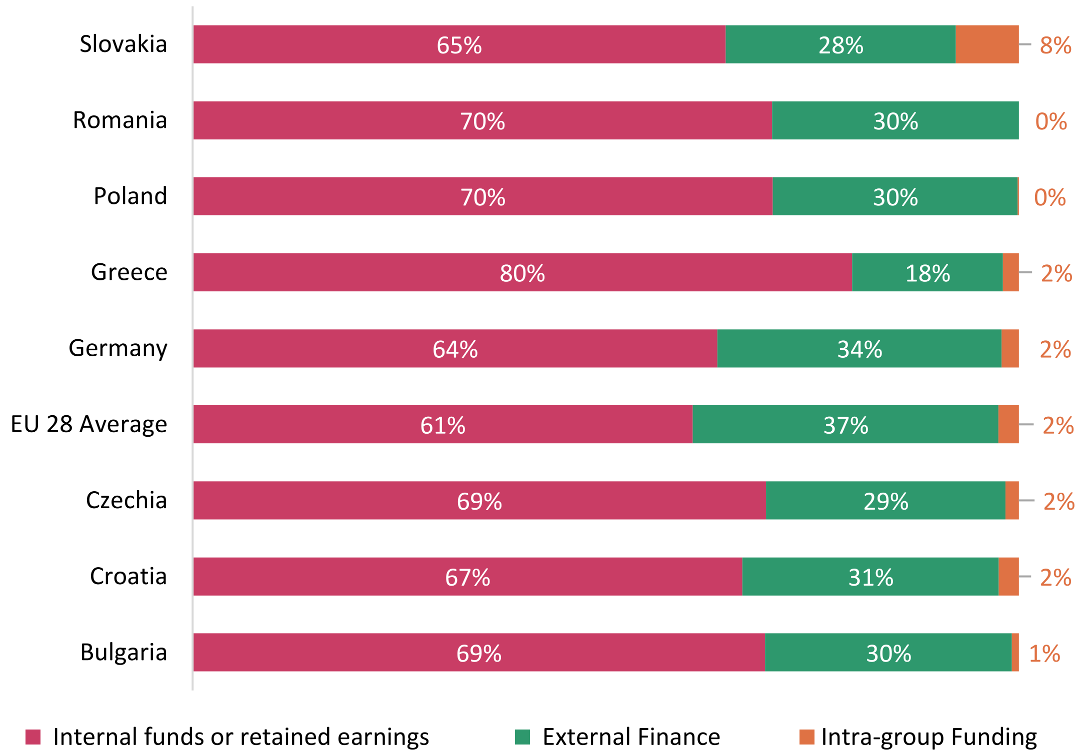
Note: Higher scores reflect more restrictive regulation or a regulatory framework least conducive to competition; OECD top 5 are UK, Denmark, Spain, Germany, Lithuania

Access to Finance

Overall access to finance is an area of strength in Bulgaria, although Bulgaria lags behind some peers in innovation finance investments. Numerous indices rate Bulgaria highly in terms of access to finance for SMEs and startups, including the European Commission's SBA implementation indicators and the Global Competitive Index. The cost difference between borrowing rates for small loans relative to large loans is one of the lowest in the EU (European Commission, 2019). Bulgarian firm satisfaction with the amount, cost, maturity, collateral and type of finance received in 2019 was higher than the EU average (EIB Investment Survey, 2019).

About 69 percent Bulgarian firms finance their investments through internal funds or retained earnings, while 30 percent finance through external sources (bank loans and credits, leasing, grants, and other sources) and one percent finance through intra-group funding (Figure 55). These financing patterns are roughly the same as regional peers Croatia, Czech Republic, Poland, and Romania, though in Germany and the EU 28 average, firms tend to get more financing externally than Bulgarian firms.

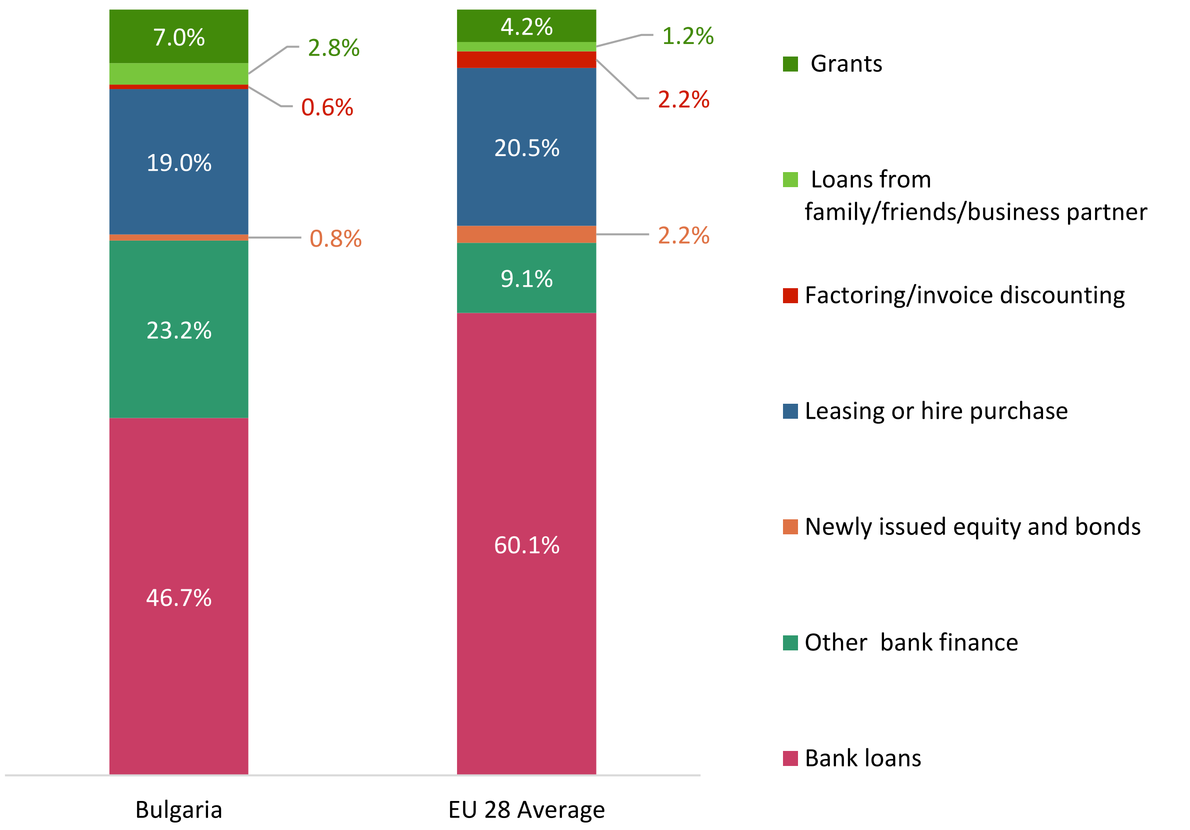
Figure 55. Bulgarian firms finance more than two-thirds of their investment from internal sources, similar to regional peers, 2019



Source: EIB Investment Survey (2019)

Bank loans and other bank finance (overdrafts and other credit lines) account for about 70 percent of external financing, roughly the same as the EU 28 average (Figure 56). However, Bulgarian firms tend to get more financing from grants and loans from friends and family, while the average EU firm tends to get more from newly issued equity or bonds and from factoring or discount invoicing.

Figure 56. Bank finance accounted for most of Bulgarian firms' external financing, 2019

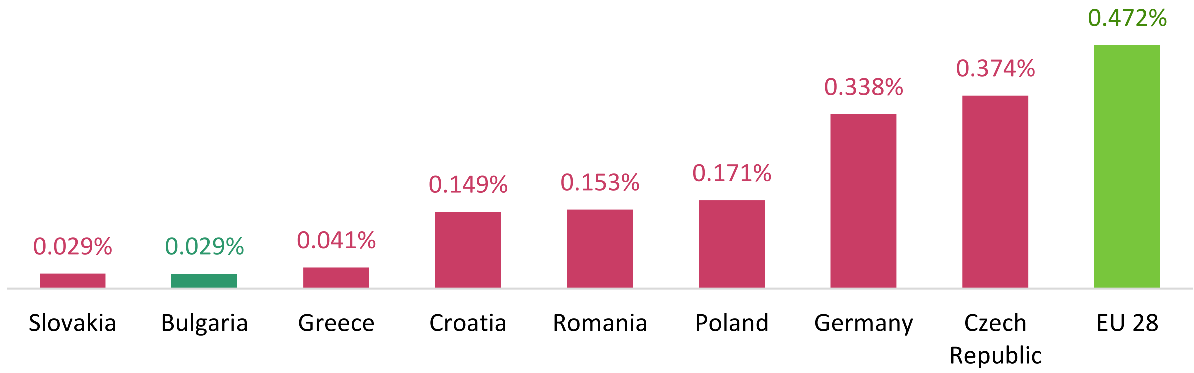


Source: EIB Investment Survey (2019)

While bank lending is relatively accessible to SMEs and startups, Bulgaria lags behind many of its peers in terms of risk financing investments. Bulgaria shared last place with Slovakia among its peers in private equity and venture capital investments as a percentage of GDP in 2018 (Figure 57).

The seed stage accounts for about 40 percent of private equity investments in Bulgaria (Table 4). Business angel investment activity in Bulgaria is comparable in size to many of its CEE peers (Figure 58).

Figure 57. Bulgarian firms received little private equity and venture capital investments as a percent of GDP, 2018



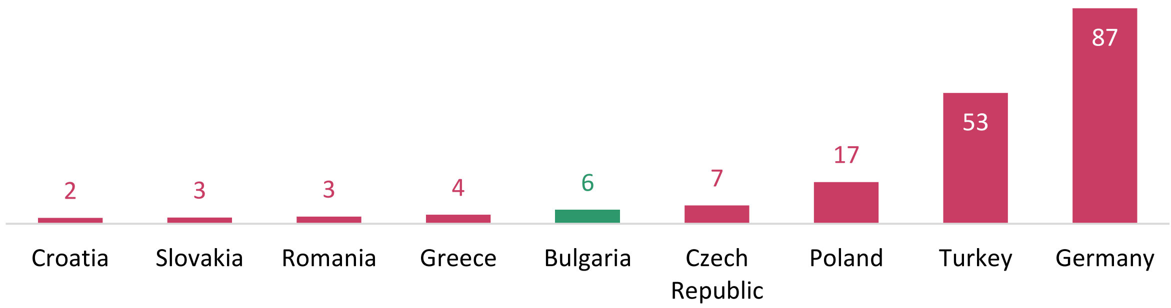
Source: Invest Europe (2019)
Note: Private equity investments include seed, startup, later stage venture, growth, replacement capital, and buyout investments.

Table 4. PE investments in Bulgaria by stage in 2018 (thousand EUR)

	2018
Seed	3,921
Start-up	820
Later-stage venture	2,261
Growth	2,877
Total	**9,879**

Source: Invest Europe

Figure 58. Business angel investments were comparable in size to many CEE peers, 2018



Source: EBAN, 2019

Bulgaria is home to a number of venture capital funds, largely based in Sofia, which include Eleven Ventures, LaunchHub Ventures, Neveq Capital Partners, and the new Brightcap Ventures, which was established as part of the EIF JEREMIE programme, through which JEREMIE invested €20 million and BrightCap Ventures raised additional private capital. Additional public support for risk capital is available through the Risk-Sharing Micro-Finance Facility, which provides micro loans to support the establishment and development of start-ups; the National Venture Capital Fund, which makes €24.4 million in public funds available for financial support to start-ups/SMEs during their first 5 years; as well as the Innovation Accelerator Bulgaria Financing Fund, a €15.6 million fund with the mandate to provide access to equity and quasi-equity funding to Bulgarian start-ups targeting entrepreneurs at the earliest stages of developing their business ideas.

Given the number of active VC funds in Bulgaria, largely backed by EIF funding, it is likely that the low levels of risk finance observed thus far are due, at least in part, to the lack of investment-ready early stage companies, rather than a lack of investment supply.

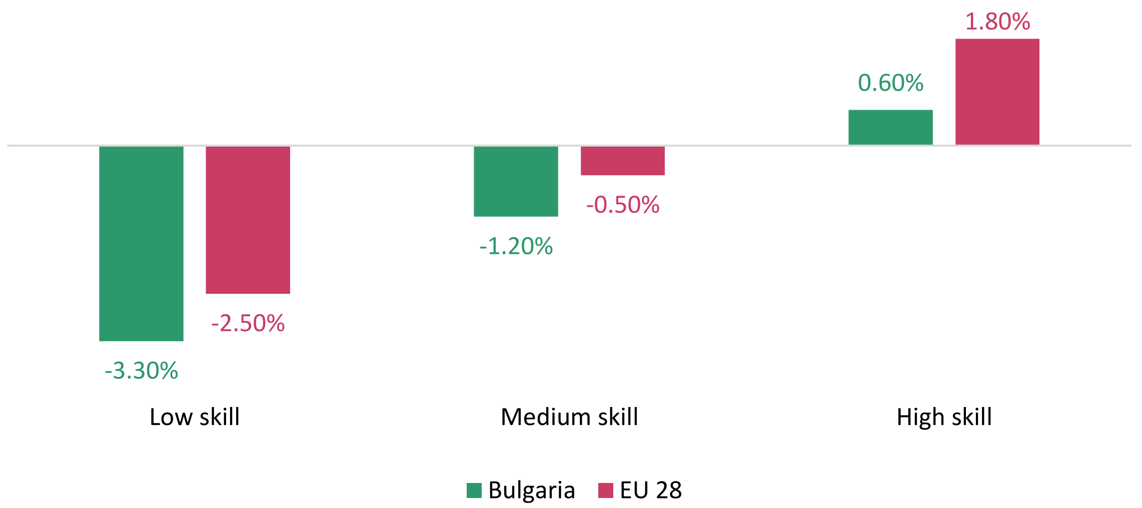
Labor Market and Skills

The unemployment rate in Bulgaria dropped continuously after the 2008 financial crisis, reaching a historic low of 5.2 percent in 2018, and labor shortages have become an issue for employers, although unemployment has risen above these historic lows during the COVID-19 pandemic. Labor shortages will likely become a larger constraint on businesses in the near future, as Bulgaria's workforce is projected to decline further due to an aging population and net emigration (IMF, 2019). Like its European peers, demand for advanced skills is projected to grow in Bulgaria, yet the country lags in terms of share of labor force with STEM degrees, advanced degrees, and with other relevant digital skills.

The 2019 World Bank Enterprise Survey of Bulgaria finds that inadequately trained workforce is one of the largest business environment constraints in the country, with 22 percent of responding firms reporting challenges finding skilled workers, higher than the Europe and Central Asia average of 13 percent. This constraint is most acute in larger firms, where 27 percent of medium firms and 30 percent of large firms reported issues with finding skilled workers (World Bank, 2020). The 2019 European Investment Bank Investment Survey finds that the availability of skilled staff is the most cited barrier to investment in Bulgaria, with 86 percent of firms believing skills shortages to be a barrier to investment, higher than the EU average of 77 percent (EIB Investment Survey, 2019). A 2018 Eurostat firm survey shows that 45 percent of Bulgarian businesses believe that labor shortages limit their production. Similarly, in a 2019 survey of 68 Bulgaria CEOs, PwC finds that 64 percent believe that the difficulty in finding skilled workers was impacting quality standards or customer experience, 57 percent believe that lack of skills is impacting their abilities to pursue market opportunities, and 53 percent believe it harms their ability to hit growth targets – all of these perceived impacts are higher in Bulgaria than CEE averages (PwC, 2019).

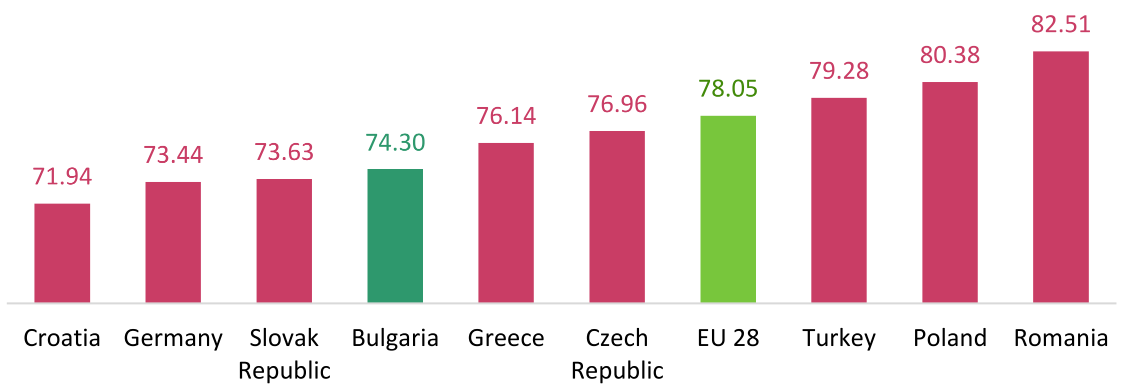
Like many other European economies, the demand for advanced skills is projected to increase over the next decade, while the demand for low- and medium-skilled workers is expected to decline (Figure 59). At present, workers with advanced degrees constitute a relatively low share of the Bulgarian workforce when compared to the EU average and many peers (Figure 60), and like many other CEE countries, unemployment for workers with advanced degrees is extremely low (Figure 61) – due in large part to high demand.

Figure 59. The demand for advanced skills is projected to increase, shares of total employment, 2018-2030



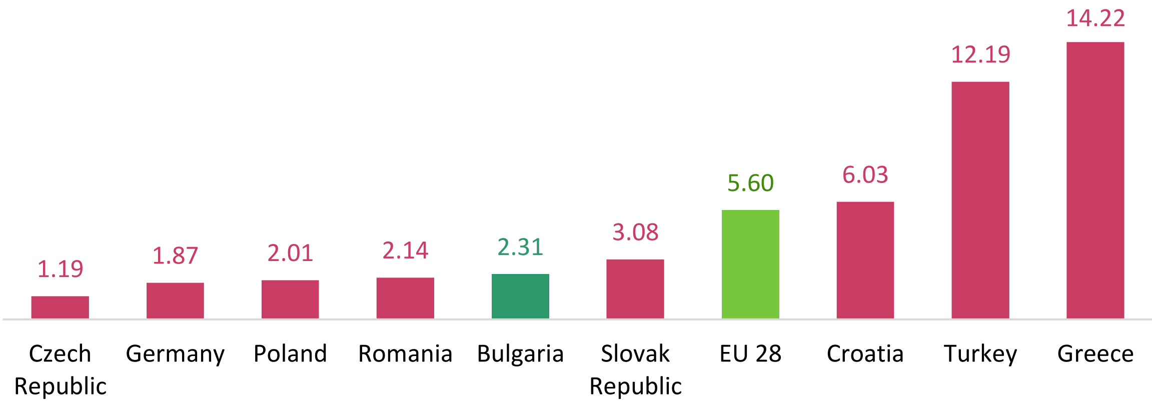
Source: European Centre for the Development of Vocational Training (2019)

Figure 60. The share of labor force with advanced degrees was lower than the EU average, 2018 (Percent of labor force)



Source: World Development Indicators

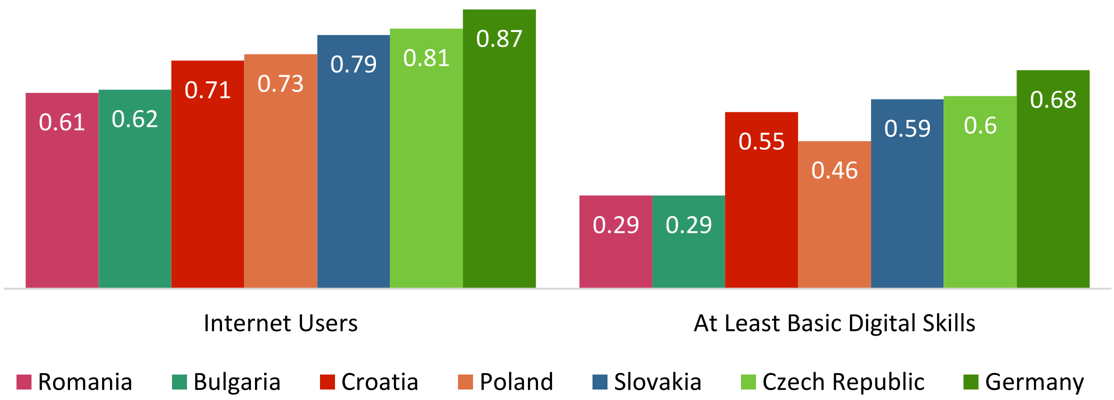
Figure 61. The unemployment rate for workers with advanced degrees was lower than the EU average, 2018



Source: World Development Indicators

The demand for skilled labor, particularly for the advanced digital skills required to develop and operate the new wave of Industry 4.0 and other digital technologies, will continue to rise, and it will be critical that Bulgaria's workforce be equipped with the skills to meet these changing needs. Bulgaria ranked last or near last in most of the Digital Economy and Society Index (DESI) indicators related to digital skills in 2019. This is true for basic internet usage and basic digital skills (Figure 62), as well as advanced skills, such as ICT specialists and STEM graduates (Figure 63).

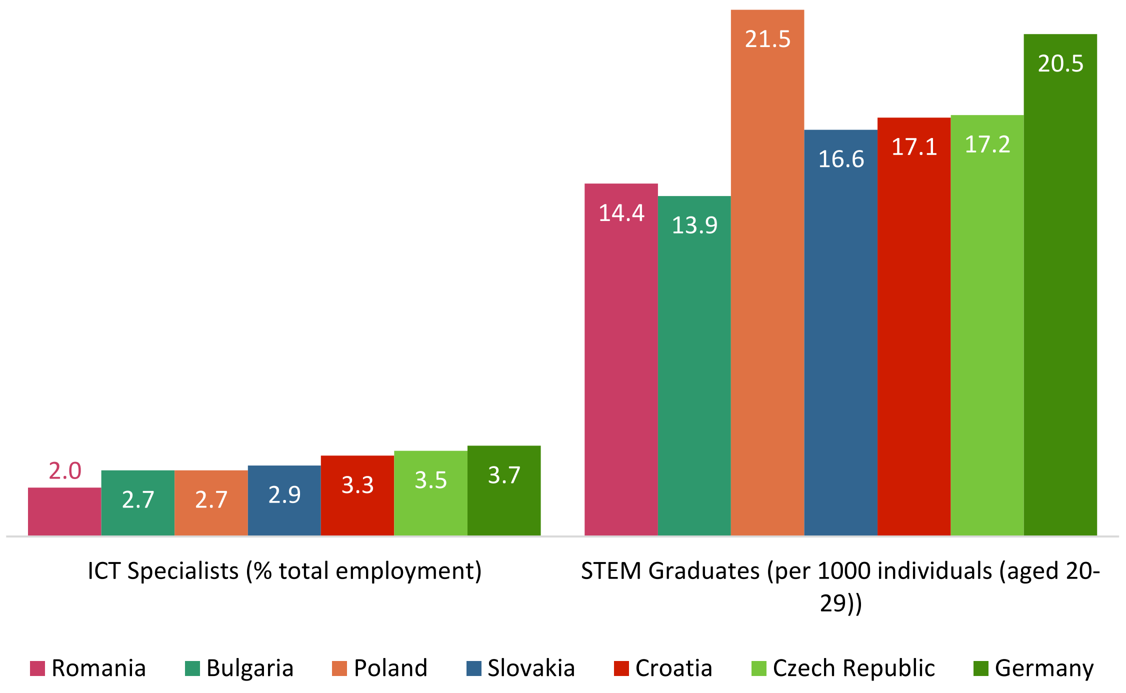
Figure 62. The share of the population that were internet users or had at least basic digital skills was low, 2018



Source: European Commission DESI (2018)

Note: Data for Croatia is from 2017

Figure 63. The share of workers who were ICT specialists and the number of STEM graduates were low, 2018



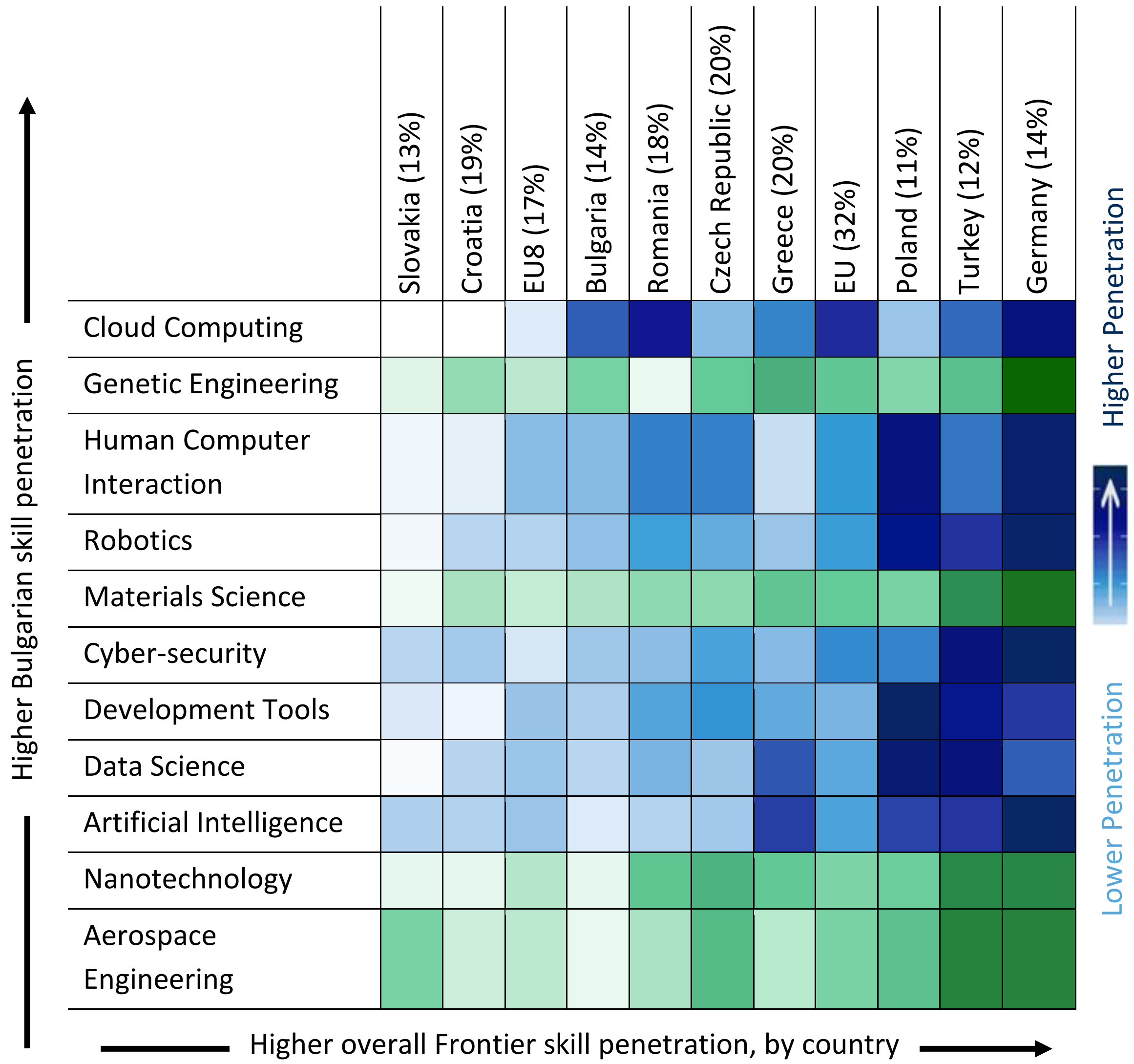
Source: European Commission DESI (2018)

A comparative analysis of the skills of Bulgaria's LinkedIn users[27] shows that, compared with regional peers, the Bulgarian workforce lacks a clear advantage in Industry 4.0 skills. Figure 64 compares skills between countries measured using "Relative Skill Penetration", defined as the sum of the penetration[28] of a given skill across occupations in a given country, divided by the average global penetration of the same skill across the same occupations. Cloud computing and human-computer interaction skills are areas of strength for Bulgaria, but Romania and other peers are doing as well or better in these areas. In more advanced skills such as AI, Bulgaria lags behind all peers. Similar results are seen for Data Science and Development Tools skills, suggesting that Bulgaria lags in key Industry 4.0 skills, and those areas in which it excels are exceeded by neighboring countries.

[27] LinkedIn members in Bulgaria are predominantly college educated and spread across 17 sectors and 705 unique occupations. Following global trends, the LinkedIn data in Bulgaria is skewed towards the highly-educated and highly-skilled labor segment, as well as those working primarily in knowledge sectors. Although not representative of the entire labor force, LinkedIn data provides skills supply insights of high-tech and knowledge-intensive occupations..

[28] The "raw" skill penetration is defined as the percentage of the top 50 individual skills that belong to a given skill group (i.e. if five of the top 50 *individual* skills for Data Scientists in Bulgaria fall into the Artificial Intelligence skill group, Artificial Intelligence reports a 10% penetration for Data Scientists in Bulgaria).

Figure 64. The penetration of frontier skills was low among Bulgarian LinkedIn users, 2015-2018

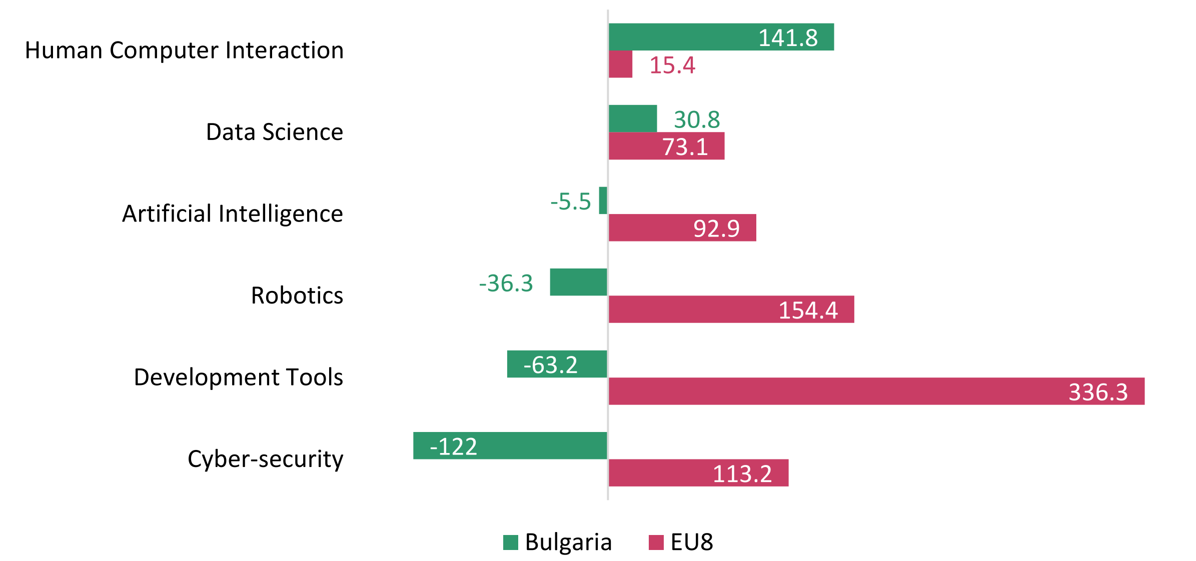


Source: "World Bank LinkedIn Digital Data for Development" by World Bank Group & LinkedIn Corporation, licensed under CC BY 3.0, 2015-2018.
Note 1: Percentage value in brackets behind each country in X Axis is LinkedIn membership penetration rate as a percentage of the working age population 15-64 years old (LinkedIn, World Bank WDI, 2017).
Note 2: Countries ordered left to right by overall penetration of Frontier Skills (e.g. Bulgaria ranks 8th out of the 11 comparator countries listed).
Note 3: Skills along the y-axis are ranked by Bulgaria's relative penetration, with skills decreasing in prevalence in Bulgaria from the top to the bottom.

EU8[29] countries are attracting Industry 4.0 talent, while Bulgaria shows mixed results in developing and attracting frontier digital skills. Considering the Industry 4.0 skills discussed above, only the Data Science and Human Computer Interaction fields are attracting, rather than losing, talent in Bulgaria (Figure 65). By comparison, EU8 countries are performing well in terms of net talent attraction of all Industry 4.0 skills. Skills in which LinkedIn data suggests Bulgaria is losing the most are cybersecurity skills, where for every 10,000 LinkedIn members in Bulgaria, over 100 people with cybersecurity skills are moving abroad. Development Tools and Robotics similarly report a net talent loss in 2018. On the other hand, EU8 countries report some of the highest talent inflow for the same set of skills. Where for every LinkedIn member with development tools that Bulgaria is losing, EU8 countries are gaining about seven skilled workers.

Figure 65. Bulgaria is losing Industry 4.0-related skills, 2015-2018

Net Change in LinkedIn Member with Skill (out of 10,000 members)



Source: "World Bank LinkedIn Digital Data for Development" by World Bank Group & LinkedIn Corporation, licensed under CC BY 3.0., 2015 -2018.
Note: Skill migration measures the net number of members with a given skill departing or arriving in a country. For example, in Bulgaria out of every 10k members with skills in Human Computer Interaction, approximately 150 are immigrating to Bulgaria, while for the EU8 average this value is under 50.

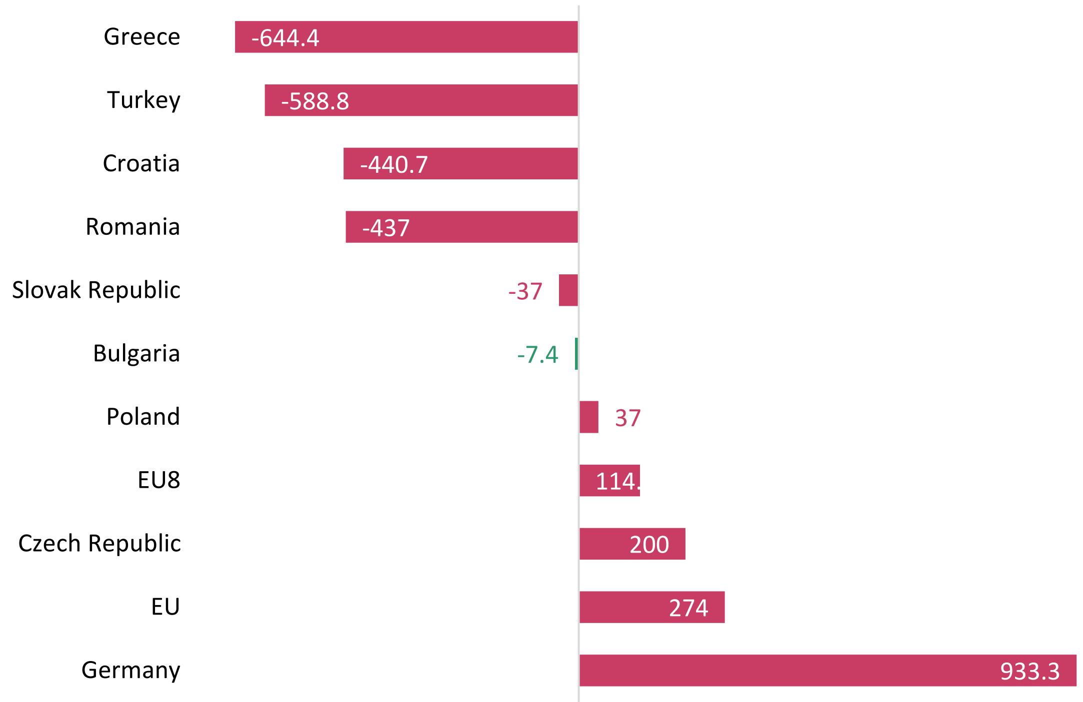
Considering Industry 4.0 skills as a whole, Bulgaria reports a net loss of skills to emigration, although the observed emigration is not as large as in some peer countries. Bulgaria reports only a small net loss of talent on average across Industry 4.0 skills, marginally outperforming

[29] EU8 refers to 8 of the 10 countries that joined the EU during the 2004 enlargement, including Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovak Republic and Slovenia.

Slovakia. On the other hand, Croatia and Romania report a rapid out migration of these skills. Across comparators, Germany attracts the most talent, increasing its already dominant position in skill penetration (Figure 66).

Figure 66. Bulgaria experienced a small net loss of frontier skills, 2015-2018

Net Change in LinkedIn Member with Skill (out of 10,000 members)

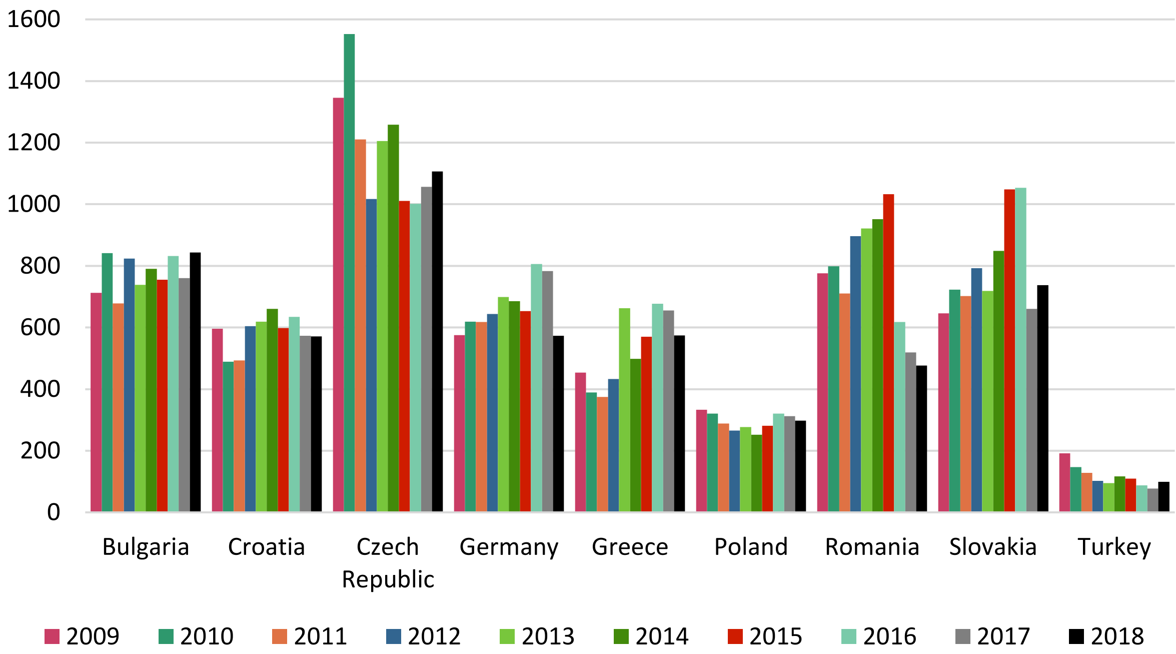


Source: "World Bank LinkedIn Digital Data for Development" by World Bank Group & LinkedIn Corporation, licensed under CC BY 3.0., 2015 -2018.
Note: Skill migration measures the net number of members with a given skill departing or arriving in a country. Industry 4.0 Skills: AI, Cyber Security, Data Science, Development Tools, Human Computer Interaction, and Robotics.

Data on management capabilities in Bulgaria are relatively scarce – particularly data which benchmark management skills in Bulgaria against regional peers. The adoption of international quality certifications can be used as a measure of management quality, which shows Bulgaria ranked second among its peers in terms of number of ISO 9001 certificates per capita in 2018 (Figure 67). The number of registered certificates has remained stable over the last ten years in Bulgaria. Evidence from the firm-level productivity analysis shows that in the manufacturing sector, the within component, which relates to firms' internal capabilities (such as adopting technologies or managerial practices), is driving the sector's aggregate productivity growth. This indicates that upgraded management practices may have contributed to the sector's productivity improvement.

In a 2018 survey of 444 managers in Bulgarian SMEs, 58 percent of managers believed them to improve their skills for developing a long-term strategy for business development, 51 percent believe they needed improvement in employee motivation and commitment, and 43 percent needed improvement in managing organizational change. Respondents' main resource for improving their management practices were business-related books (78 percent) and business websites (72 percent) (Kreston Bulmar, 2018).

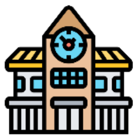
Figure 67. Bulgaria ranked second among peers in the number of ISO 9001 certificates per million inhabitants (2009-2018)



Source: ISO Survey (2018)

BULGARIAN STI POLICIES

STI institutions suffer from fragmentation and weak governance structures, which has resulted in a lack of a coordinated national vision that combines the R&I agenda with clear targets and defined responsibilities.



Lack of capacity of public and private research institutions and poor implementation of STI instruments resulted in significant delays in EU disbursements to support STI.

Funding of the STI policy mix is heavily weighted toward firm support, as opposed to support for public research activities.

The instrument mix is predominately made up of grants and matching grants, which may not always be the best mechanism for achieving impact, depending of the program objectives.

There are several gaps in the policy mix, including support for technology transfer, Industry 4.0 technology adoption, early-stage company support, improvements to the business environment and digital skills.

This section provides an overview of Bulgaria's key public STI organizations and strategies, and performs a descriptive analysis of the country's portfolio of STI instruments, detailing the instruments' objectives, mechanisms of intervention (e.g., grants, vouchers, advisory services, etc.), intended beneficiaries, and other characteristics. This section concludes with an analysis of the cohesion of the policy mix with the country needs (detailed in the previous section) to identify where specific needs have not been addressed, or insufficiently addressed, by STI instruments.

STI Institutions and Governance

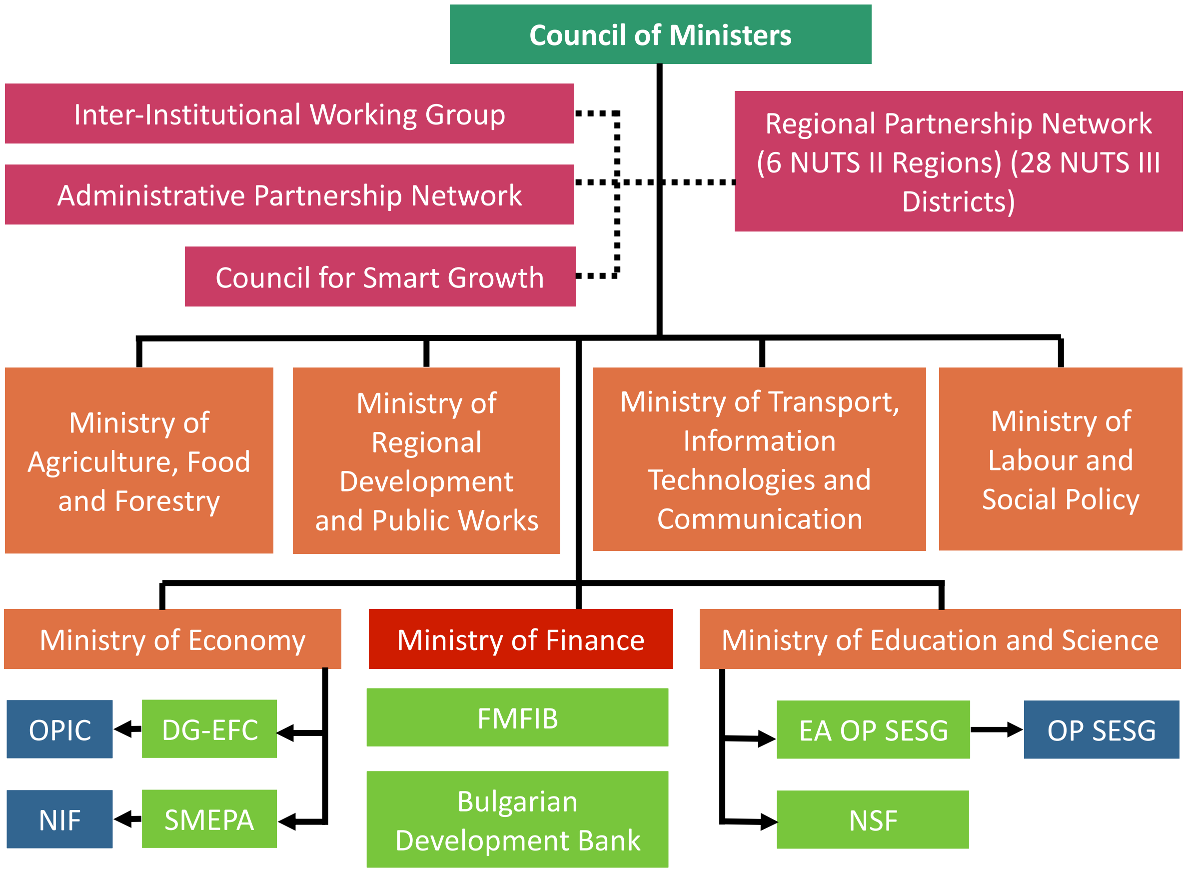
Bulgaria's STI institutions are largely disconnected from one another and suffer from weak governance, and as a result, STI support programs are fragmented, without linkages between them or appropriate governmental coordination. There is no overarching national vision for STI that the various R&I actors can work toward.

The central role in governing science, technology and innovation in Bulgaria is divided between the Ministry of Education and Science (MoES), which covers science and scientific research, and the Ministry of Economy (ME), responsible for technology development and innovation.

MoES functions as the regulator of the national education system and designs and carries out national science and scientific research policy. Within its Science Directorate, MoES hosts the National Contact Point for the EU framework programmes and Horizon 2020 and organizes the work of the National Council for Science and Innovation. MoES is responsible for the implementation of the National Roadmap for Research Infrastructures, an instrument for enhancing the development of public research organizations. MoES also manages the participation of national consortia in Pan-European research infrastructures. Prior to 2017, the MoES Structural Funds and International Educational Programmes Directorate served as a Managing Authority of the Operational Programme “Science and Education for Smart Growth” (OP SESG) for the current programming period, with dual funding from ESF and ERDF. After November 2017, a new Executive Agency became the OP SESG managing authority, following recommendations to improve the administrative and absorptive capacity in the field of science and education (see Appendix V for more details). MoES oversees the National Science Fund (NSF), which is the main national funding instrument for R&D of scientific and higher education organizations on a project- and program-basis in the priority scientific fields identified in the National Strategy for Scientific Research.

The Ministry of Economy (ME) develops, organizes, coordinates and controls the implementation of state policy for the economy and defines national innovation policy. It develops and participates in the implementation of the Innovation Strategy for Smart Specialization (IS3) 2014-2020 and for “Industry 4.0” strategies and programs. Within the ME, the European Funds for Competitiveness General Directorate is the Managing Authority of OP “Innovation and Competitiveness” (OP IC) and OP “SME Initiative 2014-2020” (SMEI) for the 2014-2020 programming period. A key administrative unit of ME is the Bulgarian SME Promotion Agency (SMEPA), an agency within ME that implements the state policy for promoting entrepreneurship and for development and internationalization of SMEs. SMEPA implements the National Innovation Fund (NIF), which provides national funding predominantly to private enterprises for applied research. The strategic goal of the National Innovation Fund is to increase the competitiveness of the Bulgarian economy through the encouragement of market-oriented applied research and to create an environment for private investments in innovation according to the Bulgarian IS3 priorities. In addition to administering NIF funds, BSMEPA also organizes and coordinates the participation of the Republic of Bulgaria in Eurostars – the joint program of the EUREKA initiative of the European Commission.

Figure 68. STI governance structure in Bulgaria



Source: Authors' illustration.

Apart from MoES and ME, other key government ministries responsible for STI governance in Bulgaria are as follows:

- The Ministry of Finance is responsible for financial oversight of structural fund programs through the National Fund Directorate, which acts as the certifying authority, and the Executive Agency for the Audit of European Union Funds, which acts as the audit authority.
- The Ministry of Agriculture, Food, and Forestry is responsible for the Agricultural Academy, the National Plant Protection Service, as well as the Food Safety Agency and the entities in the field of veterinary medicine. It is the managing authority of the "Rural Development" Programme through the Rural Development Directorate, and the "Maritime and Fisheries" Programme through the Fisheries and Aquaculture Executive Agency.
- The Ministry of Transport, Information Technology, and Communications is responsible for the Digital Agenda and e-government, especially through its new State eGovernment Agency. It is the managing authority of the OP "Transport and Transport Infrastructure".

- The Ministry of Regional Development and Public Works is the managing authority of the OP "Regions in Growth" and the Programmes for territorial cooperation 2014-2020 for which the MRDPW is the Managing Authority, the National Partner Body, or the National Contact Point.

A 2015 peer review of the Bulgarian STI system finds that there is little coordination between key Ministries, agencies, and research and innovation funds, and that the institutions that perform and support STI are fragmented without linkages between them or appropriate governmental coordination (Soete et al, 2015). There are coordinating bodies in place, but many of these bodies do not meet regularly or work at full capacity. The most important of the coordinating entities is the Council for Smart Growth (established by the Council of Ministers), which determines the smart specialization trends of the IS3 thematic areas, and the vision, strategic objectives, coordination and monitoring of the implementation of the strategy. Other coordination bodies include the Inter-Institutional Working Group, which coordinates work between ministries in the areas of policy and funding of science and innovation; the Administrative Partnership Network, a network of public sector experts that aims to address policy issues in support of innovation and science; and the Regional Partnership Network, comprised of regional representatives of the six economic regions of the country – this network has met only once in 2018. In response to these observed coordination issues, the Bulgarian government is planning the creation of a new R&I Agency, which, given a suitable mission, resources, and governance structure, may be able to serve as an STI coordination and implementation hub for STI policies and instruments (See Box 7).

Box 7. Bulgaria's envisioned R&I Agency

To address persistent STI coordination and implementation challenges, the Bulgarian government is planning on establishing a new (state) R&I Agency, which will consolidate the implementation of instruments related to research and innovation under one umbrella. Although the formal announcement about the establishment of the agency is expected in the coming few months, no clear information is currently available as of its mission, orientation, structure, budget, or governance.

For the new agency to deliver on the promise of improving the coordination and implementation of the STI policy mix, it can (i) leverage the findings from the STI policy mix included in this report, the upcoming functional analysis of the STI policy mix (Phase II of this project), and the findings of previous and current assessments by the EC; and (ii) build on the lessons learned from international experience in designing and running innovation agencies.

Box 7. Bulgaria's envisioned R&I Agency

A recent World Bank analysis of the experiences of 13 innovation agencies from different countries present seven building blocks as enablers for the success of innovation agencies including: a clear but adaptable mission; capable staff; effective governance and management structures; diagnostic-based interventions; robust monitoring and evaluation (M&E); sustainable funding; and strategic partnerships and networks (Aridi and Kapil, 2019). Building the analytical and operational capabilities of this envisioned organizations to deliver outcomes will become increasingly important if it is to be tasked with supporting the digital deployment and dissemination among Bulgarian firms.

The division of STI responsibilities between MoES, ME, and other key ministries has led to the development of a large number of strategies related to STI, many of which have overlapping agendas (Appendix VI). There is no obvious hierarchy among these strategies (i.e., no indication whether one strategy outweighs or governs another). In most cases, ministries provide comments on strategies developed by other ministries through working groups and other consultative bodies comprised of representatives of various institutions.

Monitoring and evaluation of the STI system has been identified as an area of concern by several reviews of the Bulgarian research and innovation frameworks (Soete et al, 2015; World Bank, 2013). At the strategic level, Bulgarian national strategies generally have extensive analytical sections and provide at least some detail on the implementation of the strategy (action plans, tasks, and indicators), but lack plans for monitoring and evaluation of implementation. NSF, in particular, has been singled out for a lack of an adequate framework for monitoring and evaluation (World Bank, 2013). At the project level, the 2015 peer review of the Bulgarian STI system found a need to bring project evaluation practices up to international standards (Soete et al, 2015). Research and innovation institutions generally lack clear objectives and targets, and thus are often uncertain on which areas to focus their activities and resources.

Public Research Organizations

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.

There are 91 public research organizations in Bulgaria, including 56 operating under the umbrella of the Bulgarian Academy of Sciences (BAS), 25 under the Agricultural Academy, as well as three military research centres, three national medical centers under the responsibility of respective ministries, and four university hospitals.

Bulgarian Academy of Sciences

BAS is the primary Bulgarian research organization. It is a public-funded autonomous body composed of 566 independent institutes, with 36 institutes in STEM fields. Apart from the Central Laboratory of Applied Physics in Plovdiv and the Institute of Oceanology in Varna, all of the institutes are located in Sofia.

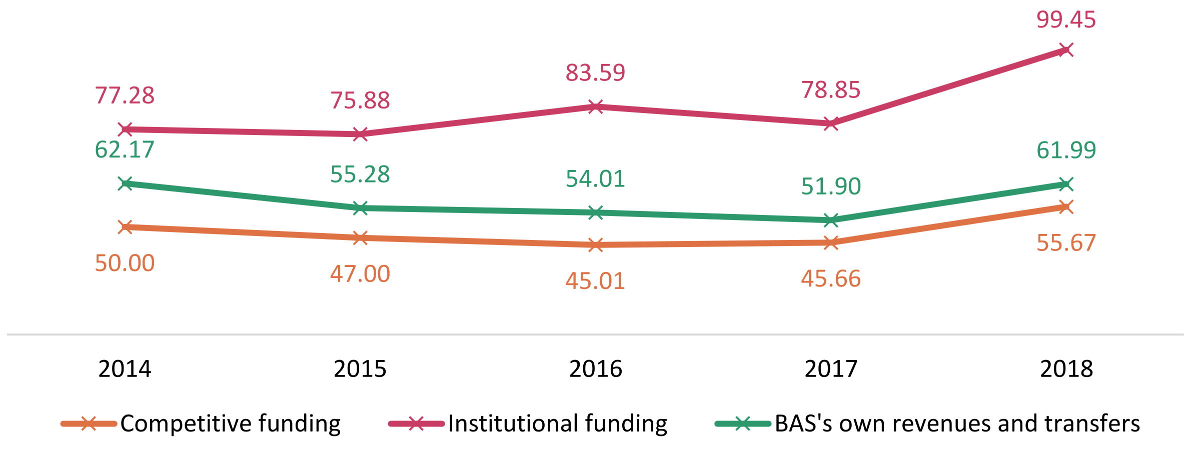
BAS was established by the statute of the Bulgarian Academy of Sciences, which specifies the Academy's structure and management, the conditions for creating, transforming and closing down the academic institutes and the other independent research entities, and other issues related to BAS activities. However, the institutes under BAS do not have uniform legal statuses. BAS Headquarters is registered under the BAS Act, granting it 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. However, several BAS institutes were created through consolidation of several separate units by the decision of the General Assembly of BAS and are not recognized by MoES as public research organizations, creating problems related to funding, eligibility for research programs, and reporting. These differences in legal status can impact the real or perceived autonomy of PROs; in the recent World Bank Survey of Bulgarian Public Researchers and Research Organizations, 69 percent of respondents felt their organizations were only partially autonomous in setting institutional policies and 46 percent felt their organizations were partially autonomous in setting research objectives.

Direct institutional funding is the main source of income for BAS, and the share of subsidies in BAS total funding has increased in recent years, making up over 45 percent of funding in 2018. This block funding has three components:

- Block grants, which make up 90 percent of direct funding and covers the remuneration for the administrative and academic staff;
- Performance-based funding, which is only a small portion of direct funding and is allocated based on reported institutional scientometric impacts, commercialization revenues, number of PhD students, and project funds raised; and
- Funds for overhead and facility maintenance.

Revenues from BAS activities (consultancies, contract research, commercialization, etc.) were the second largest funding source in 2018, with over 28 percent of all funding received. Competitive funding, in the form of project-based financing (from national, European, and other international programs), was the smallest source of funds in 2018, making up about 25 percent of funding received. Competitive funding has decreased as a share of total funding since 2015 (Figure 69).

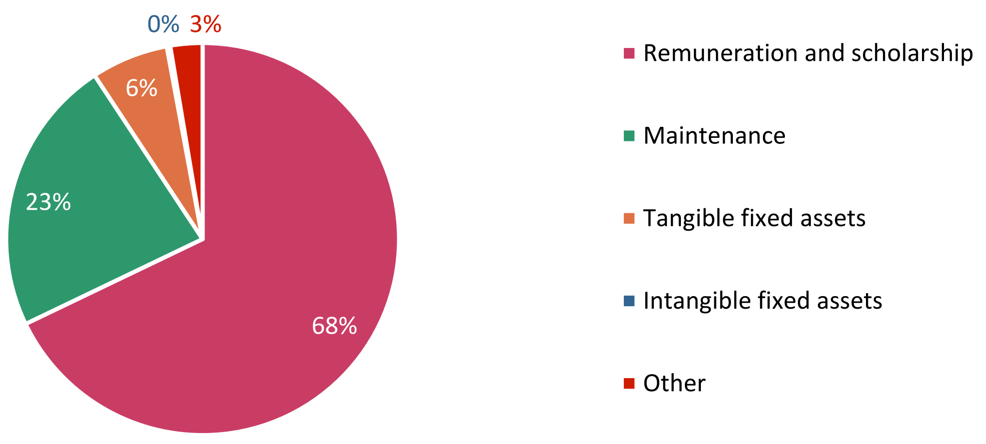
Figure 69. Direct institutional funding was the largest source of finance for the BAS, millions of BGN, 2014-2018



Source: BAS annual reports

The primary expenditures for BAS were staff salaries and scholarships, comprising nearly 70 percent of expenses in 2018. Facility and equipment maintenance (23 percent) and tangible assets (6 percent) were the other major expenses in 2018 (Figure 70).

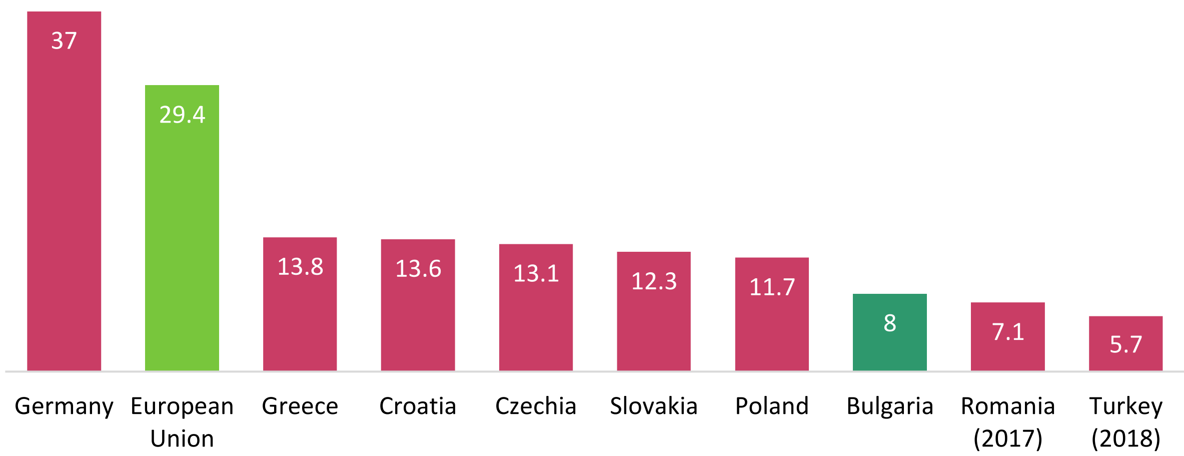
Figure 70. Most of BAS expenditures were devoted to staff salaries and scholarships, 2018



Source: BAS annual budget (2018)

Public researchers (at BAS, other PROs, and HEIs), receive very low average salaries relative to their CEE peers (Figure 71). In the 2017 Survey on Researchers in European Higher Education Institutions, Bulgarian public researchers at all career stages expressed dissatisfaction with their renumeration, sentiments shared by researchers in many CEE peer countries (Janger et al, 2017). A 2015 peer review of the Bulgarian research system finds that, while Bulgarian institutions have a very 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 funding for salaries gives the universities/BAS no ability to use their discretion to attract researchers and reward excellence (Soete et al, 2015). These low salaries deter young Bulgarians from entering into the public research sector and likely contribute to the ongoing brain drain of research talent.

Figure 71. Public research salaries were low in Bulgaria, 2019 (Average hourly wage, Euros)



Source: Eurostat

Soute et al. (2015) also note that low salaries can result in behavior with adverse effects on research. Currently, research grants from the NSF are legally permitted to be used to supplement the salaries of those working on the research. This practice can have unintended consequences and is open to misuse, in which research funding is sought primarily to augment salary rather than to carry out the grant's intended research objectives.

Agriculture Academy

The Bulgarian 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 scientific institutes; 4 research centres; and 13 experimental stations.

The management structure of AA consists of a Board of Directors and an Executive Bureau (Chairman, Vice-Chairman and Chief Scientific Secretary). The Board of Directors adopts the Strategy for basic and applied research and innovation in the field of the agricultural sector; adopts the annual plan and the annual reports on the activity of the Academy; approves the annual budget of the Academy and the report on its implementation; approves the distribution of the budget of the Academy to its structural units; determines the rules for the realization of products and IP rights of the Academy; and adopts rules for attestation of the academic staff.

Funding for AA, in the form of revenues, grants and donations amounted to approximately €6 million in 2018, with the main share (88.7 percent) which coming for the sale of services and products. The expenditures for 2018 amounted to €15.7 million, split between personnel costs (66.5 percent of expenditures), maintenance costs (32.8 percent), and capital expenditures (0.7 percent).

Higher Education System

Bulgaria's higher education system is comprised of 51 HEI institutions, of which 14 are private and 37 are public institutions. Of these 51 institutions, 37 have STEM-related programs and degrees and 12 have university research centers (Table 5).

Table 5. Universities, universities with STEM programs and STI University centers

	Higher education institution	Universities with STEM programs	STI University centers
Number of private entities	14	6	
Number of public entities	37	31	12
Total	**51**	**37**	**12**

Source: Orbis

MoES is responsible for implementing the national policies in the area of higher learning. Apart from MoES, the system of higher education includes the following coordination bodies:

- The National Assembly makes the final decision about establishment, transformation and closing of higher education institutions, as well as branches and departments where there are provisions for study programs of the regulated professions.
- The National Evaluation and Accreditation Agency (NEAA) is the national statutory body for evaluation and accreditation in higher education.

HEIs receive block funding for research activities amounting to approximately ten percent of their budget for education, which are administered by individual universities' R&D Sectors (internal administrative units that support the implementation of research projects and manage the allocation of state funding for R&D activities). This block funding is internally allocated on a competitive basis to university research staff following the individual HEIs' procedures for research project funding. State funds can also be used for activities that support R&D, such as the publication of R&D results. There is no performance-based funding scheme for HEIs. Universities can also receive funding for research through contract research, donations, and other sources.

There were 9,765 researchers working in the higher education sector in 2019, with the sector making up 31 percent of all researchers in Bulgaria. As noted in the discussion of the Academy of Sciences, public researchers at HEIs receive very low salaries, which acts as a deterrent for young researchers to join the public workforce and contributes to Bulgaria's brain drain.

Despite the large number of researchers working in HEIs, overall, universities contribute very little to research and innovation, performing only six percent of the Bulgaria's overall R&D, far less than in any of the peer countries (see Figure 29 in the Innovation Inputs section of this report). Outside of a few high-performing universities in the capital region, HEIs produce few academic publications of impact and commercialization outputs from universities, such as licenses and startups, are almost nonexistent. Universities are also largely disconnected from other national research and innovation institutions.

Box 8. Public Innovation Support Institutions

In the past several years, the Bulgarian government has developed several new public institutions that aim to improve the national innovation system by supporting innovation, entrepreneurship, and technology transfer to the private sector:

Sofia Tech Park (STP)

Sofia Tech Park, 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. STPSTP consists of several separate units, including a business incubator, laboratories, and exhibition spaces. Partners include several local universities, business clusters, large international companies, the local government, and several key ministries.

Box 8. Public Innovation Support Institutions

A 2018 evaluation of STP finds that, while the park has many of the components of a successful technology park (state of the art facilities, competent laboratory managers, etc.), STP is hindered by ambiguity in its mission, objectives, and governance; the lack of a sustainable business model; and a lack of clear commitment to the project by its main stakeholders – particularly those from the national government.

Centres of Excellence and Centres of Competence

The establishment of four Centres of Excellence and nine Centres of Competence is a key component of the current Operational Programme Science and Education for Smart Growth (OP SESG). At the present, 16 contracts (ten for CoCs, four for CoEs, and two additional CoEs co- funded by Horizon 2020) with a total budget of more than €200 million are under implementation. These Centres are intended to bring together the efforts of more than 60 research organizations, including the BAS, national universities, and other key scientific and business organizations. The objective of these Centres is to build research capacity, form partnerships and linkages between research actors, and raise the level and market orientation of the research activities of participating research organizations.

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. Centre designs also did not take into consideration the implementation and management capacity of the organizations tasked with those efforts, which has further contributed to implementation delays. Finally, the initiative is yet to define a clear monitoring and evaluation framework that sets clear objectives and tracks relevant key performance indicators. 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.

Characteristics of the STI Policy Mix

The STI portfolio mapping exercise provides the basis for evaluating the coherence between identified STI policy needs (as described in the Country Needs Assessment section) and the makeup of Bulgaria's portfolio of support instruments. This mapping includes all STI instruments that were operational during the 2014 to 2020 period and that were managed at the national level (national instruments with a regional focus also are included). By looking at the full portfolio of STI instruments (and their stated goals, beneficiaries, and allocated and disbursed funding), this exercise analyzes what the Bulgarian government *intends* to do in its support for research and innovation in the current programming period. The exercise does not include analysis of the *actual* activities and beneficiaries of these instruments. For example, an instrument may have been designed to target small, medium, and large firms, but in practice only provides support to large firms. The second phase of this project, the Governance and Functional Analysis of STI Instruments[30], will include an analysis of the actual beneficiaries (where data are available) of a subset of the instruments analyzed in this report.

Based on the following criteria for including STI support instruments, a total of 118 instruments are mapped:

- Instruments that support research, development, and/or business innovation and use public budget (i.e. from government or international development agencies);
- Instruments that support research, development, and/or business innovation through public inputs (e.g., provision of access to information services);
- Instruments that support creation and survival of new ventures and entrepreneurship (e.g., supporting potential entrepreneurs via incubators/accelerators, social entrepreneurship).

The full list of covered programs, as well as caveats to the analysis, is provided in Appendix I. This portfolio mapping framework was constructed based on previous World Bank PERs conducted in Poland, Brazil, Colombia, Czech Republic, and Croatia, but was tailored to fit the Bulgarian context and capture issues that are relevant to the country, while still maintaining core elements that would allow for cross-country comparison.

The instrument policy mix was assembled and analyzed in a matrix containing detailed information about each STI support instrument included in the scope of the analysis. A total of 169 variables were collected per instrument along 23 categories for each instrument. Data were sourced from program documentation available online, followed by verification with agencies' and ministries' points of contact to ensure data quality. Note that many of the variables in the table above are not mutually exclusive; instruments can target multiple economic/societal outcomes, beneficiaries, etc.

[30] The *Functional and Governance Analysis* component of this World Bank project is an in-depth assessment of the design, implementation, and governance of instruments and institutions in the Bulgarian STI portfolio. It consists of extensive field work and data collection through semi-structured interviews with program managers. It complements the work done in this report by looking at the mapped instruments across and within key implementing institutions and will provide a detailed assessment of gaps, weaknesses, and bottlenecks in the design, implementation, and governance of public support for innovation.

The total budget allocated to STI instruments from 2014 to 2019 was €1.6 billion[31]. The key implementors of the STI policy mix, in terms of allocated funding, are the Ministry of Economy and the Executive Agency for OP Science and Education for Smart Growth, which implement programs that account for 85 percent of allocated funding (Table 6). The Ministry of Education and Science; National Science Fund; Ministry of Agriculture, Food and Fisheries; and Bulgarian Small and Medium Enterprises Promotion Agency (SMEPA) also play significant roles in administering STI instruments.

Table 6. Implementing Ministries/Agencies by Allocated Budget, 2014-2019

Implementor	Allocated Budget	Share of Budget
Ministry of Economy	€ 1,078,341,602	70.4%
Executive Agency "Operational Programme Science and Education for Smart Growth"	€ 219,987,308	14.4%
Ministry of Education and Science	€ 111,151,520	7.3%
Bulgarian National Science Fund	€ 68,084,240	4.4%
Ministry of Agriculture, Food and Fisheries	€ 39,069,687	2.5%
SMEPA	€ 29,043,424	1.9%
Ministry of Labour and Social Policy + Ministry of Economy (co-implementors)	€ 11,299,440	0.7%
Ministry of Labor and Social Policy	€ 9,985,817	0.7%
FoF, FMFIB EAD	€ 6,247,923	0.4%
ARC Consulting	€ 5,613,527	0.4%
Bulgarian Investment Agency	€ 5,000,000	0.3%
Ministry of Tourism	€ 4,935,684	0.3%
Fulbright Bulgaria	€ 4,063,666	0.3%
Consumer Protection Commission	€ 3,000,000	0.2%
Agency for Sustainable Energy Development	€ 2,983,881	0.2%
Bulgarian Institute of Metrology	€ 2,045,168	0.1%

[31] Where no data for allocated budget was available for a program, the team assumed that the allocated budget was equal to the disbursed budget of the program in a given year. The STI matrix does not include information on the financial support provided by the Bulgarian Development Bank and European Bank for Reconstruction and Development due to the lack of publicly available data and difficulties in communication with their representatives arising from the COVID 19 pandemic. The STI matrix does not include instruments provided directly by European and international sources where national authorities are not involved at any stage of projects assessment, administering, monitoring or evaluation.

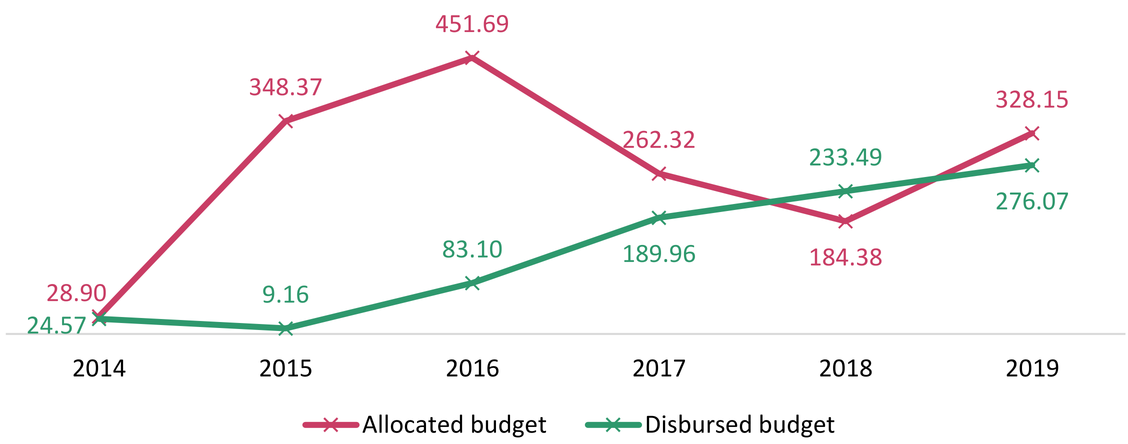
Implementor	Allocated Budget	Share of Budget
Executive Agency "Bulgarian Accreditation Service"	€ 1,938,699	0.1%
State Agency for Metrological and Technical Supervision	€ 1,022,584	0.1%
Bulgarian Patent Office	€ -	0.0%

Source: Authors' calculation

EU Operational Programmes represent the majority of allocated funding for STI in Bulgaria, with the OP IC alone accounting for 67 percent of the allocated budget (Table 20). Only 19 percent of allocated funds were not part of an Operational Programme.

Disbursed funding amounts are much lower than allocated funding over the study period due to a significant lag in disbursement (Figure 72). This dramatic lag in funding disbursement indicates issues in the implementation of STI instruments and challenges in absorbing STI funding on the part of the Bulgarian public and private sectors.

Figure 72. Disbursements of EU funds were much smaller than allocations, 2014-2019 (Millions of Euros)



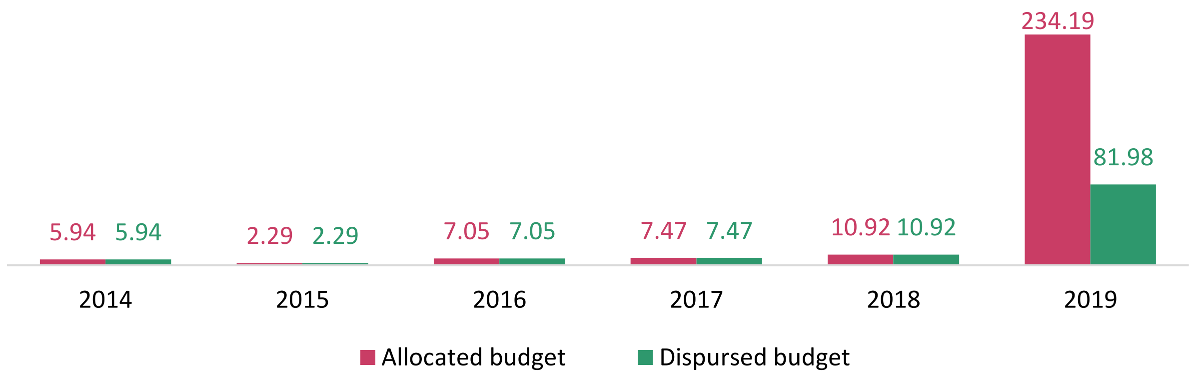
Source: Authors' calculation

Looking specifically at instruments under the Ministry of Education and Science (those from the OP SESG and the National Science Fund), the instruments had very low levels of allocated and disbursed funding (between €5-11 million per year) from 2014 to 2018 before a major increase in allocation and disbursement in 2019 (Figure 73). Much of the funding increase is due to the initial allocation and disbursement of funds for two major instruments under the

OP Science and Education in 2019: the Centres of Excellence and Centres of Competence, which combined totaled €189 million in allocated funding and €67 million in disbursed funding in 2019 (see Box 8 for a description of the challenges related to the implementation of these key instruments).

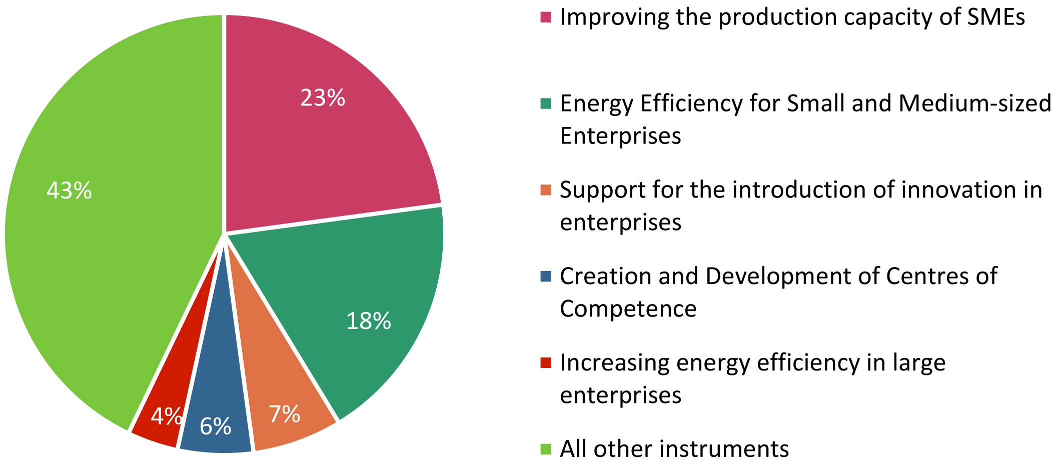
Of the funding that was disbursed from 2014-2019, 66 percent came from the EU, while about 34 percent came from the national government.

Figure 73. Until 2019, disbursements from OP Science and Education and National Science Fund Instruments were low, 2014-19 (Allocated and Disbursed Funding, 2014-2019, Millions of Euros)



Source: Authors' calculation

Figure 74. A small number of instruments account for a large share of total disbursements for STI instruments



Source: Authors' calculation

Looking at disbursed funding, the STI policy mix is dominated by a small number of instruments that account for a large share of the total funding disbursed (Figure 74). The top two instruments by funding ("Improving the production capacity of SMEs" and "Energy Efficiency for SMEs") accounted for 41 percent of all funding disbursed, and the top five instruments by funding accounted for 58 percent of all funding disbursed (Figure 74). All of the five largest instruments, except the "Creation and Development of Centres of Competence", target innovation and/or technology upgrading in the private sector.

An analysis of the instrument mix revealed the following (the complete descriptive analysis of the Policy Mix is provided in Appendix I):

- Instruments are relatively evenly spread across the economic/societal outcomes of productivity growth, economic diversification, knowledge creation, human capital, and/or environmental outcomes, with the smallest amount devoted to societal inclusion. But in terms of disbursed funding, instruments targeting environment and productivity growth objectives accounted for over €600 million, while no other outcomes received more than €400 million in disbursed funding. Skills formation, research excellence, and environment are the intermediate objectives targeted by over 30 percent of instruments, but environment is the leading objective in terms of disbursed funding.
- Research and commercialization activities (including research services, technology transfer, testing, certification and standards, and product development) are the leading activities supported by STI instruments by both share of instruments and by disbursed funding.
- Grants and matching grants are by far the most common type of instrument both by share of instruments and by disbursed funding. Regulatory instruments, research infrastructure, tax incentives, and public goods and platforms (such as websites and registries) are used by between 10-20 percent of instruments. Note that, by their nature, tax incentive instruments had no funding disbursed and this report did not attempt to calculate the tax benefits of such instruments. Formal firms are the largest recipients of disbursed funding, although universities, research institutes, private research entities, and researchers were targeted by a large share of instruments. Firms in the scale-up and mature stages of development were targeted by the largest number of instruments and received the bulk of funding, as opposed to firms in the start-up or idea/concept stage.
- The number of instruments and disbursements were roughly equally distributed across micro, small, and medium sized firms, with a much smaller share devoted to large firms.
- Eighty-one percent of instruments and 40 percent of disbursed funding had no sectoral focus, followed by a smart specialization focus and manufacturing.
- Eighty-four percent of instruments and 99 percent of funding had a national, rather than a regional or city, focus.

Cluster Analysis

In addition to the above descriptive analysis of the policy mix, a cluster analysis[32] was also conducted to assesses the similarity of instruments across three categories of variables: objectives, mechanism of support, and direct beneficiaries. The aim of the cluster analysis is to identify redundancies and overlaps in the policy mix across instruments and support institutions.

The cluster analysis revealed seven instrument clusters:

- Cluster 1 (R&D support): This is a large cluster consisting of 23 instruments primarily aiming to achieve research excellence, develop the national research infrastructure, and develop skills in universities and research instituted through grants or through grants and funding support for research infrastructure. These instruments were administered by the Executive Agency "OP Science and Education for Smart Growth", National Science Fund, or MoES. All of the instruments under the OP Science and Education for Smart Growth 2014-2020 are housed within this cluster.
- Cluster 2 (environment plus additional objectives): This cluster includes 11 instruments with environmental objectives, as well as one of three other objectives (research excellence, management practices, or non-R&D innovation), which are supported through grants to universities or to formal firms. These instruments are administered by the National Science Fund, MoES, ME, or Ministry of Labor and Social Policy. About 60 percent of the instruments under the OP Innovation and Competitiveness 2014-2020 are housed within this cluster.
- Cluster 3 (skills formation): Four instruments supporting young researchers through awards, fellowships, and grants that are administered by MoES.
- Cluster 4 (market access and non-R&D innovation): A cluster of 10 instruments targeting formal firms, consortia, and business support institutions to support market access and non-R&D innovation. These instruments are administered by the Bulgarian SME Promotion Agency (SMEPA) and ME. About 40 percent of the instruments under the OP Innovation and Competitiveness 2014-2020 are housed within this cluster.
- Cluster 5 (capabilities of formal firms): This cluster includes three instruments that support a mix of objectives related to firm capabilities (management practices, skills formation, access to finance) in formal firms through loans and business advisory services. The instruments are administered by ARC Consulting and the DG for European Funds and International Programmes and Projects.

[32] The cluster analysis was conducted using a Jaccard similarity coefficient to compare overlaps in intermediate objectives, mechanisms of intervention, and direct beneficiaries among instruments and then to group the instruments into clusters based on these similarities. This analysis was conducted on a subset of the policy mix: instruments with a regional focus and direct funding to national agencies under operational programs were not included in the analysis.

- Cluster 6 (business environment): This large cluster of 17 instruments is a mix of tax incentives and other regulatory instruments aiming to improve the business environment and a mix of other objectives. The instruments are primarily administered by the Ministry of Finance.

Table 7. Policy mix clusters

Cluster	Implementor(s)	Objective(s)	Type(s) of Instruments	Beneficiary(s)
1. R&D Support (23 instruments)	Executive Agency "OP Science & Education", National Science Fund, and Ministry of Education & Science	Research excellence, plus research infrastructure and/or skills	Grants and matching grants, research infrastructure support	Universities and research institutes
2. Environment plus additional objectives (11 instruments)	National Science Fund, Ministry of Education and Science, Ministry of Economy, and Ministry of Labor & Social Policy	Environmental, and one of three other objectives (research excellence, management practices, or non-R&D innovation)	Grants and matching grants	Universities and formal firms
3. Skills Formation (4 instruments)	Ministry of Education and Science	Skills	Grants, awards, and fellowships	Researchers
4. Market Access and Non-R&D Innovation (10 instruments)	SMEPA and Ministry of Economy	Market access and non-R&D innovation	Grants and matching grants	Formal firms, consortia, and business support institutions
5. Firm Capabilities (3 instruments)	ARC Consulting and DG European Funds and International Programmes and Projects	Management practices, skills formation, or access to finance	Loans and business advisory services	Formal firms

Cluster	Implementor(s)	Objective(s)	Type(s) of Instruments	Beneficiary(s)
6. Business Environment (17 instruments)	Ministry of Finance	Improvements to the business environment	Regulatory instruments and tax incentives	Formal firms

Source: Author elaboration

This analysis shows that, on the whole, there is little overlap between administering agencies in terms of objectives, and therefore there appear to be few redundancies due to duplicative efforts. Key implementors, such as the OP SESG Executive Agency, MoES, ME, SMEPA, and NSF appear to have fairly distinct areas of focus in their instruments, which likely has contributed to the lack of duplication.

Within the clusters, there are a few areas of overlap between agencies that could be consolidated under a single implementor to improve coordination: In the R&D cluster, the Ministry of Education and Science and National Science Fund implement instruments with similar objectives and targets; similarly, in the market access and non-R&D innovation cluster, SMEPA and the Ministry of Economy implement instruments with similar characteristics

Coherence of the STI Policy Mix to the Country Needs

By comparing the key findings of the country needs assessment with the analysis of the STI Policy Mix, the coherence of the STI policy mix can be assessed by identifying where specific country needs have not been addressed or insufficiently addressed by STI instruments.

Public-sector Research Agenda

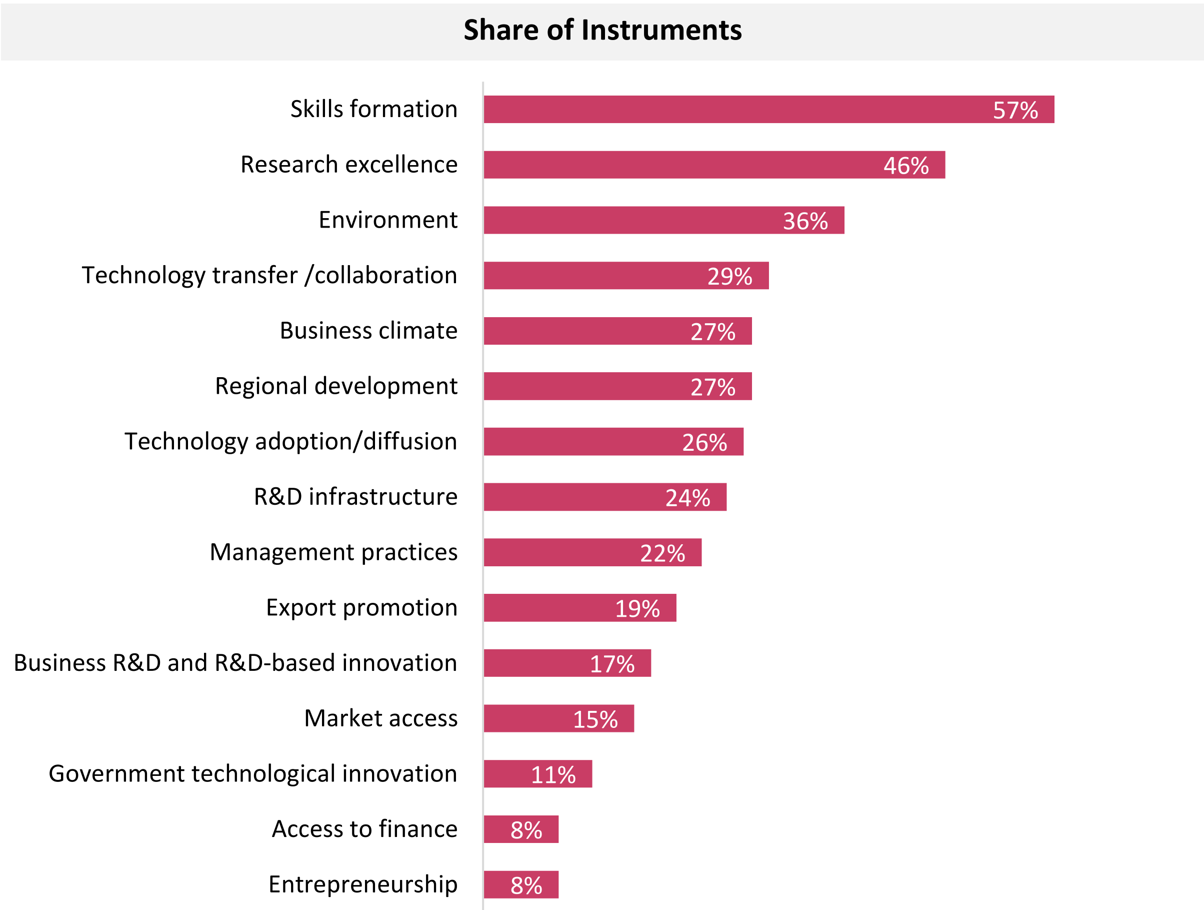
Research Excellence and Relevance

The country needs assessment found that the public research sector is relatively poor performing, generating few impactful publications or patents and almost no commercialization outputs to the private sector. However, when looking at the policy mix, there is a relatively large share of the STI portfolio (46 percent of instruments that disbursed €275 million) that aims to improve research excellence of the public sector (see Figure 75). Rather than a lack of targeting, key challenges to improving public research sector performance appear to be related to governance and implementation of the STI agenda (as described in the STI Institutions and Governance section). The second phase of this project, the Functional and Governance Analysis, will delve in depth into these implementation and governance issues for a subset of the STI instruments.

Technology Transfer Policies and Resources

The lack of research commercialization outputs from the public sector is due, at least in part, to a lack of clear legislation governing who owns IP generated by public research institutions, insufficient incentives for public researchers to commercialize their work, and a lack of resources for IP protection and commercialization in public institutions. There are a number of instruments (34) related to research excellence where technology transfer is a secondary objective (see Figure 75), but only one where technology transfer is the primary objective[33]. There are currently no instruments that directly support HEI/PRO tech transfer activities or provide funding for IP protection and commercialization.

Figure 75. Instruments by intermediate objective and disbursed funding, 2014-19



[33] "Patent Board of Bulgaria Reduction of Service Charges", under which inventors, SMEs, and public research and educational organizations pay 50% of the application fees for inventions disclosure, patents and utility models.

Figure 75. Instruments by intermediate objective and disbursed funding, 2014-19

Millions of Euros

Source: Authors' calculation

Private Sector Agenda

Technology Upgrading and Digitization in Firms

Much of the productivity gains in the manufacturing sector in recent years appear to be due, at least in part, to improving firms' internal capabilities through technology upgrading and managerial capabilities, as evidenced by productivity growth of the within component (productivity growth of existing firms) since 2014. Given that Bulgaria's manufacturing sector still lags behind most peers in technology adoption and firm digitization, it is clear the country has not exhausted the potential productivity gains to be made from additional upgrading and digitization. Managerial capabilities play a role firms' abilities to adopt new technologies, but there is scant evidence available on the strength of managerial skills in Bulgarian firms. Technology adoption and diffusion is a strong area of emphasis of the policy mix, both in the share of instruments (26 percent) and disbursed funding (€346 million), as is managerial capabilities (targeted by 22 percent of instruments for €275 million in disbursed funding) (see Figure 75). However, it is unclear how focused these instruments are on I4.0 technologies and digital adoption. Beyond a pilot voucher scheme supporting SME digitization being implemented by SMEPA, no instruments specifically support I4.0 technology development or adoption.

Business R&D

The Bulgarian service and construction sectors show a lower productivity performance of the within component (productivity growth of existing firms), emphasizing the need for policies to motivate R&D and innovation in this segment of the economy. A small share of instruments (17 percent) support business R&D (see Figure 75), though only seven of these instruments provide direct funding for R&D (totaling €47 million). The rest of the instruments provide indirect support though tax incentives, access to research infrastructure, or advisory services.

Support for Knowledge-based Startups and Entrepreneurs

Bulgaria produces a relatively large number of startups, but few that are knowledge-based or that develop new products or services. Firm-level productivity analysis shows that young firms are much less productive than established firms in the manufacturing, construction, and services sectors, even after five years of operation. Despite these challenges, there are few instruments that support entrepreneurship (4 instruments for €20 million in disbursed funding), specifically target early-stage companies (10 instruments for €34 million), or support important early-stage intermediaries, such as incubators and accelerators (1 instrument for €3 million).

Framework Conditions

Business Environment

Bulgaria lags behind its peers in the development of a conducive business environment and a competitive market. Evidence from firm-level productivity analysis shows that barriers to resource reallocation prevent more productive firms from growing and that barriers to firm entry and exit drag down productivity growth. The Ministry of Economy operates a number of regulatory instruments and tax incentives that aim to incentivize R&D, but only a single instrument specifically aimed at improving the business environment[34].

[34] "Improving business regulatory environment" under the SME Act of the MoF, which includes measures for the development, internationalization, and capacity building of SMEs by ensuring a favorable business environment and innovation infrastructure

Digital Skills Development

The demand for advanced skills is projected to increase over the next decade, while Bulgaria ranks last in the EU in both basic and advanced digital skills and is losing important digital and Industry 4.0-related skills through emigration. Instruments with a skills component account for 23 percent of disbursed funding (see Figure 75), but these instruments are primarily focused on other objectives, such as research excellence or non-R&D innovation in firms, with skills as a secondary objective. Many of these instruments provide little or no actual support for skills development - for example, many of the basic research projects in the policy mix list "skills" as an objective, but do not provide resources for skills development; it is simply assumed that researchers and post doctorates will gain skills while undertaking the research.

Note that if an identified need is targeted by a large number of instruments, this does not mean that this need is being adequately addressed. Instruments tend to list a number of secondary objectives but may not include interventions that achieve these objectives. Further, even if an identified need is being directly addressed by a number of instruments, the fact that it remains an area of need could indicate a problem with the functionality and effectiveness of the instruments that target it. This specific issue related to the policy mix functionality and effectiveness will be further investigated in the second and third phases of this PER STI project.

RECOMMENDED AREAS FOR POLICY ACTION

This section details three key areas for improvement to Bulgaria's STI policy mix and to framework conditions: i) the coherence of the STI policy mix; ii) the governance and performance of the research system; and iii) support for innovation and technology adoption in firms (Table 8).

Table 8. Areas for recommended action, responsible stakeholders, prioritization, and type of reforms

Recommendation	Timeline	Type of reform	Stakeholder(s)
Coherence of the STI Policy Mix			
Improve STI policy coordination	Short-term	Governance and Coordination	Council of Ministers, MoES, ME, planned R&I Agency
Adjust the policy mix to address gaps and maximize impact	Short-term	Programmatic	MoES, ME, EA SESG, other STI implementers
Increase national funding for STI with clear and defined targets	Long-term	Programmatic	Council of Ministers, MoES, ME, planned R&I Agency, MoF, FMFIB, NSF, SMEPA, EA SESG
Improve the Governance of the Research System			
Address persistent fragmentation and implementation challenges of the STI policy mix	Short-term	Governance and Coordination	Council of Ministers, MoES, ME, planned R&I Agency
Adopt a conducive monitoring and evaluation (M&E) framework of R&D activities and outcomes	Short-term	Governance and Coordination	MoES, MoE, MoF, planned R&I Agency, NEAA, National Audit Office, FMFIB
Enhance research capabilities and ensure the economic and societal relevance of research activities	Mid-term	Programmatic	MoES, NSF, planned R&I Agency

Recommendation	Timeline	Type of reform	Stakeholder(s)
Improve researchers' career advancement criteria and remuneration schemes to attract and retain young talent	Mid-term	Regulatory	MoES, NEAA
Remove ambiguities from the IPR framework	Mid-term	Regulatory	MoES, PORB
Improve the incentive framework and resources for tech transfer and commercialization of public research	Mid-term	Regulatory, Programmatic	MoES, PORB
Support Innovation and Technology Adoption in Firms			
Promote firm digitization and tech adoption	Short-term	Programmatic	Council of Ministries, ME, MTITC, planned R&I Agency
Build the supply of digital skills	Mid-term	Programmatic	Council of Ministries, ME, MoES, Universities, MTITC, planned R&I Agency
Introduce targeted support to leverage private sector R&D	Mid-term	Programmatic	Council of Ministries, planned R&I Agency, SMEPA
Address constraints related to the operating business environment and the mobility of resources	Mid-term	Regulatory	ME, MoF
Promote innovative entrepreneurship and remove impediments to ventures' growth	Mid-term	Programmatic	ME, MoES, FMFIB, SMEPA

These areas for policy action are drawn from the country needs assessment and the assessment of the national STI policy mix. These recommendations will be further refined by subsequent components of this project: the *Functional and Governance Analysis* will review the quality of design, implementation, and governance of the policy mix, and the *Efficiency*

Analysis will evaluate the efficiency of a sample of instruments, to assess their ability to produce the expected outputs given the inputs and resources used.

The recommendations discussed below take into account the new Bulgaria 2030 National Development Programme and it's 11 policy priorities. Priority 2, Science and Scientific Infrastructure, outlines Bulgaria's research ambitions along four key areas: efficient public spending on research; internationalization and participation in the European Research Area (ERA); modern research infrastructure; and research staff. Firm-related priorities, such as Smart Industry (P3), Circular and Low-Carbon Economy (P4), and Digital Connectivity (P8), outline the country's targets in terms of firm and industry performance and readiness for the digital age.

These policy directions also build on and expand the recommendations from previous assessments and diagnoses of the Bulgarian research and innovation ecosystem. The EC policy support facility report in 2015, as well as the consequent semester country reports (2018) and other assessments have outlined the key policy areas where reforms are needed. The 2018 Public Support Facility expert report stipulates that "Bulgaria's research and innovation landscape urgently needs reform to reduce fragmentation, increase funding, and improve international competitiveness. This can prepare the ground for an integrated, fair, and transparent system for relating research funding to performance." Moreover, the expert report calls for doubling Bulgaria's national public funding of research and innovation. Nevertheless, the implementation of these recommendations has been delayed or efforts at implementation were insufficient. Thus, the findings from this report add to the existing body of evidence that the need for these reforms is yet more relevant in this coming period for Bulgaria to achieve its stated objective of becoming an innovation-driven economy.

Address the Coherence of the STI Policy Mix

Improve STI policy coordination

Priority timeline: Short-term

Problem:

- STI policymaking is largely divided between the MoES, which focuses on science and scientific research, and the MoE, which focuses on technology development and innovation.
- STI policies are set by a large number of strategies (National Strategy for Development of Scientific Research, National Roadmap for Scientific Infrastructure, Innovation Strategy for Smart Specialization, Europe 2020: National Reform Program, and others) related to STI, many of which have overlapping scopes and objectives.

- Communication channels and consultative processes are weak or sometimes ineffective. There are six consultative bodies to the Council of Ministries in the field of science, technology and innovation, but many of them do not meet regularly or work at full capacity.
- Stakeholders outside of the national government (regional authorities, the private sector) have little input into the design of these STI strategies and policies. The Council for Smart Growth and the National Council for Science and Innovation does not include any representatives of the regional/ local authorities. The Regional Partnership Network, which provides access to representatives of the regional governments to the process of smart specialization, has met only once in 2018.

Approach:

- Activate communication and coordination channels among STI policy actors through existing consultative bodies to set a commonly agreed upon R&I vision and strategic objectives.
- Streamline and monitor the results of the implementation of STI policy through the envisioned R&I Agency.
- Ensure that STI strategies consider both research *and* innovation, rather than focusing on only one of these aspects, and are coordinated with other relevant national and subnational strategies.

Type of reform: Governance and Coordination

Responsible stakeholder(s): Council of Ministers, MoES, ME, planned R&I Agency

Adjust the policy mix to address gaps and maximize impact

Priority timeline: Short-term

Problem:

- The analysis of the STI policy mix reveals several gaps in the STI policy mix, including few resources devoted to technology transfer; insufficient instruments that support I4.0 technology adoption; a lack of targeted support for early-stage companies and for incubators, accelerators, and other business support; and a lack of instruments to address barriers in the business environment.
- The instrument mix is predominately made up of grants and matching grants, which may not always be the best mechanism for achieving impact, depending of the program objectives.

Approach:

- In areas where instruments have been insufficient or ineffective at addressing STI challenges, review the design, implementation, and effectiveness of instruments and consider measures that could improve coordination, transparency, and uptake of the instruments.
- Instrument design should consider the market failure being addressed. For example, vouchers instead of matching grants could be used for public-private research collaborations, where the money for the research activity goes directly to the research organizations, making them a critical partner of the research collaboration. Indirect measures such as fiscal incentives (e.g., business angel tax incentives, R&D tax credits) and promotional schemes can complement the existing policy portfolio.

Type of reform: Programmatic

Responsible stakeholder(s): MoES, ME, EA SESG, other STI implementers

Increase national funding for STI with clear and defined targets

Priority timeline: Short-term, Long-term

Problem:

- Government budget appropriations on R&D (GBARD) increased by less than 15 percent from 2015 to 2017, and GBARD remains below all peers on a per capita basis and less than ten percent of the EU 28 average.
- Bulgaria 2030 sets an ambitious target of 3 percent GERD as a share of GDP by 2030, but GERD only reached 0.7 percent of GDP in 2018 and no clear mechanisms for increasing allocations have been adopted to reach the new target. Earlier evaluations of the Bulgarian R&I system, such as the PSF 2018 report, recommended doubling the national public funding for R&I.
- Bulgaria's public research institutions (PROs and HEIs) are underfunded and perform a smaller share of national R&D than observed in peer countries.

Approach:

- Increase national funding for STI (public R&D funding, funding for researcher salaries and infrastructure investments, private funding).
- Government funding will need to at least double if the new 2030 GERD target is to be met.

Type of reform: Programmatic

Responsible stakeholder(s): Council of Ministers, MoES, ME, planned R&I Agency, MoF, FMFIB, NSF, BSMEPA, EA SESG

Improve the Governance of the Research System

Address persistent fragmentation and implementation challenges of the STI policy mix

Priority timeline: Short-term

Problem:

- Bulgaria has the lowest contribution of EU structural funds to GERD among peers, indicating large-scale challenges in implementing programs and absorbing EU STI funding.
- Severe lag in the allocation and disbursement of EU structural funding in the current programming period is further evidence for challenges in the implementation of STI programs at the national level.
- Very few of the recommendations of recent EU reports and evaluations of Bulgaria's R&D funding system, Centres of Excellence and Competence, etc., have been implemented.
- There is little to no coordination or linkages across research institutions (BAS, AA, HEIs, Centres of Excellence and Competence) and innovation support institutions (tech transfer offices, regional innovation centers, clusters, industrial parks, fund of funds, etc.). These fragmented initiatives lack a binding, coherent, and comprehensive vision that could translate into a holistic STI framework with measurable targets.

Approach:

- Adopt a policy-driven approach (rather than an institution-led approach) to R&I policy and reflect this approach into the policy mix design.
- Consolidate the implementation and coordination of the policy mix under the envisioned R&I Agency.
- Integrate universities into the research system through expanding support to university-based research activities and ensure that these activities are aligned with regional industrial specializations to promote demand for research and knowledge services from private sector actors.
- Streamline the research performing sector by consolidating public research institutions (BAS and AA). The consolidation should be based on rigorous analysis and

complemented by a clear framework for PRO funding through a hybrid formula of performance-based public funding and market/contract research funding.

Type of reform: Governance and Coordination

Responsible stakeholder(s): Council of Ministers, MoES, ME, planned R&I Agency

Adopt a conducive monitoring and evaluation (M&E) framework of research activities and outcomes

Priority timeline: Short-term

Problem:

- Few evaluations have to done to measure the impact of Bulgaria's STI support instruments or public research institutions.
- STI institutions often lack measurable objectives and targets.

Approach:

- Set measurable objectives for STI programs and institutions as part of their design.
- Increase resources devoted to M&E activities and improve data collection in STI institutions and programs through built-in M&E procedures.
- Build analytical capabilities and commit resources to M&E and evidence-based policy making for the targeting, design, and evaluation of STI instruments and institutions.
- Improve STI data collection and utilization with the National Statistical Institute.

Type of reform: Governance and Coordination

Responsible stakeholder(s): MoES, MoE, MoF, planned R&I Agency, NEAA, National Audit Office, FMFIB

Enhance research capabilities and ensure the economic and societal relevance of research activities

Priority timeline: Medium-term

Problem:

- The poor performance of research outputs (Bulgaria ranks poorly compared to peers in publication h-index, number of international co-publications, share of publications that have been cited, and international patents per capita) is indicative of a national research system that has little impact on the international scientific community.

- The small share of performance-based financing in PROs' overall budgets provides limited financial incentives for institutions to foster research excellence and relevance. Performance-based financing constitutes a very small share of funding for PROs compared to institutional block funding.
- Competitive funding (project-based funding) only makes up 25 percent of funding for PROs, and competitive funding has decreased as a share of total funding since 2015.
- Technology transfer from the public sector to the private sector is very low, with almost no licensing or spinout activity coming from PROs/HEIs.

Approach:

- Continue reforms towards making a larger share of research funding to public institutions competitive and introduce international evaluation of projects to improve the quality and impartiality of the process.
- Introduce robust project evaluation mechanisms to improve the quality of funded proposals, with a focus on internationalization.
- Increase support for the internationalization of the Bulgarian research system though grants for collaboration and researcher mobility (both outward and inward). Bolster programs that foster the pipeline of Horizon 2020 applications and the uptake of other EU research support programs. Continue support for programs that form connections to researchers in the Bulgarian diaspora (such as the VIHREN and Petar Baron research programs).
- Gradually increase the performance-based component for public research activities to incentivize researchers and PROs to produce high-quality outputs. The performance-based portion of funding should be used to improve research excellence.
- Introduce a modernization program for PROs, including the design and implementation of institutional transformation plans for select PROs to address industry needs.
- Establish channels to allow industry involvement in the definition of public research and innovation agendas.
- Increase the focus of applied research grants and other HEI/PRO funding on commercialization outputs (licenses, contract research, spin offs, etc.), not only on IP outputs.
- Introduce an incentive framework for researchers who produce high-quality outputs. Performance-based portion of funding should be used to incentivize the work of top researchers.
- Pilot a nationally funded research commercialization capacity building program targeting public researchers, which focuses on building researchers' commercialization

skills through intensive training modules delivered through certified trainers. A good model to consider is the US National Science Foundation I-Corps program.

Type of reform: Programmatic

Responsible stakeholder(s): MoES, MoE, planned R&I Agency

Improve researchers' career advancement criteria and remuneration schemes to attract and retain young talent

Priority timeline: Medium-term

Problem:

- Research staff in Bulgarian PROs and HEIs receive very low salaries compared to those of CEE peers and private-sector counterparts. This has deterred young researchers from entering the public research sector and has arguably contributed to Bulgaria's ongoing brain drain. Low pay also has led to unfavorable research practices at both the personal and institutional level.
- In the recent World Bank Survey of Bulgarian Public Researchers and Research Organizations, the lack of critical mass of human capital in science and technology was cited as the largest obstacle that researchers face for creating impactful research and commercialization, with 87 percent of researchers saying that the lack of human capital was a large or very large challenge.
- Bulgaria 2030 includes policy directions to increase the attractiveness of the scientific profession and support talent retention but does not include steps to directly increase researcher salaries.

Approach:

- Increase funding for scholarships, internships, and post doctorates to attract young talent in public research institutions.
- Increase public researcher salaries to levels that at least match those of CEE peers.
- Create a bonus framework for researchers who produce high-quality outputs. The performance-based portion of funding should be used to incentivize the work of top researchers.
- Provide adequate regulation for mobility schemes between science and business and ensure their support

Type of reform: Regulatory

Responsible stakeholder(s): MoES, NEAA

Remove ambiguities from the IPR framework

Priority timeline: Medium-term

Problem:

- While the regulations governing IP ownership are generally clear, there is no clear legislation governing who owns IP generated by public research institutions (PROs and HEIs).
- There is no specific technology transfer law, such as the U.S.'s Baye-Dole Act, that governs the transfer of public research to private applications.
- The 2016 amendments to the Higher Education Act state that every HEI should have a system for IP protection, management, and ownership, which has resulted in systems of IP ownership that vary from one academic institution to another.

Approach:

- Develop a single national framework for IPR and technology transfer (in lieu of leaving IPR policies to the discretion of individual PROs/HEI). In the absence of a single national framework, review and standardize the IP frameworks of Bulgaria's PROs and HEIs to remove ambiguity and variance across institutions.
- Encourage universities to pursue research collaborations and contract research with and for industry by addressing informational and IP-related barriers.

Type of reform: Regulatory

Responsible stakeholder(s): MoES, PORB

Improve the incentive framework and resources for tech transfer and commercialization of public research

Priority timeline: Mid-term

Problem:

- There are very low levels of technology transfer from the public sector to the private sector.
- Public researchers are not currently incentivized to commercialize their research. Anecdotal evidence shows public researchers at times patent and commercialize their work on their own, without institutional support or involvement.
- Public institutions generally lack sustainable funding and resources for IPR and tech transfer activities. Not all HEIs/PROs have dedicated TTOs or even dedicated IPR experts.

- Those TTOs that do exist lack sustainable funding and have lost staff and skills when EU funding for the establishment of these units ended.

Approach:

- Promote the third mission (to generate knowledge for the benefit of the social, cultural and economic development) of Bulgarian universities through sustained financial support for HEI research collaborations, contract research, early technology validation and demonstration, licensing and tech transfer, and academic spinoffs.
- Make commercialization outcomes part of researchers' career development paths to incentivize spinoff creation.
- Clarify ownership of equity stakes in spinoffs from academic research institutions at both individual and institutional levels.
- Introduce instruments that provide reliable and sustainable funding for technology transfer offices and other intermediaries in support of research commercialization and the acceleration of knowledge-based startups, including support for capacity building and training assistance on international best practices.

Type of reform: Regulatory, Programmatic

Responsible stakeholder(s): MoES, PORB

Support Innovation and Technology Adoption in Firms

Promote firm digitization and tech adoption

Priority timeline: Short-term

Problem:

- Bulgaria received the lowest score in the EU on the Digital Economy and Society Index (DESI) business digitization sub-indicator in 2019, which measures the use of digital technologies (such as cloud computing and big data) and e-commerce in firms.
- Several recent studies assessing the Industry 4.0 "readiness" of European countries have shown that Bulgaria is largely not prepared to participate in the creation or adoption of I4.0 technologies.
- There is scant evidence available as to the strength of managerial capabilities in Bulgarian firms, which play a key role in firms' abilities to adopt new technologies.
- Teleservices and e-commerce are of vital importance in dealing with the aftermath of the COVID 19 outbreak. Yet e-commerce suffers from a number of logistical and

technical challenges, and the use of e-commerce lags behind all other countries in Europe.

Approach:

- Help identify firm technology and digitization needs through diagnosis tools and/or tech extension services.
- Clarify (and, where appropriate, relax) the legal framework surrounding online delivery of professional services, support businesses in adopting electronic payment options, and address last mile delivery challenges (logistics and postal delivery service).
- Gather more evidence on firms' managerial capabilities – particularly in SMEs – to get a better understanding of whether existing instruments adequately address the needs of Bulgarian firms in this area.

Type of reform: Programmatic

Responsible stakeholder(s): Council of Ministries, ME, MTITC, planned R&I Agency

Build the supply of digital skills

Priority timeline: Medium-term

Problem:

- The demand for advanced skills is projected to increase over the next decade, while Bulgaria ranks last in the EU in both basic and advanced digital skills.
- The country is experiencing a net loss in some important digital and Industry 4.0-related skills due to emigration.
- Digital skills are essential enablers to Industry 4.0 technology adoption in firms, as area where Bulgaria lags behind much of Europe.

Approach:

- Support firms in providing training and capacity building modules on data science, analytics, cloud computing, digital marketing and sales, and other digital tools.
- Promote key Industry 4.0 skills and degrees to students to help boost emerging I4.0 clusters (such as AR/VR).

Type of reform: Programmatic

Responsible stakeholder(s): Council of Ministries, ME, MoES, Universities, MTITC, planned R&I Agency

Introduce targeted support to leverage private sector R&D

Priority timeline: Medium-term

Problem:

- Firm-level analysis of the services and construction sectors show that the within component of productivity (the productivity of the average firm) is low and indicates a need for R&D and innovation in this segment of the economy.
- Business R&D investments are generally financed by the business sector, with very small contributions from government sources.

Approach:

- Targeted instruments to incentivize firms' R&D investments to boost productivity performance in sectors where more R&D is needed to boost firm performance.
- Promotional schemes targeting domestic firms to help increase take-up of existing instruments.

Type of reform: Programmatic

Responsible stakeholder(s): Council of Ministries, planned R&I Agency, SMEPA

Address constraints related to the operating business environment and the mobility of resources

Priority timeline: Medium-term

Problem:

- In the manufacturing sector, the efficiency of resource allocation has worsened over time, meaning that a lack of resources is limiting growth by more productive firms, which limits the increase in the overall productivity of the sector. This is due in part to the survival of large, inefficient incumbent firms. If these large firms exited the market, more resources could flow to productive firms.
- Both the global Doing Business rankings and OECD Product Market Regulation (PMR) indicators show the Bulgarian business environment ranks poorly compared to regional peers. In particular, regulations related to starting a business represent a significant constraint on market access and consequently to competition. The contribution of entrant firms to aggregate productivity growth is negligible or negative. Similarly, the dominance of state-owned enterprises further restricts competition in specific sectors.

Approach:

- Conduct an in-depth assessment of product market regulations to identify and remove competition and market constraints.
- Prioritize regulations aimed at increasing the mobility of production factors across producers, such as facilitating firms' exit and resolving insolvency.
- Facilitate firm entry across the economy to boost aggregate productivity performance.

Type of reform: Regulatory

Responsible stakeholder(s): ME, MoF

Promote innovative entrepreneurship and remove impediments to ventures' growth (risk finance, deal flow)

Priority timeline: Medium-term

Problem:

- Bulgaria has a smaller share of early-stage startups belonging to knowledge-intensive industry sectors than innovation-driven economies do; rather, the industry sector distribution of Bulgarian startups is similar to the distribution in factor- and efficiency-driven economies.
- Young firms are much less productive than established firms, even after five years of operation.

Approach:

- Support early stage entrepreneurship through ideation, national competitions, and development programs (prototyping, PoC), and target early stage business intermediaries to create a steady supply of investible knowledge-based companies.
- Support investment readiness programs, which target startups and teams through mentorship and investors' relations.
- Develop instruments that can improve firms' post entry and scale up performances, such as business advisory services and technology extensions
- Develop the business angels' market and support the professionalization of angel investors.

Type of reform: Programmatic

Responsible stakeholder(s): ME, MoES, FMFIB, SMEPA

APPENDIX I. INSTRUMENTS OF THE STI POLICY MIX

The STI portfolio mapping exercise provides the basis for evaluating the coherence between identified STI policy needs (as described in the Country Needs Assessment section) and the makeup of Bulgaria's portfolio of support instruments. The mapping covers instruments that were operational during the 2014 to 2020 period and that were managed at the national level (national instruments with a regional focus also are included). Based on the following criteria for including STI support instruments, a total of 118 instruments are mapped:

- Instruments that support research, development, and/or business innovation and use public budget (i.e. from government or international development agencies);
- Instruments that support research, development, and/or business innovation through public inputs (e.g., provision of access to information services);
- Instruments that support creation and survival of new ventures and entrepreneurship (e.g., supporting potential entrepreneurs via incubators/accelerators, social entrepreneurship).

The instrument policy mix was assembled and analyzed in a matrix containing detailed information about each STI support instrument included in the scope of the analysis. A total of 169 variables were collected per instrument along 23 categories for each instrument.

- General (22)
- Call type (3)
- Economy/societal outcomes (6)
- Alignment with national (S3) objectives (2)
- Instrument objective (16)
- Type of support (2)
- Mechanism of intervention (18)
- Grant usage (29)
- Sectoral orientation (7)
- Geographic coverage (3)
- Beneficiaries (20)
- Life cycle of firm (4)
- Enterprise size (4)
- Innovation propensity (5)
- Supported R&D and implementation phases (8)
- Supported TRL phases (9)
- Allocated budget/funding (7)
- Allocated budget/funding source (4)
- Disbursed budget/funding (7)
- Disbursed budget/funding source (4)
- Co-financing (2)
- Support parameters (2)
- Applied state aid rules (15)

Data were sourced from program documentation available online, followed by verification with agencies' and ministries' points of contact to ensure data quality.

Information clarification

- For the instruments administered by the National Science Fund, Ministry of Education and Science and OP Science and Education for Smart Growth, the indicators under life cycle, size, and firm innovativeness are not relevant.
- The instruments administered by the National Science Fund and Ministry of Education and Science, except bi-lateral programs, use only national financing. The same is true for the National Innovation Fund.
- The time period covered is 2014-2019 and available information for the program period 2014-2020. The STI matrix excludes data related to financial support and procedures started during the previous program period (for example financing provided through the OP "Competitiveness" 2007-2013 disbursed during the present program period).

Information limitations

- The information regarding the instruments provided by the National Science Fund and Ministry of Education and Science is not publicly available, or only specific parts are available, which made the process of gathering the required data very difficult. The same is true for the National Innovation Fund.
- For a small number of instruments, the information regarding the allocated budget is not provided or not publicly available.
- The STI matrix does not include information on the financial support provided by the Bulgarian Development Bank and European Bank for Reconstruction and Development due to the lack of publicly available data and difficulties in communication with their representatives during the pandemic and engagements of the financial institutions in addressing the negative business impact.
- The information regarding the national private funds leveraged as part of the OP IC is not provided by the MoE.
- Both EEN related projects are not administered by any national authority.
- The STI matrix does not include instruments provided directly by European and international sources where national authorities are not involved at any stage of project assessment, administering, monitoring or evaluation.
- The financial data regarding the operational programs, are publicly available on a dedicated Internet platform. Nevertheless, the platform does not cover all the required

information. In addition, representatives of the managing authorities stated that for some individual cases this information is misleading or even mistaken.

- The financial data related to the instruments provided by the National Science Fund and Ministry of Education and Science are to be used with caution even though the information was validated by their representatives, as both institutions do not apply any electronic platform for administering, monitoring and assessing the procedures and achieved results. Moreover, the information is not organized as a database, and in many cases is not complete and consistent.

Table 9. Full list of instruments

Program /Instrument full name	Managing authority (MA)
Creation and Development of Centres of Excellence	EA OP SESG
Creation and Development of Centres of Competence	EA OP SESG
Additional support for scientific organizations with approved projects under H2020, WIDESPREAD-TEAMING Competition, Phase 2	EA OP SESG
University science complexes	Ministry of Education and Science
Fundamental Research	Ministry of Education and Science
Fundamental Research on Societal Challenges	Ministry of Education and Science
Fundamental Research for Young Scientists and Postdoctoral Students	Ministry of Education and Science
Bulgarian scientific periodicals	Ministry of Education and Science
Bilateral cooperation programmes Bulgaria-Austria	Ministry of Education and Science
Bilateral cooperation programmes Bulgaria-Germany	Ministry of Education and Science
Bilateral cooperation programmes Bulgaria-France (RILA Programme)	Ministry of Education and Science
Bilateral cooperation programmes Bulgaria- Francophonie University Agency	Ministry of Education and Science

Program /Instrument full name	Managing authority (MA)
Bilateral cooperation programmes Bulgaria-China, Mobility	Ministry of Education and Science
Bilateral cooperation programmes Bulgaria-China, Research projects, 2018, Pilot Session	Ministry of Education and Science
Bilateral cooperation programmes Bulgaria-India	Ministry of Education and Science
Bilateral cooperation programmes Bulgaria-Russia	Ministry of Education and Science
Bilateral cooperation programmes Bulgaria-Slovakia	Ministry of Education and Science
Programme Quant ERA	Ministry of Education and Science
Programme BiodivERsA	Ministry of Education and Science
Programme M-ERA	Ministry of Education and Science
Programme Core Organic	Ministry of Education and Science
Programme ERA.Net RUS Plus	Ministry of Education and Science
Programme CONCERT-Japan, 2017	Ministry of Education and Science
COST Actions national co-financing	Ministry of Education and Science
Support of international scientific forums held in the Republic of Bulgaria	Ministry of Education and Science
VIHREN-National Scientific Program “Excellent Research and People for the Development of European Science”	Ministry of Education and Science
Petar Beron-National Scientific Program “Petar Beron. Science and Innovation with Europe”, 2019	Ministry of Education and Science
European Organization for Nuclear Research	Ministry of Education and Science
7 Framework Programme (since November 2016) BNSF	Ministry of Education and Science

Program /Instrument full name	Managing authority (MA)
7 Framework Programme (up to November 2016) MoES	Ministry of Education and Science
Public Procurement Procedures for National Subscription agreements (ScienceDirect Freedom Collection of Elsevier 2000 Journals, SCOPUS and Web of Science), 2019	Ministry of Education and Science
Bulgarian-Swiss Cooperation Programme Thematic Fund Research	Ministry of Education and Science
Bulgarian-Swiss Cooperation Programme Thematic Fund Dual Education	Ministry of Education and Science
Bulgarian-Swiss Program for Young Scientists	Ministry of Education and Science
Financing of scientific or artistic activity inherent in public higher education institutions	Ministry of Education and Science
Research Infrastructure	Ministry of Education and Science
National Science Programs 2018-2022	Ministry of Education and Science
National program Young scientists and postdoctors	Ministry of Education and Science
Pythagoras Science Award	Ministry of Education and Science
Competitions “Young Talents”	Ministry of Education and Science
Annual membership fee for research infrastructure	Ministry of Education and Science
Bulgarian-American Commission for Educational Exchange – Fulbright	The Fulbright Commission Board
Support for the participation of young talent and academics in European and international competitions such as “Laboratory of Fame”; Science Festival, Forums “	Ministry of Education and Science
Polar Logistics Programme	Ministry of Education and Science
Doctoral fellowships	Ministry of Education and Science
Support for the introduction of innovation in enterprises	Ministry of Economy

Program /Instrument full name	Managing authority (MA)
Support for development of innovations by start-up companies	Ministry of Economy
Phase 2 of the project “Establishing a science and technology park” Sofia Tech Park	Ministry of Economy
Development of a modern industrial property system by supporting the activity of the Patent Office of the Republic of Bulgaria	Ministry of Economy
Development of product and process innovations	Ministry of Economy
LAG – Support for introducing innovations in enterprises	Ministry of Economy
Improving the production capacity of SMEs	Ministry of Economy
Development of management capacity and growth of SMEs	Ministry of Economy
Creating conditions for sustainable development and successful integration of Bulgarian enterprises on the European and international markets by supporting the activities of BSMEPA	Ministry of Economy
Provision of institutional support to the State Agency for Metrological and Technical Supervision to enhance the effectiveness of market surveillance, metrological surveillance and quality control of liquid fuels	Ministry of Economy
Increasing the efficiency and effectiveness of the services offered by the Consumer Protection Commission for Bulgarian enterprises	Ministry of Economy
Positioning Bulgaria as a known and preferred investment destination by supporting the activities of the Bulgarian Investment Agency	Ministry of Economy
Provision of institutional support to The Executive Agency “Bulgarian Accreditation Service” for improving the quality infrastructure	Ministry of Economy
Development of clusters in Bulgaria	Ministry of Economy
Provision of institutional support to the Ministry of Tourism for activities related to enhancing the capacity of SMEs in the field of tourism	Ministry of Economy
Improving the business environment for Bulgarian manufacturers and creating conditions for testing facilities by supporting the activities of the Bulgarian Institute of Metrology	Ministry of Economy

Program /Instrument full name	Managing authority (MA)
LAG – Improving the production capacity of SMEs	Ministry of Economy
LAG – Improving the production capacity of SMEs	Ministry of Economy
LAG – Improving the production capacity of SMEs	Ministry of Economy
Enhancing the growth of SMEs through pilot application of a voucher scheme by BSMEPA	Ministry of Economy
LAG – Improving the production capacity of SMEs	Ministry of Economy
LAG – Improving the production capacity of SMEs	Ministry of Economy
LAG – Capacity growth of SMEs	Ministry of Economy
LAG – Capacity growth of SMEs	Ministry of Economy
LAG – Improving the production capacity of SMEs	Ministry of Economy
LAG – Technological innovation and implementation of standards in SMEs	Ministry of Economy
Enhancing the entrepreneurship	Ministry of Economy
LAG – Improving the production capacity of SMEs	Ministry of Economy
LAG – Capacity growth of SMEs	Ministry of Economy
LAG – Improving the production capacity of SMEs	Ministry of Economy
LAG – Improving the production capacity of SMEs	Ministry of Economy
LAG – Improving the production capacity of SMEs	Ministry of Economy
LAG – Improving the production capacity of SMEs	Ministry of Economy
LAG – Capacity growth of SMEs	Ministry of Economy
Implementation of measures for internationalization of Bulgarian SMEs by supporting the activities of the Executive Agency for Promotion of Small and Medium-Sized Enterprises	Ministry of Economy
Energy Efficiency for Small and Medium-sized Enterprises	Ministry of Economy
Increasing energy efficiency in large enterprises	Ministry of Economy
Sustainable Energy Development of Bulgarian Enterprises by Supporting the Activities of the Agency for Sustainable Energy Development	Ministry of Economy
Support for pilot and demonstration initiatives for effective use of resources	Ministry of Economy

Program /Instrument full name	Managing authority (MA)
Sustainable Energy Development of Bulgarian Enterprises by Supporting the Activities of the Agency for Sustainable Energy Development	Ministry of Economy
National Innovation Fund	Ministry of Economy
Eurostars Joint Program	Ministry of Economy
Eureka Initiative	Ministry of Economy
National export portal	Ministry of Economy
SME Register	Ministry of Economy
Bulgarian-Swiss Co-operation Program	Ministry of Economy
Technostart	Ministry of Economy
Risk-sharing Micro-Finance facility (Financing with Risk-Sharing)	European Funds and International Programmes and Projects Directorate General (DG EFIPP), MLSP
Support for entrepreneurship	Directorate General European Funds, International Programs and Projects
Productive investments in aquaculture	Maritime and Fisheries Directorate
Exemption from corporate tax and value added tax	Ministry of Finance
Exemption of import from value added tax	Ministry of Finance
Exemption from personal income taxes	Ministry of Finance
Tax reduction of personal income taxes	Ministry of Finance
Tax credit for personal income taxes and corporate tax from abroad	Ministry of Finance
Accelerated depreciation of R&D fixed assets	Ministry of Finance
Recognition of accounting expenses for donations for tax purposes	Ministry of Finance
Reduction of the accounting financial result with the historical cost of intangible fixed product	Ministry of Finance
Remise of 50% of income tax	Ministry of Finance
Improving business regulatory environment	Ministry of Finance
Financial support for vocational training	Ministry of Finance

Program /Instrument full name	Managing authority (MA)
Tax reduction	Ministry of Finance
Partial reimbursement of workers' wage taxes and social security contributions	Ministry of Finance
Access to information and services	Ministry of Finance
Negotiation without prior notification	Ministry of Finance
Support for R&D	Ministry of Education and Science
Board of Trustees	Bulgarian Academy of Sciences
State Enterprise "Scientific Production Center"	Agricultural Academy
Board of Trustees	Higher Education Institutions
Enterprise Europe Network-Bulgaria	ARC Consulting
EEN Enhancing the Innovation Management Capacity of Bulgarian SMEs	ARC Consulting
Reduction of service charges, Bulgarian Patent Office	Bulgarian Patent Office
Electronic registers, Bulgarian Patent Office	Bulgarian Patent Office

APPENDIX II. FIRM-LEVEL PRODUCTIVITY ANALYSIS METHODOLOGY

The sample used in the Firm-Level Productivity Analysis covers a 9-year period until 2018.

Figure 76. Comparison of the Micro Sample with Macro Indicators in Manufacturing

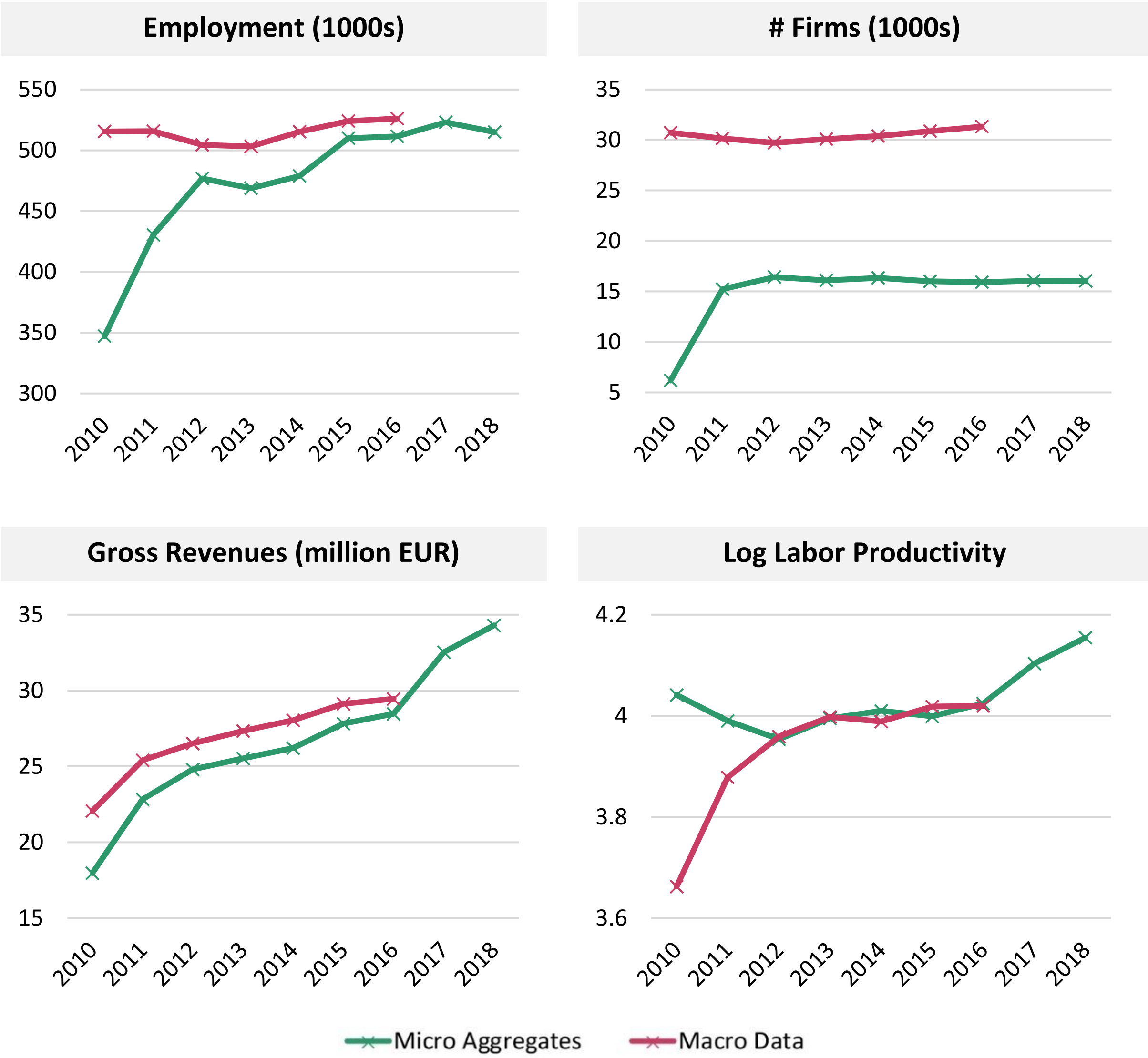


Figure 76 shows that the total gross revenues of firms in the micro sample corresponded to more than 90 percent of the revenues in the macro indicator in 2016. The gap between the macro and micro samples is larger in terms of the total number of firms, so that approximately half of the firms in manufacturing are included in the micro sample. The firms in the micro sample, however, are larger than the macro average and employed more than 90 percent of the total labor in manufacturing in 2016. Taking the macro indicator for employment and total number of firms as benchmark, the coverage of the micro sample is much lower in the initial years of the sample period, especially between 2010 and 2012. When gross revenues are compared, however, the difference between the macro and micro samples is lower in the initial years, indicating that mostly smaller firms and less productive firms are excluded from the sample until 2012. Starting from 2012, the labor productivity indices based on the micro and macro date are very close to each other.

Box 9. Production Function Estimation

The analysis of total factor productivity is based on an estimation of Cobb-Douglas type production function in the following from:

$$\boldsymbol{y_{it} = \beta_{0,it} + \beta_m m_{it} + \beta_l l_{it} + \beta_k k_{it} + e_{it}}$$

In the above equation, *y*, *m*, *l* and *k* represent the output, intermediate inputs, labor and capital of firm *i* in time *t* respectively. $\boldsymbol{\beta}$'s are the coefficients of interest where $\boldsymbol{\beta_{0,it}}$ is the vector of dummies that includes the intercept and time dummies. e_{it} is the error term.

Production functions are estimated for each 2-digit manufacturing and services industries separately using Ackerberg et al. (2015). The estimation sample covers the 6-year period from 2010 to 2018.

Production functions are estimated for each 2-digit manufacturing and services industries separately using Ackerberg et al. (2015). The estimation sample covers the 6-year period from 2010 to 2018.

Box 10. Melitz-Polanec Decomposition

The Melitz-Polanec decomposition, also known as the dynamic Olley-Pakes decomposition, decomposes productivity growth and provides insights into to the drivers of the change in productivity between two points in time.

Melitz and Polanec (2015) decompose aggregate productivity growth into 4 components:

Box 10. Melitz-Polanec Decomposition

- *Within* –growth in the mean productivity due to changes in firms' productivity performance holding their market shares constant
- *Covariance* – productivity gains due to improved allocative efficiency of resources between firms
- *Entry* – productivity gains due to the entry of new firms
- *Exit* – productivity gains due to the exit of existing firms

$$\theta_t - \theta_k = \Delta\theta_t = \underbrace{\Delta\bar{\theta}_t}_{within} + \underbrace{\Delta cov(\theta, s)_{it}}_{covariance} + \underbrace{s_{E,t}\left(\theta_{E,t} - \theta_t\right)}_{entry} + \underbrace{s_{X,t-k}\left(\theta_{x,t-k} - \theta_{t-k}\right)}_{exit}$$

where $cov(\theta, s)_{it} = \sum_i(\theta_{it} - \bar{\theta}_t)(s_{it} - 1/n_t)$, $\theta_t = \sum_i(s_{it}\theta_{it})$ and $\bar{\theta}_t = \sum_i(\theta_{it}/n_t)$.

In above formulation, θ_{it} is firm *i*'s productivity in time t, s_{it} is the firm's share in the market and n_t is the number of firms.

However, there are two main difficulties in the application which necessitate particular attention. First, the entry and exit components have to be computed based on the absence or presence of data rather than the actual information on entry and exit. This is not because of the choice of the researcher but because of a technical necessity, so that the identity only holds when entry and exits are captured based on the gaps in the data.

Second, Melitz-Polanec decomposition is often applied to annual productivity growth series, which often results in negligible or negative entry contributions. This is because entrant firms generally need a start-up period to learn the market, advertise their product and exploit their productivity advantage, if any. This start-up period is generally longer than one year, so that decomposing annual growth may not capture the real contribution of entrants in the mid or long term. Therefore, in this section, the Melitz-Polanec decomposition is applied not on annual but on 3-yearly productivity growth rates to capture entrants' productivity contribution also after their first year in the market.[35]

Table 10 uses the components of the Melitz-Polanec productivity decomposition exercise to capture the R&D impact on firm performance based on aggregate data.[36]

[35] Melitz-Polanec decomposition also applied for 5-yearly productivity growth. The results based on 5-year differencing do not differ significantly from those based on 3-year differencing.

[36] Unlike the section dedicated to the Metliz-Polanec decomposition of 3-yearly productivity growth, the estimation procedure utilizes the decomposition of annual productivity growth, so that the number of

Table 10. Regression of Melitz-Polanec Decomposition Components on R&D

Dependent Variables=>	(1) Productivity Growth	(2) Allocative Efficiency	(3) Within Component
(R&D Intensity)$_{t-1}$	-0.0111	-0.0193	0.0113*
	(0.0149)	*(0.0156)*	*(0.00636)*
Manufacturing Dummy	0.0716	0.0551	0.000479
	(0.105)	*(0.110)*	*(0.0449)*
Manufacturing Variation	0.0164	0.0184	-0.00616
	(0.0213)	*(0.0224)*	*(0.0091)*
Time fixed-effects	yes	yes	yes
Observations	129	129	129
R-squared	0.103	0.164	0.253

*Note: Standard errors in parentheses. * p<0.1*

Table 11. NACE Rev.2 codes

Nace Code	Definition
	Manufacturing
10	Food products
11	Beverages
12	Tobacco products
13	Textiles
14	Wearing apparel

observations used in the estimation is higher. Since the R&D estimation does not make use of the entry or exit components, reducing the time window in the decomposition would not bias the estimation results. Table A2.1 displays the results of the regression of aggregate productivity and the components of its decomposition on R&D intensity, measured as a ratio of R&D expenditures to total sales at the 2-digit industry-level. The data has an unbalanced panel structure, since a large portion of the observations on R&D expenditures from the Eurostat database are missing at the 2-digit level due to confidentiality restrictions. The data covers the period from 2011 to 2018; the remaining number of observations for each variable is 129 after clearing the missing observations. To reduce the problem of simultaneity, productivity growth or its components are regressed on the first lag of the R&D intensity. In all three industry-level regressions, time dummies for every year and a dummy for manufacturing industries are used as regressors. Moreover, an interaction variable, the multiplication of the lagged R&D intensity with the manufacturing dummy, is introduced to capture the potential variation in the link between R&D and productivity for the manufacturing industries.

Nace Code	Definition
15	Leather and related products
16	Wood and products of wood and cork
17	Paper and paper products
18	Printing of reproduction of recorded media
19	Coke and refined petroleum products
20	Chemicals and chemical products
21	Basic pharmaceutical products
22	Rubber and plastic products
23	Other non-metallic mineral products
24	Basic metals
25	Fabricated metal products, except mach. and equip.
26	Computer, electronic and optical products
27	Electrical equipment
28	Machinery and equipment n.e.c.
29	Motor vehicles, trailers and semi-trailers
30	Other transport equipment
31	Furniture
32	Other manufacturing
33	Repair and installation of machinery and equipment
Services and Construction	
35	Electricity, gas, steam and air conditioning supply
36	Water collection, treatment and supply
37	Sewerage
38	Waste collection, treatment and disposal activities
39	Remediation activities and other waste management services
41	Construction of buildings
42	Civil engineering
43	Specialized construction activities
45	Wholesale, retail trade and repair of motor vehicles
46	Wholesale trade, except of motor vehicles and motorcycles
47	Retail trade, except of motor vehicles and motorcycles

Nace Code	Definition
49	Land transport and transport via pipelines
50	Water transport
51	Air transport
52	Warehousing and support activities for transportation
53	Postal and courier activities
55	Accommodation
56	Food and beverage service activities
58	Publishing activities
59	Motion picture, video, TV programme, recording and publishing
60	Programming and broadcasting activities
61	Telecommunications
62	Computer programming, consultancy and related activities
63	Information service activities
64	Financial service activities, except insurance and pension
65	Insurance, reinsurance and pension fund
66	Activities auxiliary to financial services and insurance
68	Real estate activities
69	Legal and accounting activities
70	Activities of head offices; management consultancy activities
71	Architectural and engineering activities
72	Scientific research and development
73	Advertising and market research
74	Other professional, scientific and technical activities
75	Veterinary activities
77	Rental and leasing activities
78	Employment activities
79	Travel agency, tour operator and other reservation service
80	Security and investigation activities
81	Services to buildings and landscape activities
82	Office administrative, office support and other business support

Table 12. Descriptive Statistics, Manufacturing

Nace	Sample Size			Labor	Output	In. Inputs	Capital	Av. Age
10	#obs	18627	mean	32	1784	1073	200	11
	#firms	3097	std	74	8604	4539	2663	8
11	#obs	2617	mean	43	2777	1346	788	14
	#firms	429	std	124	13714	5647	3372	17
12	#obs	110	mean	223	28369	18220	1685	42
	#firms	15	std	256	43410	26304	3857	38
13	#obs	2712	mean	39	2080	948	1130	13
	#firms	441	std	179	17594	6307	18208	17
14	#obs	15453	mean	47	609	209	28	11
	#firms	2668	std	121	2404	1384	149	10
15	#obs	2299	mean	51	619	217	50	11
	#firms	371	std	82	1304	766	443	9
16	#obs	7398	mean	16	516	285	128	10
	#firms	1289	std	36	3725	2193	2566	8
17	#obs	2666	mean	30	1767	1052	137	13
	#firms	410	std	69	7219	4215	739	13
18	#obs	5151	mean	14	477	227	57	11
	#firms	794	std	31	1649	792	671	8
19	#obs	118	mean	158	250242	239782	2872	26
	#firms	16	std	426	839003	811575	9205	21
20	#obs	3490	mean	34	3957	1881	587	13
	#firms	555	std	82	23793	10424	3306	11
21	#obs	366	mean	238	20767	6050	2354	20
	#firms	53	std	687	75535	18543	9665	17
22	#obs	9305	mean	26	1305	805	121	11
	#firms	1435	std	89	6054	3886	1318	9
23	#obs	6193	mean	28	1726	820	495	13
	#firms	978	std	90	9201	4293	3775	12
24	#obs	1133	mean	84	28513	25226	2115	16

Nace		Sample Size		Labor	Output	In. Inputs	Capital	Av. Age
	#firms	162	std	195	195429	181798	9694	16
25	#obs	16771	mean	27	861	408	115	12
	#firms	2634	std	199	5538	2551	1713	10
26	#obs	2398	mean	42	2282	978	178	13
	#firms	356	std	114	9398	3897	756	9
27	#obs	3135	mean	57	3627	2242	400	15
	#firms	447	std	169	17568	12342	2619	13
28	#obs	6093	mean	47	2182	1193	213	15
	#firms	882	std	165	10248	5924	1226	14
29	#obs	656	mean	243	11833	7851	1350	14
	#firms	101	std	669	32313	21890	5341	13
30	#obs	393	mean	113	6287	4223	699	14
	#firms	66	std	192	13575	10540	3737	13
31	#obs	10047	mean	16	381	207	37	10
	#firms	1662	std	49	2100	1136	514	8
32	#obs	7380	mean	10	236	117	31	11
	#firms	1199	std	43	1713	958	334	7
33	#obs	9797	mean	12	322	91	58	10
	#firms	1616	std	47	1957	655	906	8

Table 13. Descriptive Statistics, Services and Construction

Nace		Sample Size		Labor	Output	In. Inputs	Capital	Av. Age
35	#obs	8006	mean	35	7868	1644	2132	8
	#firms	1396	std	301	66304	18672	21546	7
36	#obs	521	mean	297	5661	1379	458	29
	#firms	64	std	347	12520	1899	1007	19
37	#obs	252	mean	9	249	68	62	8

Nace		Sample Size		Labor	Output	In. Inputs	Capital	Av. Age
	#firms	40	std	16	602	120	296	6
38	#obs	2767	mean	36	1420	184	96	9
	#firms	462	std	80	4164	574	715	7
39	#obs	281	mean	25	1230	149	68	6
	#firms	59	std	65	3402	483	592	5
41	#obs	30786	mean	16	594	218	87	9
	#firms	6525	std	35	2622	693	892	7
42	#obs	8233	mean	41	1899	608	153	11
	#firms	1446	std	96	7081	1956	887	10
43	#obs	41014	mean	8	240	94	20	8
	#firms	7945	std	20	1332	476	442	6
45	#obs	52384	mean	6	502	30	30	8
	#firms	9318	std	23	4157	298	342	6
46	#obs	125660	mean	10	2080	89	92	9
	#firms	23438	std	43	19146	1226	1920	7
47	#obs	219223	mean	7	362	17	52	8
	#firms	42627	std	57	5576	168	3398	7
49	#obs	58793	mean	14	513	179	96	7
	#firms	11161	std	154	3645	1066	5178	6
50	#obs	676	mean	29	1846	282	956	12
	#firms	118	std	144	6718	1797	6593	14
51	#obs	408	mean	48	11195	2473	2111	11
	#firms	71	std	112	29992	8014	9414	7
52	#obs	10372	mean	32	1229	93	589	10
	#firms	1806	std	484	5720	763	11316	10
53	#obs	2008	mean	97	1082	106	31	8
	#firms	382	std	1,045	6453	443	226	10
55	#obs	19272	mean	20	406	93	464	10
	#firms	3335	std	60	1603	277	3951	7
56	#obs	46087	mean	10	130	39	26	8
	#firms	10275	std	30	666	287	410	6

Nace		Sample Size		Labor	Output	In. Inputs	Capital	Av. Age
58	#obs	4795	mean	11	300	33	61	11
	#firms	837	std	35	1243	179	437	7
59	#obs	3958	mean	8	316	24	173	8
	#firms	753	std	37	1133	83	2878	6
60	#obs	1082	mean	24	1643	29	282	12
	#firms	187	std	75	8948	93	2002	7
61	#obs	3628	mean	46	3701	292	2549	10
	#firms	614	std	369	35231	2507	35037	6
62	#obs	27480	mean	12	437	29	38	8
	#firms	5368	std	73	2856	311	660	6
63	#obs	6259	mean	11	287	13	48	7
	#firms	1324	std	50	1252	65	414	5
64	#obs	6119	mean	17	598	120	3659	9
	#firms	1303	std	87	4621	2591	60613	6
66	#obs	8922	mean	10	405	60	201	8
	#firms	1670	std	67	10756	1416	3040	6
68	#obs	90373	mean	4	175	31	382	11
	#firms	18397	std	14	959	214	6272	9
69	#obs	54398	mean	4	50	3	7	9
	#firms	8760	std	10	331	12	80	5
70	#obs	20581	mean	5	187	20	227	8
	#firms	4742	std	33	2081	285	4250	6
71	#obs	41445	mean	4	101	14	8	9
	#firms	7006	std	11	689	147	86	6
72	#obs	1554	mean	14	882	117	73	9
	#firms	314	std	55	7150	2059	469	10
73	#obs	15277	mean	6	282	22	14	9
	#firms	2883	std	25	1299	58	113	6
74	#obs	31228	mean	4	118	15	54	8
	#firms	6577	std	28	901	128	740	6
75	#obs	1609	mean	4	49	14	10	7

Nace		Sample Size		Labor	Output	In. Inputs	Capital	Av. Age
	#firms	277	std	6	147	64	78	5
77	#obs	11654	mean	5	272	48	186	8
	#firms	2404	std	14	1146	200	1521	6
78	#obs	2069	mean	41	377	12	42	7
	#firms	446	std	211	1785	47	486	5
79	#obs	8846	mean	6	439	14	26	9
	#firms	1505	std	14	1487	80	327	6
80	#obs	6662	mean	69	393	49	23	10
	#firms	1078	std	245	1691	181	191	7
81	#obs	6880	mean	14	153	35	38	8
	#firms	1293	std	48	705	109	638	5
82	#obs	7099	mean	18	398	40	234	9
	#firms	1522	std	108	2935	200	2956	7

Table 14. Production Function Estimation in Services and Construction

Nace=>	(10)	(11)	(12)	(13)	(14)	(15)
Labor	0.400***	0.466***	0.430***	0.582***	0.612***	0.558***
	(0.00363)	(0.0161)	(0.0365)	(0.0128)	(0.00614)	(0.0129)
Capital	0.0583***	0.0480***	0.0651*	-0.00809	0.0273***	0.0546***
	(0.00364)	(0.0148)	(0.0388)	(0.0167)	(0.00554)	(0.0121)
Int. Inputs	0.638***	0.593***	0.439***	0.519***	0.492***	0.491***
	(0.00407)	(0.0260)	(0.0531)	(0.0165)	(0.00587)	(0.0127)
Time Fixed-Effects	yes	yes	yes	yes	yes	yes
#Observations	17,185	2,270	100	2,400	13,337	2,089

Nace=>	(16)	(17)	(18)	(19)	(20)	(21)
Labor	0.459***	0.502***	0.543***	0.506***	0.410***	0.556***
	(0.00783)	(0.0114)	(0.00715)	(0.0213)	(0.0123)	(0.0258)

Nace=>	(16)	(17)	(18)	(19)	(20)	(21)
Capital	0.0250**	0.0774***	0.0588***	-0.0125	0.0565***	0.0161
	(0.0120)	(0.0201)	(0.0105)	(0.0348)	(0.0110)	(0.0277)
Int. Inputs	0.594***	0.556***	0.501***	0.651***	0.624***	0.510***
	(0.00843)	(0.0145)	(0.0120)	(0.0473)	(0.00916)	(0.0242)
Time Fixed-Effects	yes	yes	yes	yes	yes	yes
#Observations	6,707	2,531	4,579	115	3,226	342

Nace=>	(22)	(23)	(24)	(25)	(26)	(27)
Labor	0.488***	0.398***	0.410***	0.497***	0.474***	0.523***
	(0.00533)	(0.0131)	(0.0210)	(0.00273)	(0.0182)	(0.00899)
Capital	0.0440***	0.0417***	0.0699**	0.0333***	0.0230	0.0295***
	(0.00711)	(0.00753)	(0.0278)	(0.00351)	(0.0171)	(0.00824)
Int. Inputs	0.610***	0.665***	0.638***	0.586***	0.568***	0.519***
	(0.00658)	(0.0107)	(0.0294)	(0.00534)	(0.0165)	(0.0109)
Time Fixed-Effects	yes	yes	yes	yes	yes	yes
#Observations	8,662	5,714	1,070	15,457	2,209	2,955

Nace=>	(28)	(29)	(30)	(31)	(32)	(33)
Labor	0.480***	0.550***	0.639***	0.557***	0.632***	0.730***
	(0.00661)	(0.0223)	(0.0619)	(0.00594)	(0.00518)	(0.00541)
Capital	0.0308***	-0.00135	-0.00495	0.0366***	0.00478	0.0466***
	(0.00728)	(0.0249)	(0.0617)	(0.00733)	(0.00934)	(0.00978)
Int. Inputs	0.538***	0.539***	0.402***	0.524***	0.566***	0.389***
	(0.00699)	(0.0257)	(0.0706)	(0.00697)	(0.00554)	(0.00672)
Time Fixed-Effects	yes	yes	yes	yes	yes	yes
#Observations	5,686	587	345	9,175	6,291	8,114

Source: Ackerberg et al., 2015

*Note: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1*

Table 15. Production Function Estimation in Services and Construction

Nace=>	(35)	(36)	(37)	(38)	(39)	(41)
Labor	0.400***	0.679***	0.597***	0.663***	0.749***	0.459***
	(0.00363)	(0.0180)	(0.0531)	(0.0216)	(0.155)	(0.00735)
Capital	0.0583***	0.128***	-0.107	0.0473	-0.159	0.129***
	(0.00364)	(0.0162)	(0.0662)	(0.0293)	(0.100)	(0.0135)
Int. Inputs	0.638***	0.290***	0.632***	0.353***	0.205**	0.483***
	(0.00407)	(0.0233)	(0.0639)	(0.0251)	(0.0955)	(0.00703)
#Observations	17,185	507	216	2,391	222	25,194
#Firms	2,905	61	32	415	47	5,381

Nace=>	(42)	(43)	(45)	(46)	(47)	(49)
Labor	0.588***	0.617***	0.883***	0.800***	1.010***	0.463***
	(0.00679)	(0.00369)	(0.00777)	(0.00338)	(0.00223)	(0.00441)
Capital	0.0750***	0.0581***	0.199***	0.124***	0.0460***	0.0301***
	(0.0145)	(0.00989)	(0.0108)	(0.00327)	(0.00323)	(0.00971)
Int. Inputs	0.470***	0.524***	0.302***	0.306***	0.272***	0.649***
	(0.00859)	(0.00862)	(0.00537)	(0.00341)	(0.00197)	(0.00482)
#Observations	7,240	35,081	37,068	90,979	124,066	52,127
#Firms	1,255	6,945	7,361	17,500	27,848	10,166

Nace=>	(50)	(51)	(52)	(53)	(55)	(56)
Labor	0.795***	0.764***	0.846***	0.709***	0.676***	0.795***
	(0.109)	(0.0721)	(0.0101)	(0.0193)	(0.00503)	(0.00322)
Capital	-0.0134	-0.0827	-0.0407**	0.0427**	0.0366***	0.0578***
	(0.0450)	(0.0817)	(0.0185)	(0.0180)	(0.00891)	(0.00880)
Int. Inputs	0.317***	0.371***	0.194***	0.368***	0.444***	0.306***
	(0.0695)	(0.0929)	(0.0102)	(0.0141)	(0.00680)	(0.00409)
#Observations	544	336	7,278	1,712	16,485	33,824
#Firms	100	59	1,363	333	2,951	8,261

Nace=>	(58)	(59)	(60)	(61)	(62)	(63)
Labor	0.894***	0.717***	0.812***	0.730***	0.914***	0.840***
	(0.0176)	(0.0278)	(0.0312)	(0.0161)	(0.0100)	(0.0207)
Capital	0.0338**	0.0450*	0.185***	0.183***	0.0649***	0.0614***
	(0.0161)	(0.0264)	(0.0650)	(0.0223)	(0.00759)	(0.0165)
Int. Inputs	0.313***	0.488***	0.275***	0.316***	0.302***	0.369***
	(0.0139)	(0.0204)	(0.0444)	(0.0177)	(0.00784)	(0.0218)
#Observations	3,226	2,773	827	2,609	18,029	3,482
#Firms	630	603	154	495	3,856	857

Nace=>	(64)	(66)	(68)	(69)	(70)	(71)
Labor	0.389***	0.829***	0.560***	0.678***	0.736***	0.771***
	(0.0254)	(0.0106)	(0.00377)	(0.00241)	(0.00950)	(0.00445)
Capital	0.145***	0.0105	0.117***	0.0882***	0.0701***	0.0575***
	(0.0380)	(0.0139)	(0.00419)	(0.00167)	(0.00916)	(0.00614)
Int. Inputs	0.481***	0.275***	0.431***	0.463***	0.395***	0.404***
	(0.0258)	(0.0142)	(0.00329)	(0.00320)	(0.00884)	(0.00347)
#Observations	2,974	5,300	50,809	34,787	10,524	27,714
#Firms	763	1,162	11,298	6,812	2,665	5,386

Nace=>	(72)	(73)	(74)	(75)	(77)	(78)
Labor	0.836***	0.908***	0.729***	1.044***	0.508***	0.708***
	(0.0347)	(0.00924)	(0.00585)	(0.0168)	(0.0120)	(0.0256)
Capital	0.0364	0.208***	0.110***	-0.000133	0.139***	-0.0323
	(0.0437)	(0.0130)	(0.00789)	(0.0279)	(0.0181)	(0.0245)
Int. Inputs	0.355***	0.308***	0.403***	0.236***	0.454***	0.396***
	(0.0235)	(0.0100)	(0.00526)	(0.0156)	(0.0130)	(0.0261)
#Observations	1,155	10,711	18,705	1,261	7,067	1,169
#Firms	245	2,184	4,366	240	1,720	292

Nace=>	(79)	(80)	(81)	(82)
Labor	1.027***	0.653***	0.576***	0.690***
	(0.0139)	(0.00743)	(0.0121)	(0.0154)

Nace=>	(79)	(80)	(81)	(82)
Capital	0.00837	0.0803***	0.0821***	0.0867***
	(0.0127)	(0.00617)	(0.0108)	(0.0163)
Int. Inputs	0.245***	0.308***	0.490***	0.427***
	(0.0158)	(0.00711)	(0.00841)	(0.0134)
#Observations	5,278	5,184	5,365	4,354
#Firms	1,097	925	1,091	1,023

Source: Ackerberg et al., 2015

*Note: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1*

APPENDIX III. LAWS AND INSTITUTIONS GOVERNING INTELLECTUAL PROPERTY RIGHTS

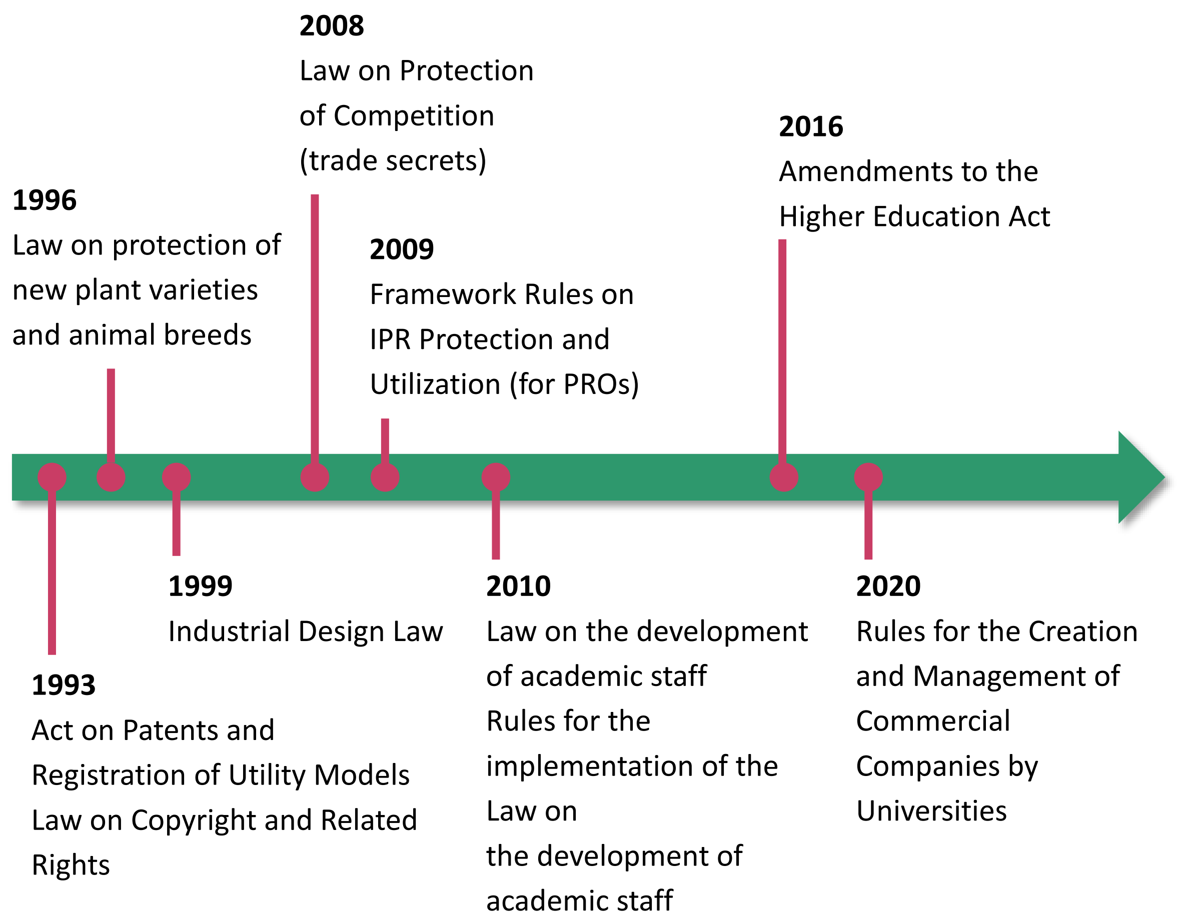
Table 16. Ownership of IP rights – national regulatory framework

IP right	IP owner	Period of protection	Regulated by
Patents Inventions and utility models	The person who created the invention or utility model is the inventor and has the right to file the patent application. Inventions from employment relationship are works for hire, i.e. the employer is the IP owner, if they file an application within 3 months of receiving the notification of the invention from the inventor. If they don't not file in 3 months, the inventor gets the right back to do so. The inventor is owed fair remuneration.	Inventions - 20 years from the date of priority. Utility models - 4 years, with 2 possible extensions of 3 years.	Law on Patents and Utility Models
Trademarks	The right to registration belongs to the first applicant (legal persons)	10 years from the filing date. Registration may be renewed up to 10 years.	Law on marks and geographical indications
Copyrights	Author is the natural person whose creative endeavors have resulted in the creation of a literary, artistic or scientific work. Copyright in work created by more persons belongs to them jointly irrespective of whether the work constitutes one indivisible entity or consists of separate parts each having	Starts automatically with the work creation for duration of author's life and 70 years after author's death.	Law on copyrights and related rights

IP right	IP owner	Period of protection	Regulated by
	individual significance. Unless agreed otherwise, copyright in computer programs and databases developed in employment relationship belongs to the employer.	Computer programs are copyrightable.	
Database sui generis rights	Rights of the makers of databases belong to the maker of the database, natural or legal person, who has taken the initiative and the risk to invest in collecting, verifying or using the contents of a database, if this investment is significant in qualitative or quantitative respect.	Databases are subject to dual protection through copyright as works and through sui generis rights – for 15 years.	
Industrial Design	The person that created design shall have the right to authorship. When the design has been created by two or more persons the right to ownership occurs for all the persons and they shall be co-authors.	Protection for a term of 10 years, with 3 possible extensions of 5 years.	Law on Industrial Designs
Trade Secrets	Owned by the entity who has taken precautionary steps to protect an asset/data/information as a trade secret.	No limitation	Law on Protection of Competition

Source: Authors' compilation

Figure 77. Timeline of key Bulgarian IPR laws and regulations



Source: Authors' compilation

Table 17. Relevant national institutions in the Bulgarian IP and tech transfer system

Institution	Role in IP and Tech Transfer
Patent Office of the Republic of Bulgaria	Responsible for the Industrial property Processing and registering inventions, utility models, industrial designs, trademarks, geographical indications, plant varieties, animal breeds, integrated circuits topographies.
Ministry of Culture	Responsible for the Copyright and Neighboring Rights Creating policy related to scientific, literary, and artistic works, performances, phonograms, recordings of audio-visual works, radio and television programs, databases.

Institution	Role in IP and Tech Transfer
Commission for protection of competition	Protection against unfair competition.
Ministry of Economy	National legislative initiatives and strategic framework in supporting the technology development, innovation, entrepreneurship and SMEs.
Bulgarian SME Promotion Agency National Innovation Fund	Promoting the implementation of research and development projects and projects for technical feasibility with the aim of acquiring new or improved products, processes or services designed to raise economic efficiency, improve the innovative potential and technological level of enterprises, increase private investment and enhance the dynamics of innovative processes.
National Science Fund	Promoting the implementation of fundamental and applied research

Source: Authors' compilation

Table 18. Sample public institutional IP regulations – summary of main provisions

Institution	Role in IP and Tech Transfer
IP management and technology transfer regulations, School of Medicine, Sofia	The IP rights belong to the university if it is a work for hire. The University is IP holder of IP rights stemming from the work of university students unless otherwise agreed. The inventor has 3 months to inform the university about the invention. The inventor has the right to be indicated as such, and also the right to fair remuneration. The regulations also envisage procedure for a detailed assessment of the commercialization potential of the invention. The IP rights of third parties will be agreed contractually.
IP Regulations Plovdiv University	The patent rights belong to the university if it is work for hire. In the case of joint IP ownership, the rights are agreed upon contractually. The copyrights belong to the author, and the University has an exclusive license to use the copyrighted work. All parties that conduct research work are obliged to sign NDAs. The IP creator needs to inform the University, and in turn, the University has 30 days to decide if they going to proceed with IP protection. The University has an IP Council that manages IP rights, gives IP assessments etc.

Institution	Role in IP and Tech Transfer
IP Regulations of the Business Academy Tsenov	The IP rights belong to the university if it is a work for hire. The university can decide whether to pursue IP protection within 3 months from the notification received by the employee. If the university decides not to proceed with IP protection, the IP rights revert to the employee. The ownership of these rights can be agreed contractually as well. Copyrights stemming from work of hire rest with the university. The university is also the owner of IP rights stemming from the creation of software and databases.
IP regulations - Medical University Paraskev Stoyanov	The patent rights belong to the university if it is work for hire. The inventor has 3 months to inform the university about the invention. The inventor has the right to be indicated as such, and also the right to fair remuneration. The University has 3 months to file for IP protection. This right can also be shared by the University and the inventor. The copyrights belong to the author, and the University has an exclusive license to use the copyrighted work without paying remuneration to the author unless otherwise agreed. The IP rights of third parties will be agreed contractually. The University has IP rights over computer programs and databases if these are works for hire.

Source: Authors' compilation from university websites

APPENDIX IV. NATIONAL STRATEGIES RELATED TO SCIENCE, TECHNOLOGY AND INNOVATION

Table 19. National STI strategies

Strategy/Program	Responsible institution	Goals
Research Excellence		
Program of the Government of the Republic of Bulgaria for the period 2017-2021	Council of the Ministries	• Strengthening and modernizing the country's scientific organizations for competitive research • Reforming management and administrative structures related to research • Expanding the participation of the Bulgarian scientific and innovation community in the European Research Area and expanding international scientific cooperation
National Strategy for Development of Scientific Research of the Republic of Bulgaria 2017-2030	Ministry of Education and Science	• Sustainable restoration of the country's international positions in terms of quantity and quality of internationally visible scientific production • Expanding the participation of the Bulgarian scientific community in the European Research Area and expanding international scientific cooperation
National Roadmap for Scientific Infrastructure 2017-2023	Ministry of Education and Science	• Sustainable development of scientific infrastructure by 2023 • Enhancing research excellence • Integration of scientific infrastructure into the European one

Strategy/Program	Responsible institution	Goals
National Science Programs 2018-2022	Ministry of Education and Science	• Overcoming fragmentation in the research system • Expanding the participation of the Bulgarian scientific community in the European Research Area and expanding international scientific cooperation • Significant intensification of the links between science and education, business, government and society
Operational Programme Science and Education for Smart Growth	Ministry of Education and Science	• Increase investment in science and research up to 1.5% of GDP • Improving the quality of research and developing innovation • Creation of Research Infrastructure - Competence Centres, Centres of Excellence
	Access to Finance	
Innovation Strategy for Smart Specialization 2014-2020	Ministry of Economy	• Improving the availability of risk financing • Creating an adequate business environment conducive to innovation
National Strategy for the Promotion of Small and Medium-Sized Enterprises 2014-2020	Ministry of Economy	• Provide an appropriate regulatory and administrative framework for SMEs by applying the "Think Small First" principle • Facilitating SMEs' access to public procurement • Improving SMEs' access to finance • Improving "second chances" for entrepreneurs
Operational Programme SMEs Initiative	Ministry of Economy	• Facilitating access to finance for businesses • Increase in investment activity of SMEs • Increase in productivity of SMEs

Strategy/Program	Responsible institution	Goals
Firm Innovation and Entrepreneurship		
Europe 2020: National Reform Program	Ministry of Finance	• Developing innovation infrastructure and improving science-business connectivity and enterprise innovation • Improving innovative infrastructure and promoting innovation in enterprises
Innovation Strategy for Smart Specialization 2014-2020	Ministry of Economy	• Support for accelerated absorption of technologies, methods, etc., improving resource efficiency and implementation of ICT in enterprises across the industry • Creating an adequate business environment conducive to innovation • Entrepreneurship development • Support for clusters and innovative infrastructure • Internationalization
National Strategy for the Promotion of Small and Medium-Sized Enterprises 2014-2020	Ministry of Economy	• Encouragement of entrepreneurial activity • Improving SMEs' access to external markets, especially outside the EU • Encouraging innovative SMEs and investing in innovation
Action Plan Entrepreneurship 2020 - Bulgaria	Ministry of Economy	• Entrepreneurship education and training to support the growth of existing businesses and the creation of new businesses
Operational Programme Innovation and Competitiveness	Ministry of Economy	• Technological development and innovation • Entrepreneurship and growth capacity for SMEs • Support for the development of technology parks and laboratories • Support for innovation clusters • Increasing enterprise R&D spending

Strategy/Program	Responsible institution	Goals
Digitization and Industry 4.0		
Innovation Strategy for Smart Specialization 2014-2020	Ministry of Economy	• Support for accelerated absorption of technologies, methods, etc., improving resource efficiency and implementation of ICT in enterprises across the industry • Provision of broadband e-infrastructure and e-governance
Concept for digital transformation of the Bulgarian industry	Ministry of Economy	• Strengthening the link between science and business in the country and accelerated integration of Bulgaria into European and international programs, initiatives and networks related to the development and implementation of Industry 4.0. • Building the human, scientific, organizational and institutional capacity to develop Industry 4.0
Skilled Workforce Development		
National Development Program: Bulgaria 2020	Council of Ministers	• Improving the quality of human capital and strengthening its link with the labour market • Improving access and improving the quality of education and training and the quality characteristics of the workforce
Government Program of the Government of the Republic of Bulgaria for the period 2017-2021	Council of the Ministries	• Developing vocational education in partnership with business through the active introduction of the dual system • Increasing skills in entrepreneurship, information technology and active citizenship
Strategy for Development of Higher Education in the Republic of Bulgaria	Ministry of Education and Science	• Build up a sustainable and effective links between higher education and the labour market, and achieved dynamic compliance of demand and

Strategy/Program	Responsible institution	Goals
2014 - 2020		supply of specialists with higher education • Expand and strengthen network for lifelong learning; broad application of the various electronic forms for distance learning
Strategy for the Development of Vocational Education and Training in the Republic of Bulgaria 2015-2020	Ministry of Education and Science	• Increasing the quality of and access to vocational education and training • Reducing early school leaving and young people with low educational and qualification levels • Updating the qualifications of teachers and attracting young teachers
Green and Sustainable growth		
National Development Program: Bulgaria 2020	Council of the Ministries	• Energy security and increasing resource efficiency
Europe 2020: National Reform Program	Ministry of Finance	• 16% share of energy from renewable sources in gross final energy consumption by 2020 • Increase energy efficiency by 25% by 2020
Operational Programme Innovation and Competitiveness	Ministry of Economy	• Energy and resource efficiency of enterprises

Source: Authors' compilation

APPENDIX V. NATIONAL AND EUROPEAN STI SUPPORT

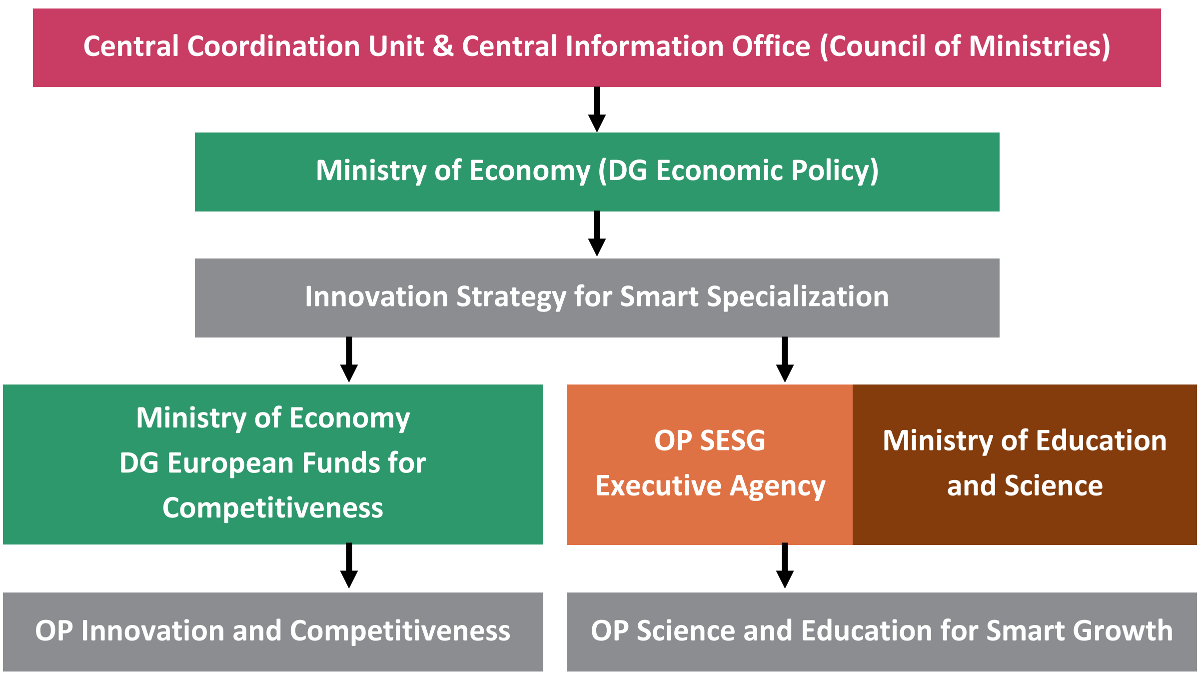
EU Operational Programmes

OP Science and Education for Smart Growth (OP SESG)

OP SESG is managed by an Executive Agency under the Ministry of Science and Education. The Executive Agency is a 115-person autonomous administrative unit that was established in order to separate management of the OP from one of the main beneficiaries of the Programme – the Ministry itself. This was the result of a mid-term audit of OP SESG, which revealed mishandling of the funds and led to the European Commission freezing all payments. The Executive Agency also has a network of 15 regional representatives at the district level, who are part of the network of Regional Education Inspectorates.

OP Innovation and Competitiveness (OP IC)

Figure 78. Governance structure of OP IC and OP SESG



Source: Authors' compilation based on the official versions of OP IC and OP SESG and the MAs' websites

OP IC is managed by the "European Funds for Competitiveness" Directorate-General under ME. The DG is a 222-person specialized administrative office within ME (the biggest unit within the ministry) and is responsible for coordination and monitoring and evaluation of the OPIC, as well as supporting the work of the OP Monitoring Committee. The ME's "Economic policies" Directorate-General Economy is responsible for, among other policy areas, smart specialization policy. The two directorates exchange data collected on the implementation of OP IC, which is used to update and report on the implementation of the IS3.

Budgetary Support for STI

Table 20. STI Instruments Administered by Operational Programmes by Allocated Budget, 2014-2019

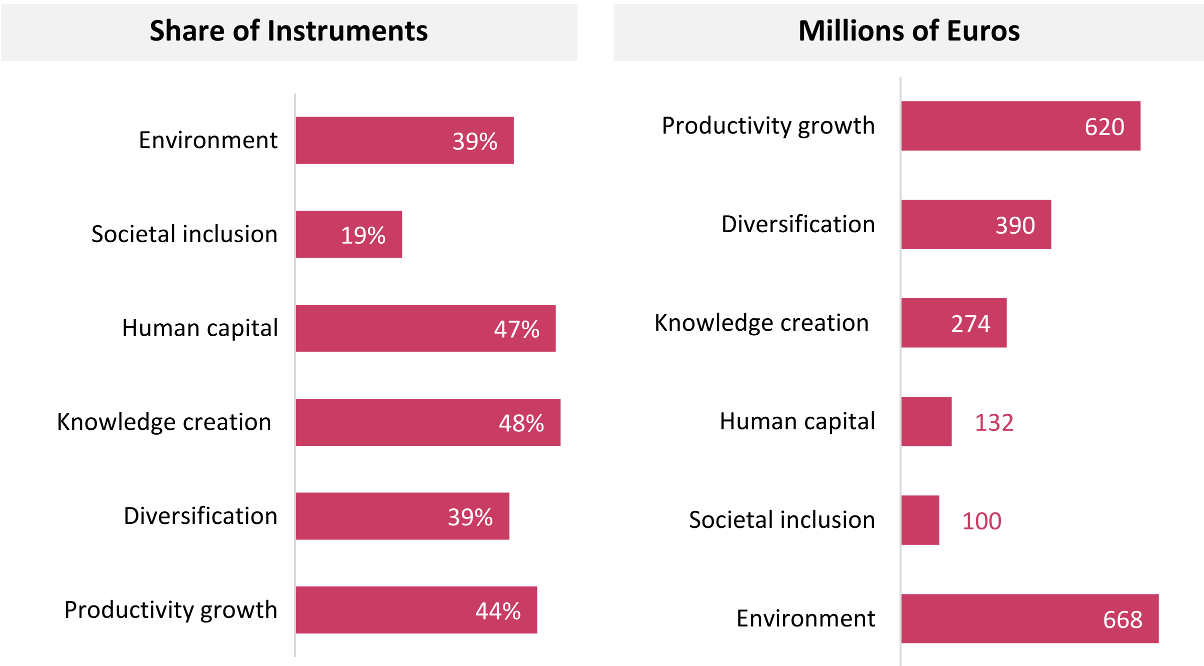
Operational Programme	# of Instruments	Allocated Budget	Share of STI Budget
OP Innovation and Competitiveness 2014-2020	40	€ 1,067,363,186	66.5%
OP Science and Education for Smart Growth 2014-2020	3	€ 219,987,307	13.7%
Operational Programme Human Resource Development 2014–2020	2	€ 16,233,740	1.0%
Instruments not part of Operational Programme	143	€ 300,229,933	18.7%

Source: Authors' calculation | Note: The two instruments included under the OP HRD are "Risk-sharing Micro-Finance facility" and "Support for entrepreneurship". The full list of STI instruments included in this report is available in Appendix I.

APPENDIX VI. DETAILED DESCRIPTION OF INNOVATION INSTRUMENTS

Instruments are relatively evenly spread across six economic/societal outcomes, with between 35-50 percent of instruments targeting productivity growth, economic diversification, knowledge creation, human capital, and/or environmental outcomes (Figure 79). Only 19 percent of instruments target societal inclusion outcomes. However, when looking at outcomes by disbursed funding, instruments targeting environment and productivity growth objectives accounted for over €600 million, while no other outcomes received more than €400 million in disbursed funding. The high levels of disbursed funding for these outcomes are due to the very large size (in terms of funding) of the "Improving the production capacity of SMEs" and "Energy Efficiency for SMEs" instruments, which both target these two outcomes. Human capital and knowledge creation, which are targeted by the largest number of instruments, ranked 4th and 5th in outcomes by disbursed funding, indicating that the instruments that target these outcomes are relatively small in funding size.

Figure 79. Instruments are evenly spread across economic/societal outcomes (left), but productivity and environment stand out in terms of disbursements (right), 2014-19



Source: Authors' calculation

Instruments also target one or more intermediate objectives. The leading objectives by share of instruments are skills formation, research excellence, and environment, which are targeted by over 30 percent of instruments (Figure 80). However, environment is by far the leading objective by disbursed funding, receiving €645 million; no other objective received more than €350 million – this is again largely due to the very large size (in terms of funding) of the "Improving the production capacity of SMEs" and "Energy Efficiency for SMEs" instruments. Other leading objectives by disbursed funding are technology adoption and diffusion (€346 million), management practices (€275 million), research excellence (€275 million), and regional development (€273 million).

Research and commercialization activities (including research services, technology transfer, testing, certification and standards, and product development) are the leading activities supported by STI instruments by both share of instruments and by disbursed funding (Figure 81). Activities that support non-R&D capital expenses (such as purchases of machinery and software and injections of working capital) are also leading activities by disbursed funding.

Figure 80. Instruments by intermediate objective and disbursed funding, 2014-19

Share of Instruments

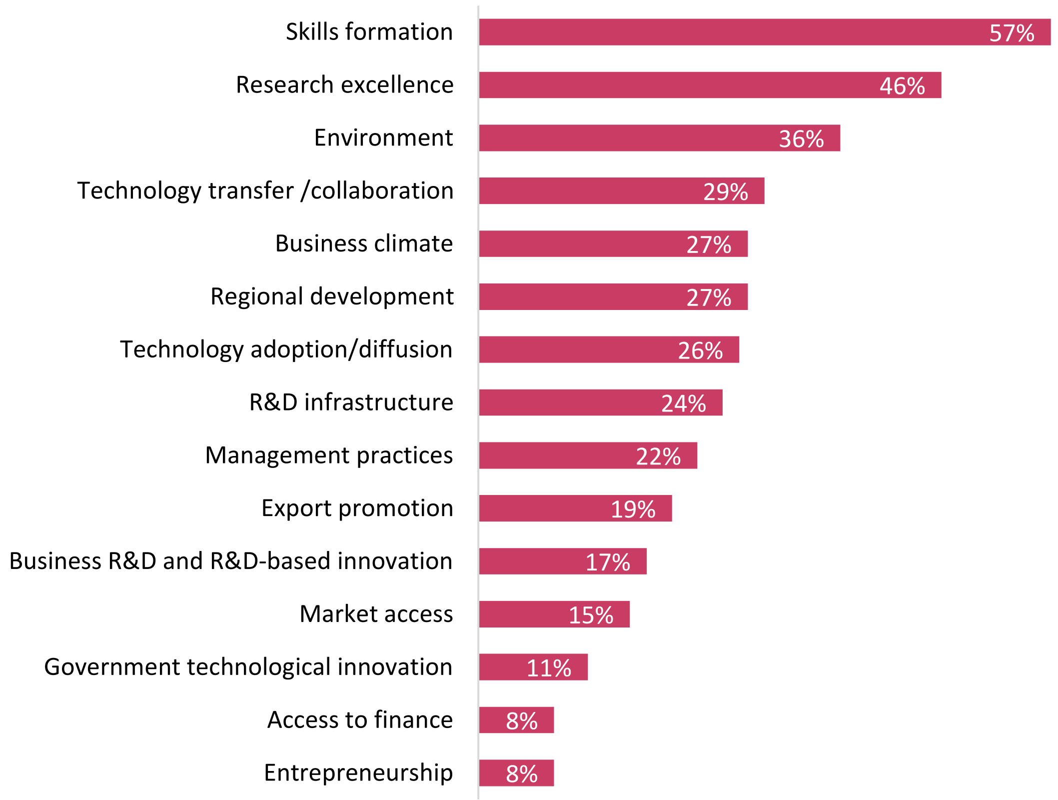
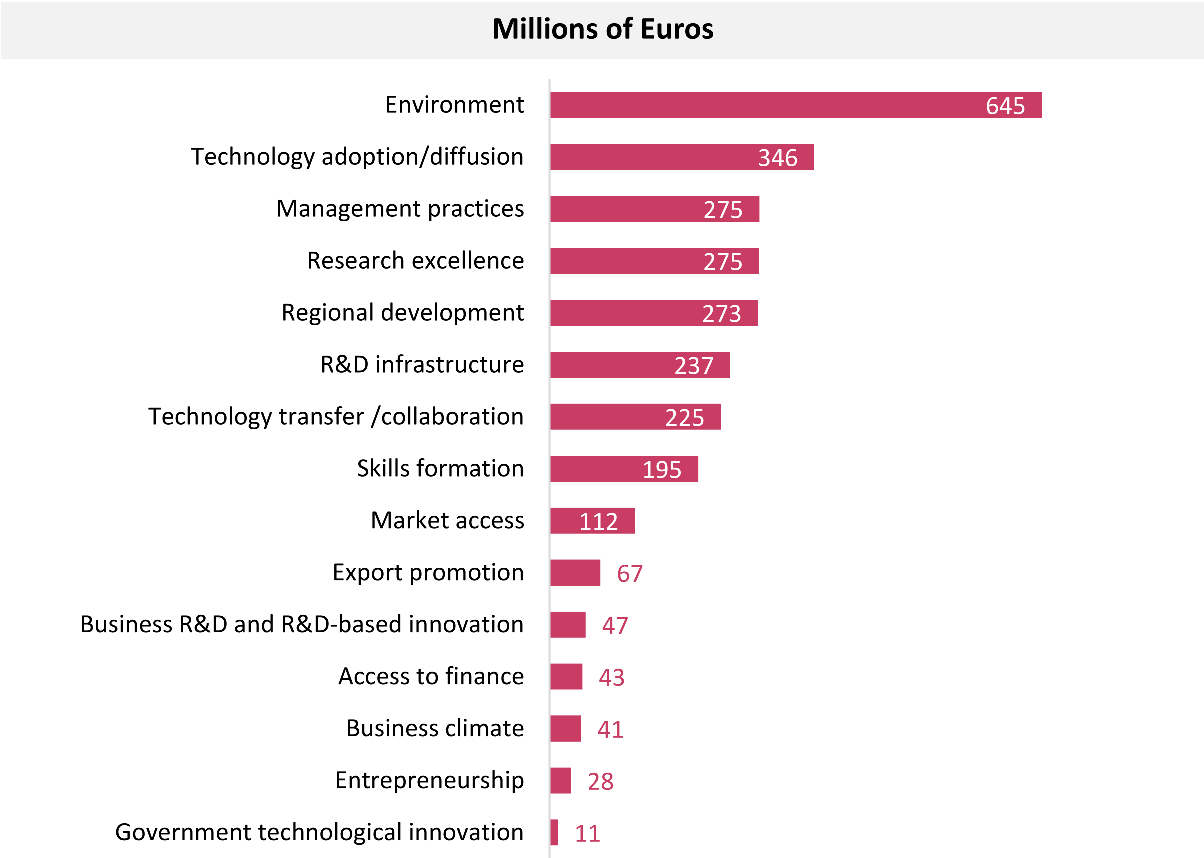
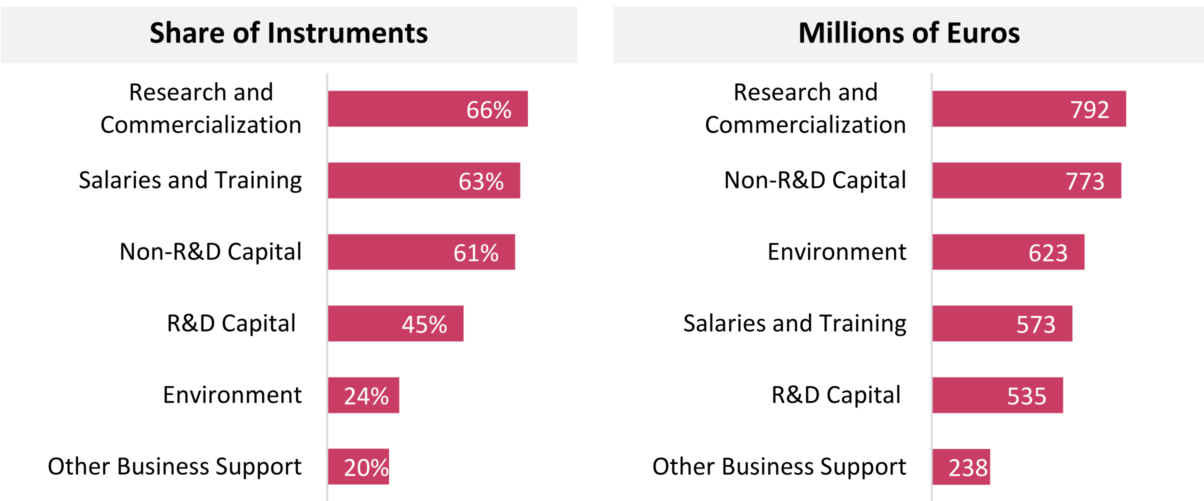


Figure 80. Instruments by intermediate objective and disbursed funding, 2014-19



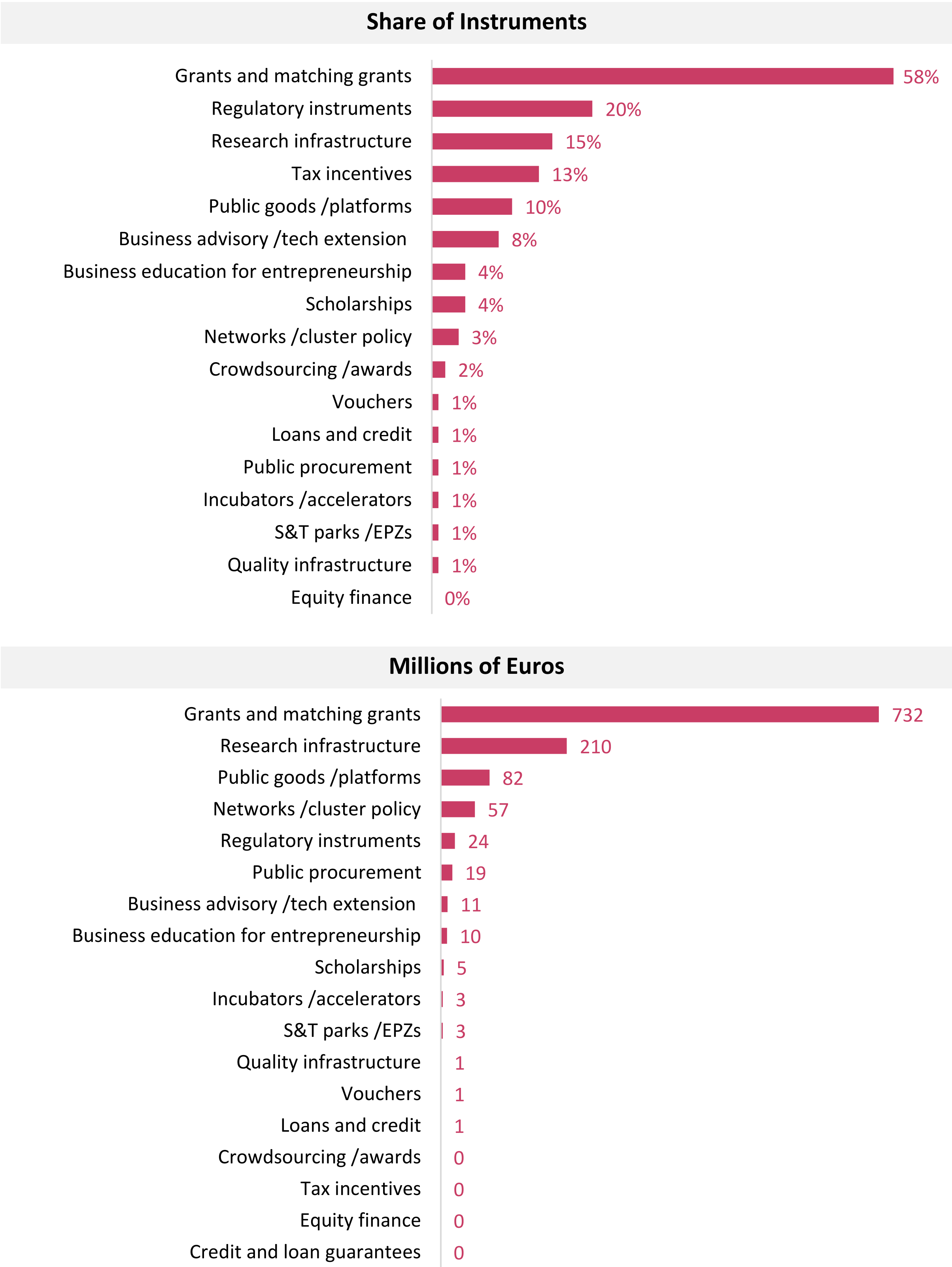
Source: Authors' calculation

Figure 81. Research and commercialization accounted for the largest share of instruments and disbursed funding, 2014-19



Source: Authors' calculation

Figure 82. Grants and matching grants dominate instruments and disbursed funding, 2014-19



Source: Authors' calculation

The instrument mix is dominated by grants and matching grants, which are by far the most common type of instrument both by share of instruments and by disbursed funding (Figure 82). Regulatory instruments, research infrastructure, tax incentives, and public goods and platforms (such as websites and registries) are used by between 10-20 percent of instruments. Research infrastructure, with disbursed funding of €210 million, is the only instrument type except grants with disbursed funding above €85 million. Note that, by their nature, tax incentive instruments had no funding disbursed and this report did not attempt to calculate the tax benefits of such instruments.

Formal firms are the largest recipients of disbursed funding. While universities, research institutes, and formal firms are the leading direct beneficiaries by number of instruments, with 37 percent of instruments targeting these groups (Figure 83), formal firms are the largest beneficiaries in terms of disbursed funding received with €538 million. Despite the fact that universities, research institutes, private research entities, and researchers were targeted by a large share of instruments, these beneficiaries received far less in terms of disbursed funding than formal firms. This is because four of the five largest instruments in terms of disbursed funding, including the two largest instruments ("Improving the production capacity of SMEs" and "Energy Efficiency for SMEs") target formal firms, while research-focused instruments tend to be smaller in size (in terms of funding).

Figure 83. Formal firms are the largest recipients of funding, 2014-19

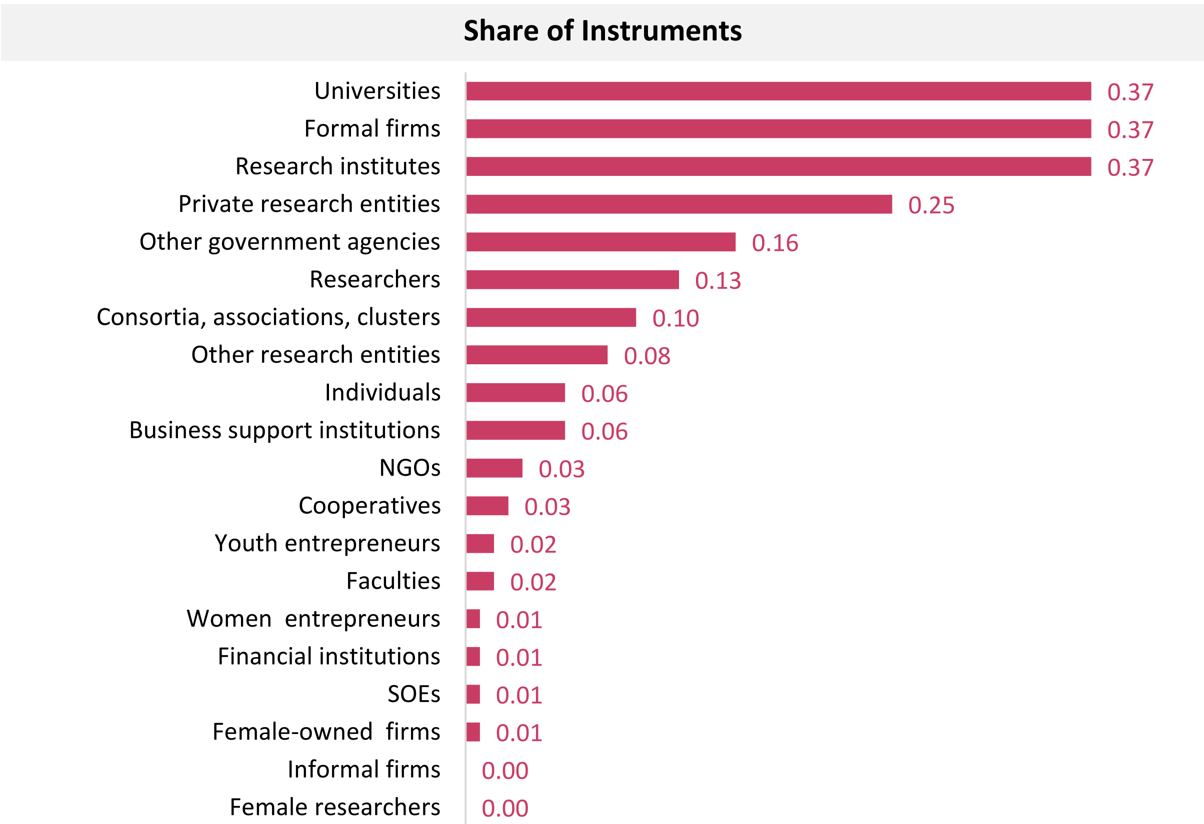
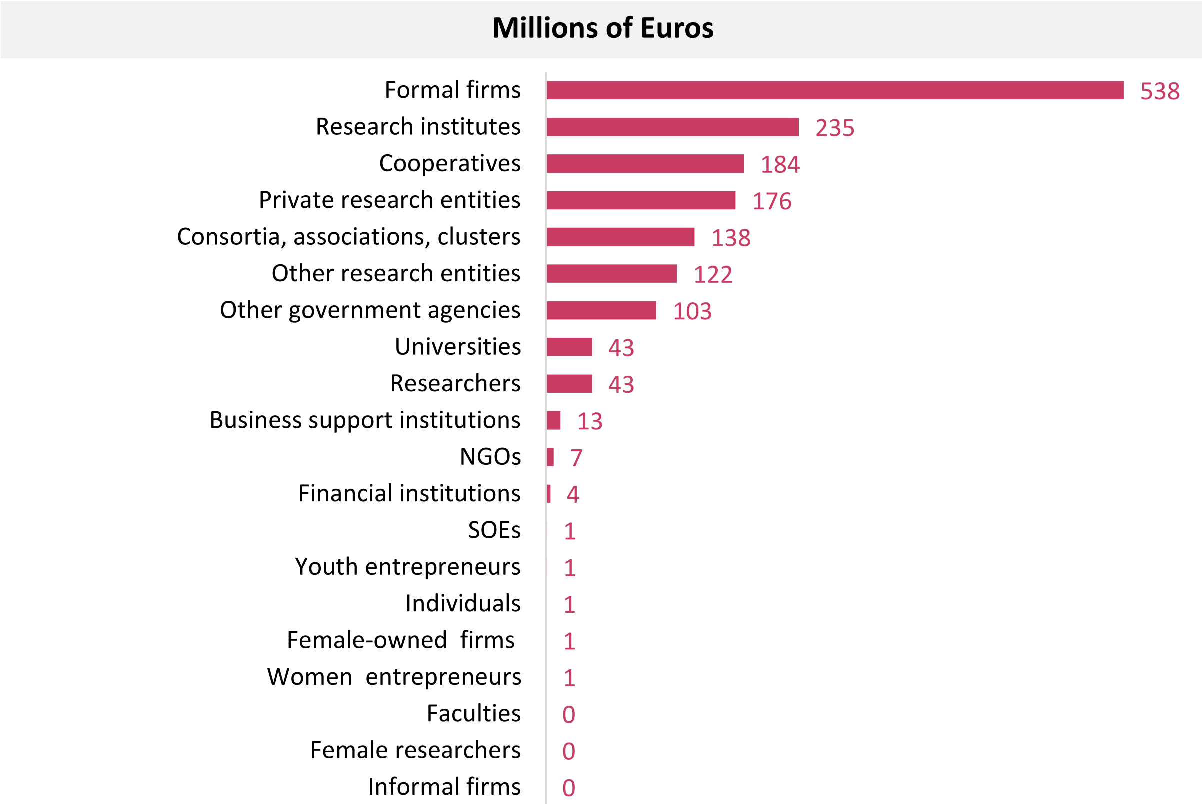


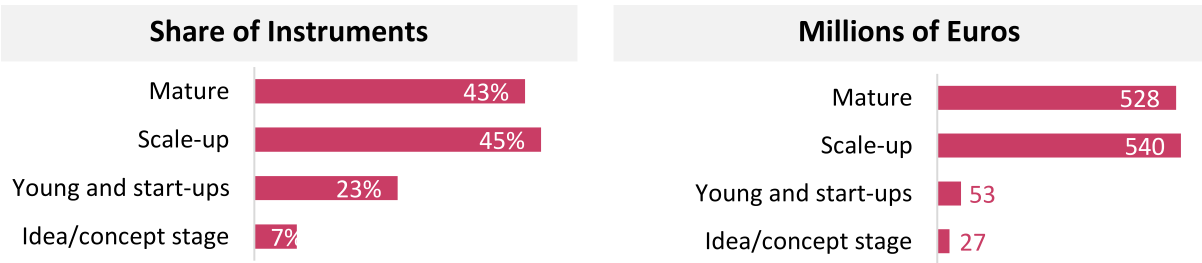
Figure 83. Formal firms are the largest recipients of funding, 2014-19



Source: Authors' calculation

Instruments tend to target firms in the scale-up (45 percent) and mature (43 percent) stages of firm development, as opposed to the startup stage (23 percent) or idea/concept stage (7 percent) of development (Figure 84). This is also reflected in disbursed funding where instruments targeting scale-up and mature stage firms disbursed more than €500 million, while those targeting the start-up stage also disbursed €53 million and the idea/concept stage €27 million.

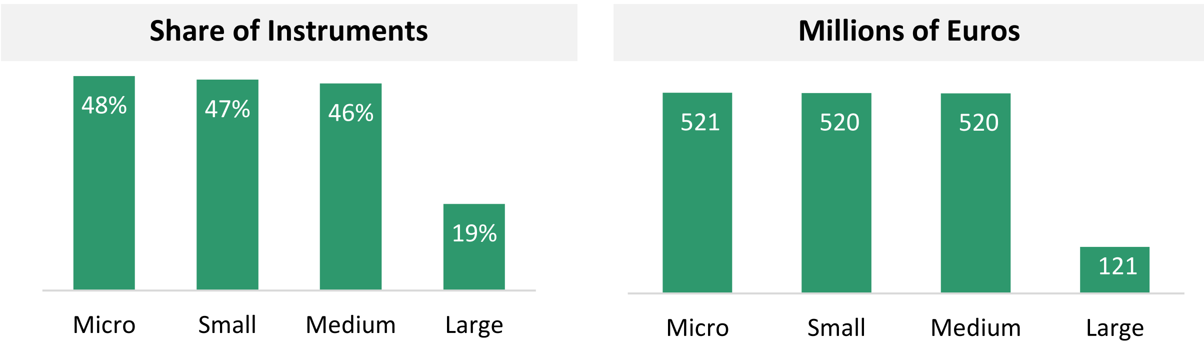
Figure 84. Start-ups and young firms account for a small share of STI instruments and disbursements, 2014-19



Source: Authors' calculation

A roughly equal share of instruments target micro, small, and medium sized firms (between 46-48 percent of instruments), while only 19 percent target large firms (Figure 85). This is very similar to disbursed funding levels, where instruments targeting micro, small, and medium sized firms disbursed between €520-521 million, far more than the €121 million disbursed to large firms.

Figure 85. Large firms account for a small share of STI instruments and disbursements, 2014-19



Source: Authors' calculation

The majority of instruments (81 percent) had no sectoral focus, while 14 percent of instruments had a smart specialization focus and between two and five percent of instruments focused on manufacturing, agriculture, knowledge-intensive services, or other sectors (Figure 86). No instrument focused on non-knowledge intensive services. Instruments not targeted to any specific sector were also the largest by disbursed budget, followed by smart specialization- and manufacturing-focused instruments.

Figure 86. Most instruments had not sectoral focus, 2014-19

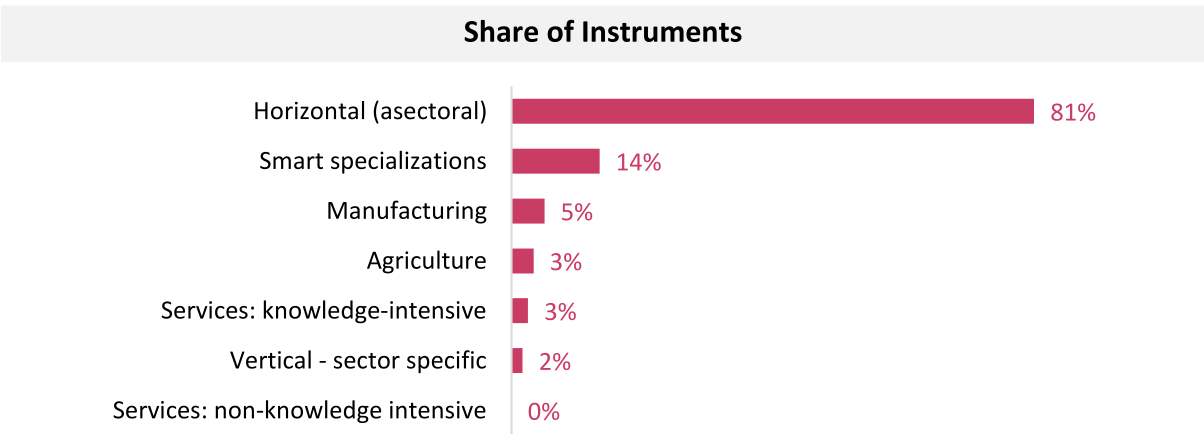
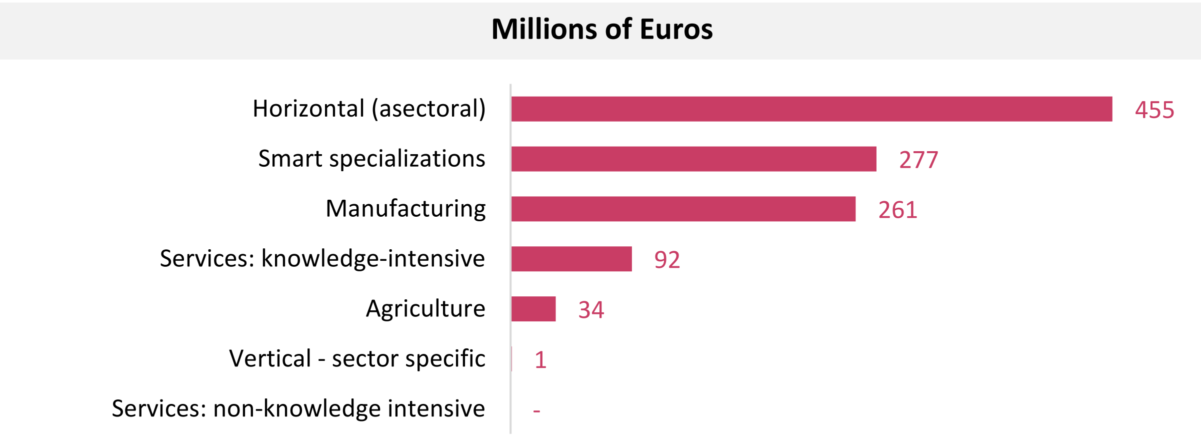


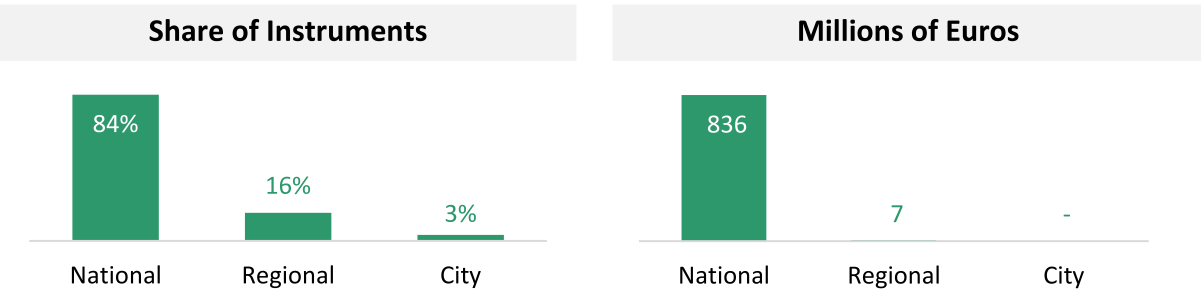
Figure 86. Most instruments had not sectoral focus, 2014-19



Source: Authors' calculation

A large majority (84 percent) of instruments have a national focus, while 16 percent of instruments have regional focuses and 3 percent city focuses (Figure 87). Nationally focused instruments are also the largest by disbursed funding, with €836 million, while regionally focused instruments only disbursed €7 million. Instruments that targeted cities were exclusively regulatory instruments, and thus had no disbursed funding associated with them.

Figure 87. Most instruments and almost all disbursements were for national projects, 2014-19

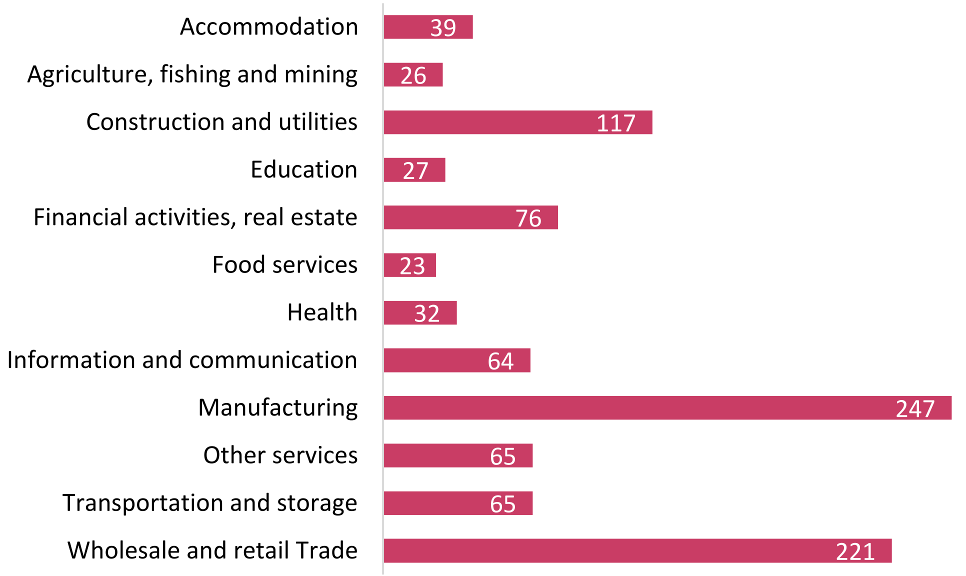


Source: Authors' calculation

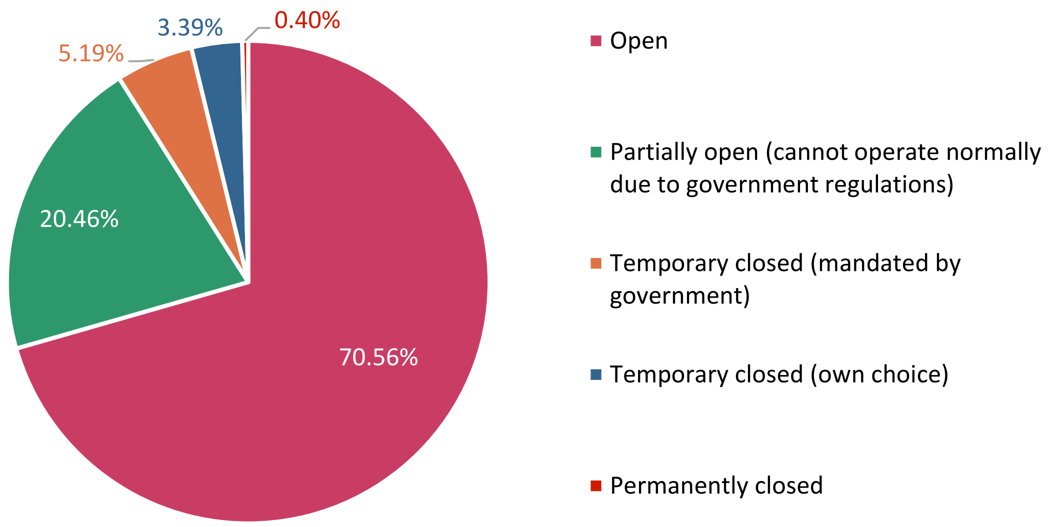
APPENDIX VII. ADDITIONAL BUSINESS PULSE SURVEY RESULTS

Figure 88. Sectoral Distribution of the Respondents and Firm's Operational Status

Sectoral Distribution



Firm's Operational Status



Source: Authors' calculation

Table 21. Description of Firm Size Classes

	#Firms	Avg. Size	Avg. Age	Std	Min	Max
micro <10	454	4	13	3	0	9
small [10,50)	363	22	19	10	10	49
medium [50,250]	149	100	24	49	50	250
large >250	36	992	28	1603	253	9000

Source: Authors' calculation

Figure 89. Firm closure rate, female employment and the share of firms started using or increased the use of internet, online social media, specialized apps, or digital platforms

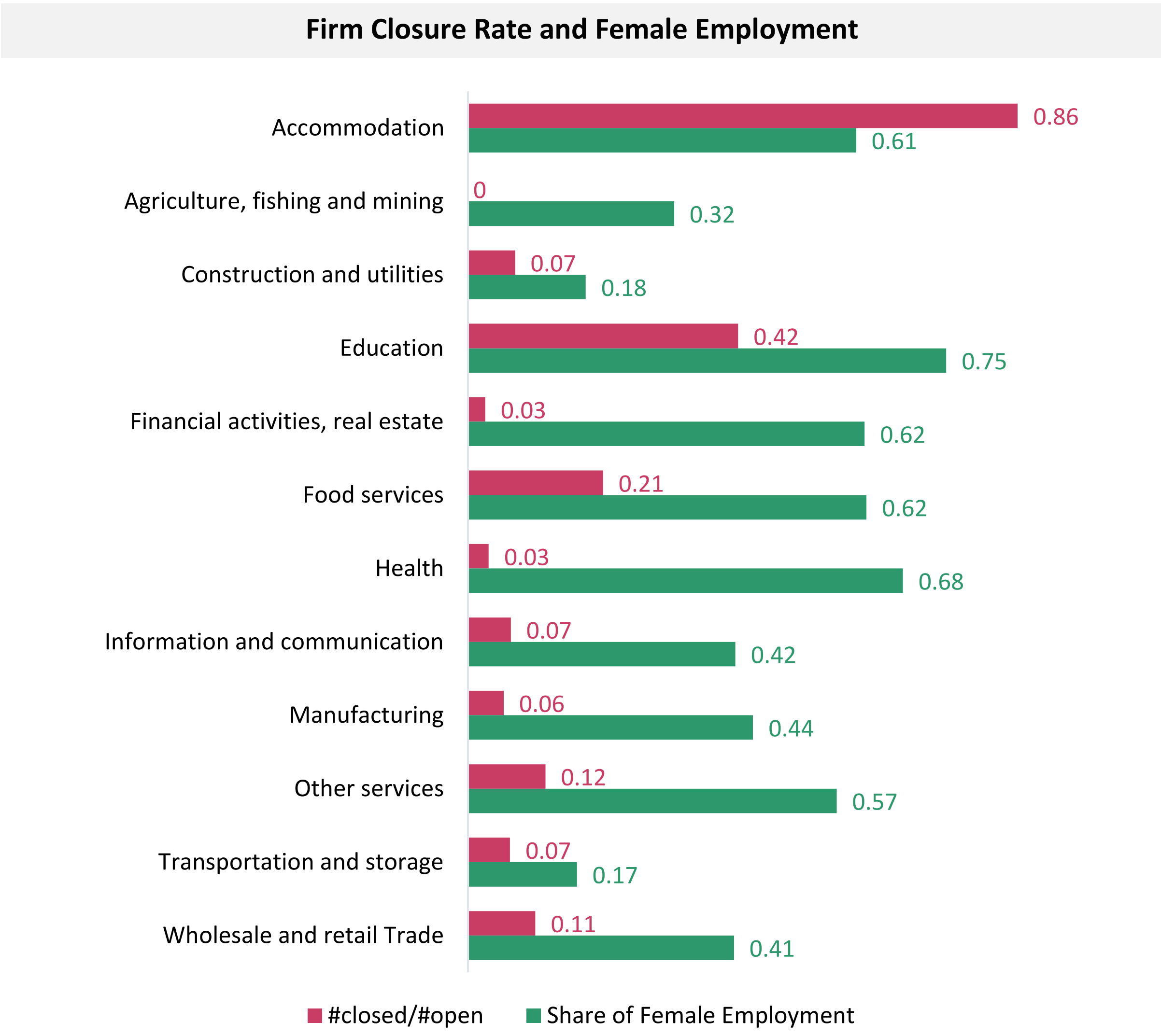
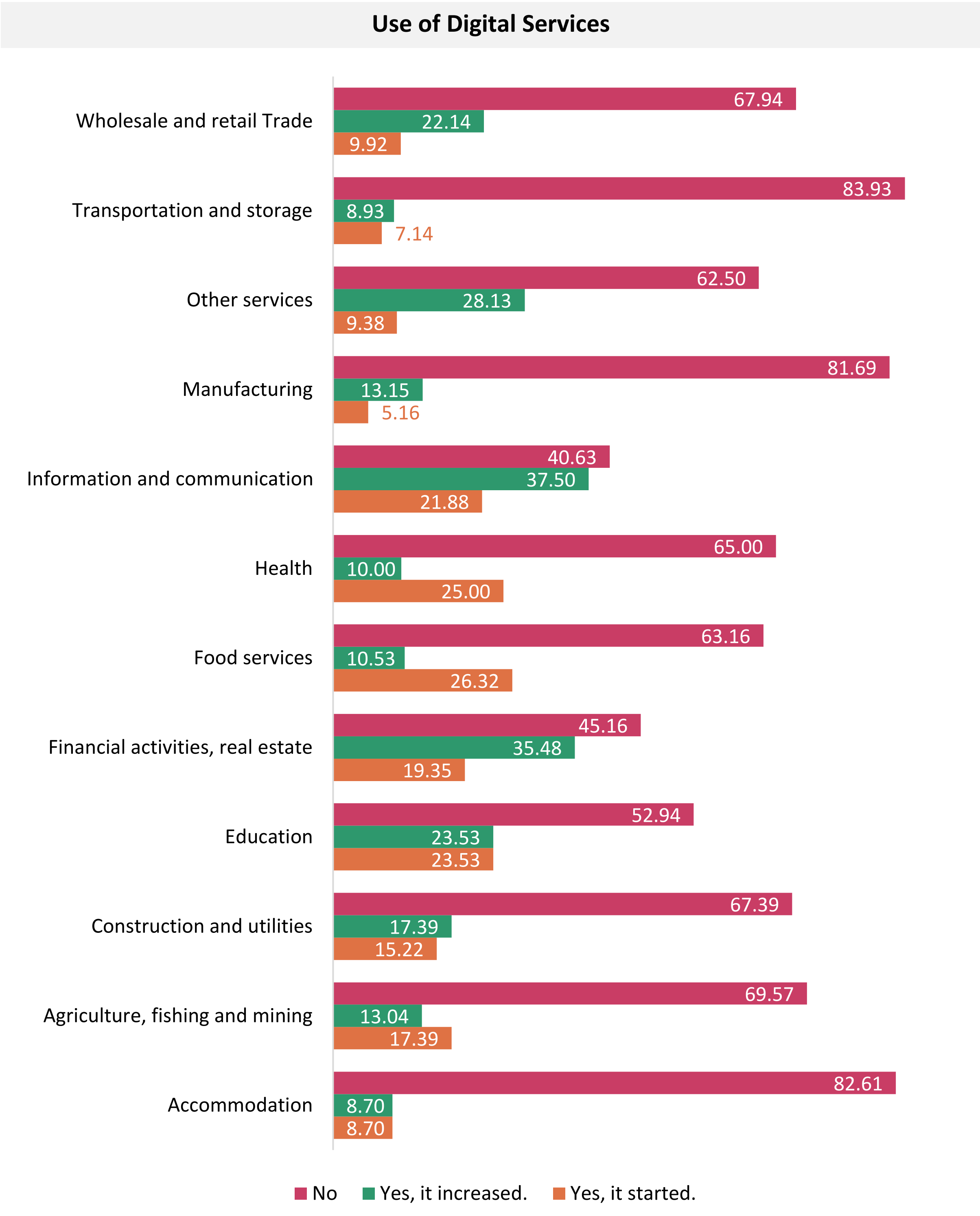


Figure 89. Firm closure rate, female employment and the share of firms started using or increased the use of internet, online social media, specialized apps, or digital platforms



Source: Authors' calculation

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