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Innovations for a Digital
and Green Transition

EDITORS

Prof. Teodora Georgieva, Senior Expert, *Innovation.bg* Group, Applied Research and Communications Fund, Department of Economics and Business Administration, Sofia University "St. Kliment Ohridski"
Ruslan Stefanov, Coordinator, *Innovation.bg* Group, Applied Research and Communications Fund

AUTHORS

Prof. Teodora Georgieva, Senior Expert, *Innovation.bg* Group, Applied Research and Communications Fund, Department of Economics and Business Administration, Sofia University "St. Kliment Ohridski"
Assoc. Prof. Todor Yalamov, *Innovation.bg* Group, Department of Economics and Business Administration, Sofia University "St. Kliment Ohridski"

INNOVATION.BG WORKING GROUP

Dr. Todor Galev, Senior Analyst, Economic Program, Center for the Study of Democracy
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Denitsa Marinova, Project Manager, Applied Research and Communications Fund
Maya Tsaneva, Expert, Applied Research and Communications Fund
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Assoc. Prof. Todor Yalamov, Department of Economics and Business Administration, Sofia University "St. Kliment Ohridski"

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LIST OF ABBREVIATIONS

AKIS	Agricultural Knowledge and Innovation Systems
BAS	Bulgarian Academy of Sciences
CRM	Customer relationship management
DESI	Digital Economy and Society Index
EC	European Commission
EDIH	European Digital Innovation Hubs
EIP-AGRI	The agricultural European Innovation Partnership
EIS	European Innovation Scoreboard
EU	European Union
FAO	Food and Agriculture Organization
GDP	gross domestic product
GII	Global Innovation Index
ICT	information and communications technologies
IPC	International Patent Classification
MFF	Multiannual Financial Framework
NACE	Statistical Classification of Economic Activities in the European Community
NGEU	NextGenerationEU
NSI	National Statistics Institute
NUTS	Nomenclature of territorial units for statistics
p.p.	percentage points
PORB	Patent Office of Republic of Bulgaria
R&D	research and development
R&D&I	research, development and innovation
SME	small and medium-sized enterprise
STEM	science, technology, engineering and mathematics
USA	United States of America
WIPO	World Intellectual Property Organization

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EXECUTIVE SUMMARY

The findings of the European Innovation Scoreboard (EIS) in 2022 show the impact of the global challenges of the last few years on the European economies and the state they are in at start the new EU financial and programming period 2021-2027. The economic crisis and the **disruption of the global supply chains** caused by the Covid-19 pandemic and Russia's invasion of Ukraine have led to a decline in some of the indicators of the EIS's composite Innovation Index. This affected primarily public and private investment in innovation. Public investment was very often redirected to the most affected sectors in the form of social payments. In Bulgaria, for example, the government chose to finance the selection of regional innovation centres at the expense of social welfare measures. Private investments in innovation offset operating losses from closed businesses and declines in orders and the availability of labour.

Bulgaria's overall performance improved compared to both 2015 (1.5%) and 2021 (3%). However, this is insufficient to advance its positions in Europe given the growth of the innovativeness of the European economy by 9.9%. In 2022, Bulgaria is again in the penultimate place among the member states, ahead of only Ukraine, Bosnia and Herzegovina, and Albania. The country's innovation performance is even weaker compared to that of candidate countries – North Macedonia, Montenegro and Serbia – despite the fact that the countries of the Western Balkans have much more limited access to European structural funds, which is what Bulgaria mainly relies on for financing its scientific and innovation policy.

Innovation.bg has repeatedly commented on the country's lack of progress on EIS indicators and the need to either find more appropriate tools to measure the innovativeness of the country's economy, or to significantly improve the quality of the innovation policy and its implementation. The EIS is the official tool chosen by the Bulgarian government as a scale for assessing the innovation potential of the national economy and the progress towards reaching the average European levels in this respect. The fact of **falling behind these levels is a harsh verdict on the innovation policy and practice** of the last financial and

programming period 2014-2020. In this respect, an improvement can hardly be expected. At the beginning of the third year of the current programming period, the Innovation Strategy for Smart Specialisation 2021-2027 – the framework document that sets the priorities and thematic areas of impact for the country's innovation policy – has not yet been adopted and is not applied. Given the political instability and overall **lack of vision and strategic goals** for the development of Bulgaria's science and innovation system, the country can hardly be expected to change its positions in the EIS significantly, such as moving into the moderate group innovators in the next decade.

The growth of GDP in 2021 (BGN 139.012 billion at current prices), increasing inflation and the revision of the data by the National Statistical Institute (NSI) worsened the picture of the funding for scientific research, technological development and innovation in Bulgaria. For the first time, **R&D investment crossed the threshold of BGN 1 billion**, marking an annual increase of BGN 50 million, but **its share in GDP fell to 0.77**% in 2021.

The **competitiveness of Bulgarian organisations in European programmes for science and innovation is growing**. Since the launch of the Horizon 2020 framework programme of the EU, the Bulgarian organisations which implemented coordination or partner projects funded by it received a total of EUR 161.9 million (0.24% of the programme budget) within 664 grant agreements (1.87% of all contracts). The success rate of the projects with Bulgarian participation is 11.14%, close to the EU average of 11.95%. In terms of funding received from Horizon 2020, business performs best (306 organisations, 32.3% of the funding), followed by scientific organisations (230; 29.1%) and higher and secondary schools (184; 25.3%). With nearly 7% of the attracted funding, public institutions rank fourth. As of November 2022, there are 148 participations and the success rate is already 20.41%. Eighty-six grant agreements were signed raising EUR 18.7 million.

Despite the series of policy documents and reforms in the field of human resources in Bulgaria the **challenges in this field remain extremely serious** and the country continues to fall behind global developments. The demographic collapse and the negative migration balance led to a decline in the number of secondary school graduates. Combined with the propensity of Bulgarian students for applying to foreign universities, in 2021 this caused **a fall of 20% (compared to 2017) in the number of bachelor's graduates** (a total of 23,269 people). There is also a drop in the numbers for scientific and technological fields of education, in most cases more serious compared to the general decline of those who completed higher education.

Along with the deterioration of the profile of the cohort of university graduates who would engage in the development and application of technological innovations, there is also **a high level of de-skilling of the adult population**. Since Bulgaria is well below the average EU levels in the share of those participating in lifelong learning (4% vs 10.8% EU average) this would widen the gap with the rest of the Union as regards the country's innovation potential and capacity to develop competitive advantages based on new technologies.

In 2021, the personnel engaged in R&D in Bulgaria amounted to 34.6 thousand people. Almost half of R&D personnel (46%) worked in enterprises where 66% of R&D spending is made. The latter is almost entirely directed to cover current costs, including wages. This makes the **professional career of highly qualified staff in the business sector more attractive** compared to government-funded research units. The second largest employer of 28% of researchers is higher education, which includes 52 accredited public and private higher education institutions. The sector has only 6% of the funding for R&D in the country, 20% of which is used for investment purposes.

As a result of the availability of EU funding after 2007, a **dynamic startup ecosystem** developed in Bulgaria. Bulgaria has 1,600 startups, compared to Greece with 1,700 and Romania with 2,800. Bulgaria has, however, the highest number of newly created jobs in startups (per 100,000 population) – 80, while Greece has 60 and Romania 45. Bulgarian startups attract foreign talent, some of whom later decide to start their own business. The country has 20% of the market for startup jobs in Southeast Europe and has a high potential for growth, especially if the government makes it easier for foreign students to enrol in Bulgarian universities. The decline in investment in startups in 2022 deserves special attention. It could be due to the reduction of public funding and the general insecurity caused by Russia's invasion of Ukraine.

According to research carried out for the European Commission, 54% of enterprises in Bulgaria use at least one of ten **artificial intelligence technologies**, with an average for Europe of 42%, which **places the country in the top three positions in Europe**. Almost a third (31%) of enterprises in Bulgaria used at least two technologies, compared to an average for Europe of 25% (8th place on the continent). Artificial intelligence technologies cannot be used without reliable and secure cloud technologies. Although cloud services and virtualisation are widely available in Bulgaria, only 12.8% of SMEs claim to be using cloud services, compared to 41% in Europe. In this regard, the distance between SMEs and large companies in Bulgaria is considerable.

An important development last year was the increased share (almost a third – 32%) of small and medium-sized enterprises that sell online not only in Bulgaria, but also in other countries of the European Union. This shows a significant internationalisation of businesses that are online. By comparison, less than 5% of all businesses in the economy export.

INTRODUCTION

The *Innovation.bg* report provides an annual assessment of the innovation potential of the Bulgarian economy in Europe and of the status and opportunities for development of the Bulgarian innovation system. It makes recommendations for improving public policy on innovation in Bulgaria and in the EU, drawing on the latest theoretical and empirical research and taking into account the specific economic, political, cultural and institutional framework within which the country's innovation system is developing.

Over the last 18 years, *Innovation.bg* has made a number of concrete proposals for improving the innovation policy and practice in the country, which have been supported by the government, business, the scientific community and the European Commission. Still, there has been no breakthrough in national innovation policy, as it remains almost entirely dependent on EU vision, instruments and funding. EU membership led to the development and implementation of the first comprehensive innovation strategy of the country – the Innovation Strategy for Smart Specialisation 2014-2020. Its successful continuation and a sustainable economic growth through innovation requires stronger private sector efforts and overcoming the serious institutional weaknesses in the development and implementation of public policies in this area.

As in its previous editions, *Innovation.bg 2022* analyses the state and opportunities for development of the national innovation system on the basis of four groups of indicators:

- gross innovation product;
- entrepreneurship and innovation networks;
- investment and financing of innovation;
- human capital for innovation;
- information and communication technologies.

Agriculture – a sector for high-tech applications

The agricultural sector[1] provided 4.3% of gross value added (GVA), just over 6% of employment and 17% of total exports of Bulgaria in 2021. It provides a significant share of the resources of a number of related industries and activities, including furniture industry (24%), food industry (20%), chemical industry (6%), paper and cardboard production (3%), textile industry and pharmaceutical production (1% each). Nearly 50% of the country's territory is used for agriculture[2].

Table 1. MAIN INDICATORS FOR THE AGRICULTURE, FORESTRY AND FISHING SECTOR, 2019

Indicator	Bulgaria	Europe
Share of added value in GDP, %	4.20	1.60
Cultivable areas in thousand hectares per person of the population	0.50	0.40
Share of irrigated areas in the total cultivated land, %	2.70	5.70
Share in total employment, %	6.60	5.20
Share of women, %	30.00	34.90
Gross fixed capital formation as a share of value added (2015 US dollar prices) (percentage)	28.40	30.30
Share of public expenditure, %	3.10	
Use of pesticides, kg. per hectare of cultivated area	1.84	1.66
Use of inorganic fertilisers, kg. per hectare of cultivated area	130.10	80.00

Source: FAO, 2021, World Food and Agriculture – Statistics Yearbook 2021, Rome.

[1] According to NACE.BG-2008, the agricultural sector includes the economic activities with code 01 "Crop breeding, animal breeding and hunting; ancillary activities". Often the statistics are at level A "Agriculture, Forestry and Fisheries".

[2] According to data from NSI and the Ministry of Agriculture, 2022. The data refer to the "Agriculture, Forestry and Fisheries" sector.

Global challenges to the development of the agricultural sector and agri-food chains

Russia's war against Ukraine has caused major upheavals in a number of global agricultural markets, fuelled inflationary trends and raised fears of social tensions and a humanitarian food catastrophe in the world's poorest countries. This focused attention on the key importance of global trade in agricultural commodities and the importance of the sector to the global social balance. Some of the most significant challenges facing humanity have a direct impact on the development of the agricultural sector:

- climate change and decline in agricultural productivity

The production of agricultural products seriously threatens the stability of the climate and the sustainability of ecosystems and is a serious factor in the deterioration of the environment.

Over the past 50 years, greenhouse gas emissions from agriculture, forestry and other land use have doubled. Projections suggest a further increase until 2050. Climate change and increased natural disasters – alternating droughts and floods and rising temperatures – are leading to reduced yields, thus straining food supply chains and threatening food security.

- scarcity of natural resources

Agricultural land globally is becoming increasingly unsuitable for productive activity: 25% of all agricultural land is now rated as severely degraded, while another 44% is moderately or slightly degraded. Water resources are increasingly limited, with more than 40% of the world's rural population living in areas with drinking water scarcity. Approximately 80% of global deforestation is the result of increasing arable land.

- increase in population and growth in food needs

In the coming decades, the world population is expected to grow by 33% to almost 10 billion in 2050. Population growth will increase the demand for food, even under a modest economic growth scenario, by approximately 50% over the levels of the last decade. This trend is accompanied by increasing levels of urbanisation and changes in the diet of the urban population towards a higher demand for animal protein.

- food waste and environmental pollution

Between 33% and 50% of all food produced globally is never eaten, and the value of wasted food is more than $1 trillion. At the same time, 800 million people go to bed hungry every night. They can feed themselves with less than a quarter of the food wasted in the USA, UK and Europe combined. According to data from the United Nations Food and Agriculture Organization (FAO) food waste is the third largest source of greenhouse gases after China and the United States.

As a result, farmers are faced with the double challenge of producing food in a cost-effective way, while protecting nature and biodiversity.

Technological factors for the growth of the agricultural sector

Technological innovations play a decisive role in the development of the agricultural sector. The application of high-tech products and services contributes significantly to increasing the productivity of the sector and to the more efficient use of resources such as land, water, fuels, fertilisers and pesticides.

Table 2. BASIC TECHNOLOGIES OF AGRICULTURE 4.0

Precision farming	Smart farming	Digital farming
An integrated management system based on digital technologies for monitoring and optimising production in agriculture. The resources used are tailored to the specific needs of the culture, they are applied in the right place, at the right time and in the right amount, avoiding unreasonable soil treatment and the application of unnecessary amounts of fertilisers and preparations.[3]	Application of information technology to optimise complex agricultural systems. Covers all farming operations – soil and plant conditions, terrain, climate, weather, resource use, labour, finance and more. The focus is on accessing real-time analytical data and using it to make management decisions.	The main goal of digital agriculture is the creation of added value based on data. It ensures the establishment of internal and external farm connectivity and the use of web-based data exchange platforms in order to automate processes in a sustainable manner. Digital agriculture applies the technologies of Industry 4.0, but takes into account the specifics of agriculture, dictated by the influence of natural and biological factors.
Precision farming technologies include, but are not limited to, the following: • Global Navigation Satellite System (GNSS) and Global Positioning System (GPS); • geographic information systems; • management of variable characteristics (variable rate technologies); • wireless sensor networks; • sensors, monitors and controllers for agricultural machinery; • a variety of software systems with options for the office, mobile devices and wireless communications; • big data analytics.	The technologies of precision farming plus: • internet of things; • artificial intelligence; • smart control devices (on-board computers); • automation; • communication technology (telematics); • unmanned technologies.	The technologies of precision and smart farming, together with: • physical products enhanced with additional non-physical services with new algorithms being developed to transform data into value-added information, optimisation of products and agronomic process, reducing the risk and limiting vulnerability to external influences such as machine failure, weather and disease; • agricultural ecosystems with platforms combining data from multiple sources in the field/farm or external sources. The farmer monitors operations on a dashboard in real or near-real time and makes decisions based on quantitative hypotheses to increase financial output; • cooperation between different actors in the agri-food chain. Data brings ecosystem actors together to deliver value along the food supply chain. Customised services are provided depending on the needs of different stakeholders based on the same data.

Source: Applied Research and Communications Fund

[3] Precision agriculture and the future of farming in Europe, Scientific Foresight Study, Brussels, European Union, 2016, ISBN 978-92-846-0475-3, doi: 10.2861/020809.

Agriculture is the art, science, and set of practices for cultivating soil and raising domesticated plants and animals. The evolution in agriculture marks the main stages in the development of human civilization, the changes in the way of life, the transformation in social and industrial relations.

Conventional agriculture provides high productivity, but often at the cost of depleted or eroded soil, polluted or drying water sources, between 20% and 40% of greenhouse gas emissions. The combined application of modern technologies leads to the creation of new and improved production methods, management practices, products and services that reduce the harmful footprint of the sector on the environment and spare natural resources and biodiversity.

Today, agriculture has become associated with the principles of precision and smart agriculture and their transformation into digital agriculture. Precision farming is a "technological approach to agricultural management that monitors, measures and analyses the needs of individual fields and crops"[4]. In turn, smart farming extends the scope of the application of information technologies to all processes in the agricultural sector by optimising complex agricultural systems through the intelligent interpretation and use of data.

Digital farming combines the methods of precision and smart agriculture by providing internal and external networking of farms and the use of web-based data platforms along with big data analysis. Digitisation allows farmers to share information with suppliers and customers, which in turn is the basis for optimising supplies, reducing costs, tracing food origins and increasing food security.

According to GlobalData, investments in technological renewal of the agricultural sector are primarily aimed at the application of artificial intelligence, robotics, new materials, cloud services, big data, the internet of things.

Table 3. GLOBAL INVESTMENTS IN AGRI-TECH, MILLION US DOLLARS

Sector	2015	2016	2017	2018	2019	2020	2021
E -commerce	0	0	11	14	82	95	398
Artificial intelligence	7	152	239	412	379	953	328
Digitisation	1	0	23	88	150	42	255
Robotics	0	2	16	107	125	84	172
Advanced materials	0	0	0	0	1	0	0
Big data	7	2	61	222	396	189	478
Internet of things	0	0	7	87	55	45	105
Digital media	0	0	0	61	52	26	58
Future of work	0	0	0	1	20	16	20
Blockchain	0	0	0	59	0	8	2
Industrial automation	0	0	0	0	25	0	24
Mobile	0	0	0	0	23	7	0

Source: GlobalData, 2022.

[4] Goode, L. et al., *Agriculture's connected future: How technology can yield new growth*, McKinsey Centerfor Advanced Connectivity and Agriculture Practice, October 2020.

One of the most serious obstacles hindering the rapid adoption of Agriculture 4.0 technologies is the fragmentation of agricultural holdings. This leads to low economies of scale, limited access to technology, high marketing costs and low productivity. Agricultural production in Bulgaria takes place within a highly polarised structure of the sector. At one extreme are the small farms that manage less than 2 hectares. These farms represent 82% of the total number of farms. They participate in the market only marginally, mostly at the local level, and diversify their production with crops with a high retail price, such as fruits and vegetables. At the other pole are the large commercial farms with an utilised agricultural area of over 100 hectares. These farms represent less than 2% of the total number of farms. They specialise in a number of less labour-intensive arable crops, such as wheat, maize or barley.

Workable solutions need to be found in the following areas, which link policies and measures to the development and access to technologies, and the regulation of clear rights and obligations for participants:[5]

- **Data rights** – ensuring ownership of data by farmers.

Information processing is increasingly done through cloud systems, where data is collected, analysed and stored automatically. This data can be retrieved using any mobile device. The advantage of cloud systems is that the data sources can be used by the service providers. Thus, the farmer receives extensive information and recommendations for action. However, it is important to ensure that the data belongs to the farmers and only they can decide with whom and to what extent to share this data. Business data in agriculture is a company secret, as is the case in other sectors. To this end, the protection of personal data must be extended to include farm, machinery and business process data. Public authorities or third parties have no general right to access this data. For its part, the latter should not contradict the obligation of agricultural producers to comply with the regulations applicable to the sector and to ensure the traceability of public funds spent, high quality and guaranteed origin of their products. Matters related to protection against cyberattacks and the occurrence of technical problems are also subject to regulation.

- **Connectivity** – provision of appropriate digital infrastructure such as network coverage and transmission speed.

The main prerequisite for the transition to high-tech systems is the expansion of the broadband network, as well as access to the internet, especially in rural areas. A digital field records system is a multi-gigabyte database that must be accessible in real time, not only for operational efficiency, but also in terms of readiness to respond to critical factors. The construction and upgrading of broadband infrastructure for next-generation access in rural areas in Bulgaria is a priority of the Strategy for Digitisation of Agriculture and Rural Areas of the Republic of Bulgaria for the period 2021-2027. In 2020, Bulgaria saw a slight increase in the development of the fixed broadband network. Next-generation high-speed broadband coverage improved from 77% in 2019 to 79%, and very high capacity network coverage increased from 42% in 2019 to 43%. According to the latest data from the Communications Regulation Commission for 2021, access to broadband internet with speeds over 100Mbps is possible in 899 settle-

[5] Bernhardt, H.; Bozkurt, M.; Brunsch, R.;Colangelo, E.; Herrmann, A.; Horstmann, J.; Kraft, M.; Marquering, J.; Steckel, T.; Tapken, H.; et al., "Challenges for Agriculture through Industry 4.0," *Agronomy 2021*, 11, 1935, https://doi.org/10.3390/agronomy11101935.

ments in Bulgaria – mainly in the densely populated cities with an overall population of 5.4 million. In 3,716 settlements, mostly in peripheral and rural areas, where 1,481,688 inhabitants live, broadband internet access with speeds above 100Mbps is not available. There is no access to the internet in 511 settlements with a total of about 15,000 inhabitants.

Along with this, digitisation is also the key to bringing agricultural producers and consumers closer together. Digitisation creates conditions for transparency of production processes and traceability of end products.

- **Accessibility** of databases, including of climate/weather, soil condition and crops data.

The collection and archiving of this data is funded by taxes. Weather data, land registry data, soil data, route networks, etc., should be available as open data in standardised data formats suitable for practical use through interfaces. A sensible approach to this would be to provide a central data portal.

- **Digital skills** – opportunities and support for inclusion in training and networking tools;

Digitisation requires qualification. Farms can only make their way with well-trained staff. Eurostat data for Bulgaria, however, point to a decline in the population with a higher educational level and deepening processes of de-skilling. Together with the low share of the population with digital skills, the data shows no improvement over the last decade in the indicator of a population with digital skills above the average level.

- **Alignment** of the policies for Agriculture 4.0.

The agricultural sector is among the critical factors for national security. The war in Europe over the past year and the disruption of global supply chains as a result of the Covid pandemic are evidence of this. Its significance can be seen in the fact that some of the largest and most industrialised economies, such as the USA, Japan, Western European countries, and China, have historically directed much of their public R&D investment to creating or stimulating the application of specific technologies in areas such as national defence, public health and agriculture.

Opportunities and challenges to European and national policy for the development of the agricultural sector

Innovations in the agricultural sector lead to a number of effects – increased labour productivity, optimisation of costs, improved quality of manufactured products. However, their sustainable effect can only be achieved in their application at scale, not in individual isolated situations or businesses. Only when the technologies of Agriculture 4.0 are widely adapted in agricultural holdings, the results will be multiplied at the national level and lead to an increase in the competitiveness of the sector as a whole. This constitutes the main objective of the strategic framework for supporting agricultural producers. In addition, policies at the European and national level reflect the specific features of the industry, the main ones being:

- despite the importance of the agricultural sector for food security, the income of agricultural producers is about 40% lower than the income from non-agricultural activities;
- agriculture depends on weather and climate to a much greater extent than other sectors;

- there is a significant time lag between changes in consumer demand and the ability of farmers to respond with a relevant change in production.

Figure 1. CONTRIBUTION OF THE AGRI-FOOD CHAIN TO ACHIEVING THE GLOBAL GOALS FOR SUSTAINABLE DEVELOPMENT

Source: FAO (2015), SDG Wheel.

Business uncertainty and the impact of the agricultural sector on the environment justify the significant role of the public sector, which finds expression above all in the development and implementation of the EU's Common Agricultural Policy (CAP). Launched in 1962, the CAP aims to support farmers and improve the quality of life in rural areas based on the following main impact mechanisms:

- income support – by means of direct payments it guarantees the security of farmers' incomes;

- market measures to deal with difficult market situations such as prices resulting from temporary oversupply in the market;
- rural development measures with national and regional programmes to address the specific needs and challenges facing rural areas.

For the period 2021-2027, under the CAP, EUR 387 billion will be provided from the European Agricultural Guarantee Fund (EUR 291.1 billion) and the European Agricultural Fund for Rural Development (EUR 95.5 billion). Payments are managed at national level by each EU country. The new CAP was officially adopted on 2 December 2021 and enters into force on 1 January 2023.

The main focus is on achieving the global development goals and the objectives of the European Green Deal:

- member states' CAP plans must be in line with environmental and climate legislation;
- payments to CAP beneficiaries will be tied to a stricter set of mandatory requirements;
- at least 25% of the direct payments budget will be allocated to eco-schemes providing stronger incentives for climate and environment-friendly farming practices and approaches (such as organic farming, agro-ecology, carbon farming, etc.) as well as improvements in animal welfare;
- rural development: at least 35% of the funds will be allocated to measures in support of climate, biodiversity and the environment;
- in the fruit and vegetable sector, the operational programmes will allocate at least 15% to the environment (an increase of 5 p.p. compared to the previous programming period);
- 40% of the CAP budget should be climate-related and support the overall commitment to allocate 10% of the EU budget to biodiversity by the end of the EU's Multiannual Financial Framework (MFF) period.

CAP is complemented by the strategies Farm to Fork and Biodiversity, which include a set of ambitious targets to increase the sustainability of the EU food system.

Figure 2. Targets of the Farm to Fork Strategy to be achieved by 2030

- 50% reduction in the use and risk of chemical pesticides
- 50% reduction in the use hazardous pesticides

- at least 50% reduction of nutrient losses while ensuring no degradation of soil fertility
- at least 20% reduction of fertilizer use

- 50% reduction in sales of antimicrobials for farm animals and aquaculture

- reaching 25% of agricultural land for organic farming
- a minimum of 10% area with high diversity landscape features

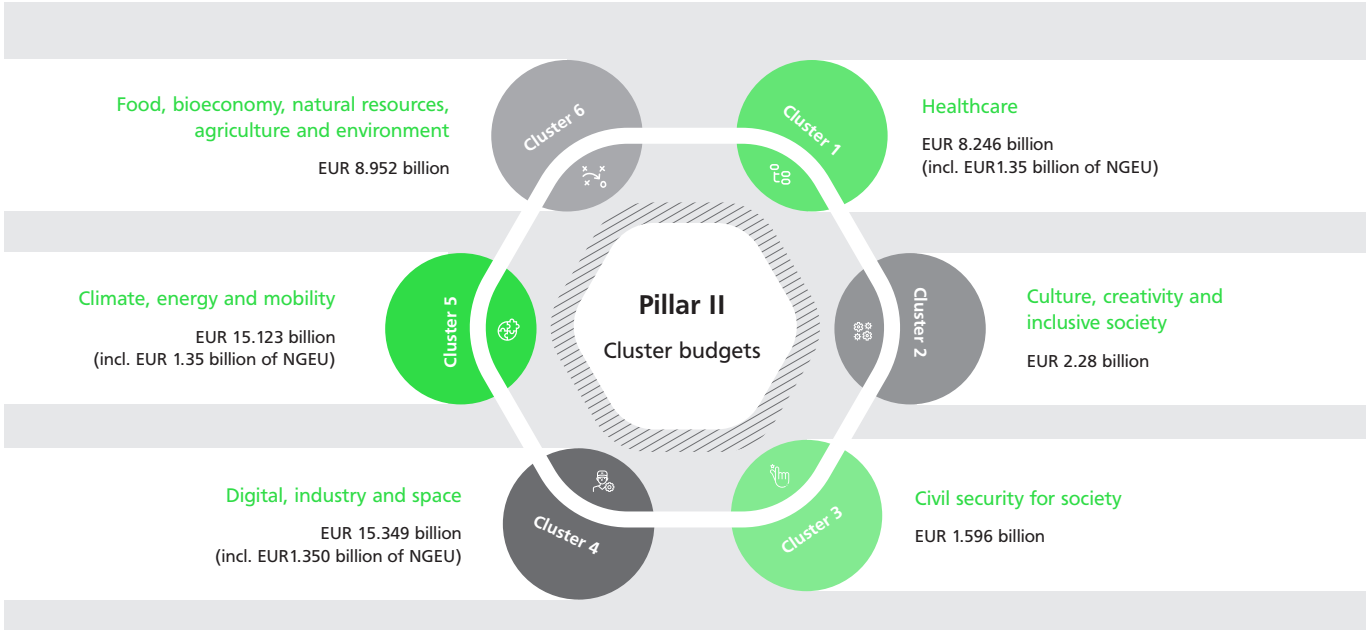
Source: https://food.ec.europa.eu/horizontal-topics/farm-fork-strategy_en

In the period 2014-2020, the European Commission introduced new tools to stimulate innovation and the development of knowledge that is of practical ap-

plication. The agricultural European Innovation Partnership EIP-AGRI is a major policy and networking initiative designed to accelerate innovation through an interactive innovation model. This model is based on collaboration between different actors (e.g. farmers, foresters, advisors, entrepreneurs, users, researchers, etc.) and identifying the needs of end users. It makes the best use of complementary types of knowledge with a view to co-creating and disseminating action-ready solutions. EIP-AGRI benefits from a unique set of instruments funded under two European policies working in close interaction: Horizon 2020 and the rural development pillar of the CAP.

For the programming period 2021-2027, the EC has allocated nearly EUR 9 billion from the Horizon Europe programme for projects related to food, agriculture, rural development and the bioeconomy. This investment is part of Pillar II of the programme addressing the global challenges and competitiveness of European industry within a budget of EUR 53.5 billion, distributed among six clusters.

Figure 3. Pillar II – Horizon Europe Clusters: Global challenges and competitiveness of European industry*



* Clusters include budget for partnerships and missions

Source: http://ec.europa.eu/horizon-europe

The Strategic Plan for the Development of Agriculture and Rural Areas of the Republic of Bulgaria is the main government instrument in Bulgaria for applying the CAP principles and related European policies in the field of the agricultural sector, agri-food chains and rural areas, including the promotion of research and innovation for the period 2023-2027. The Plan combines funding for income support, rural development and market measures intended to achieve the main objectives of the CAP. The plan complies with the principles of subsidiarity (adjustment to local conditions and needs and adaptation of CAP interventions), and focus on results and quality.

The planned budget for Bulgaria for the pillars I and II is EUR 8 million, of which EUR 5.6 million are from the European Agricultural Guarantee Fund and European Regional Development Fund, and EUR 2.4 million is the amount of national funding, and is distributed as follows:

- direct payments – EUR 4.1 million;
- market measures – EUR 3.9 million.

The total amount of funding for the development of rural areas is EUR 1.4 million and 60% national funding (EUR 2.1 million).

The interventions under the Strategic Plan for the Development of Agriculture and Rural Areas will be supplemented with funding under the National Plan for Recovery and Sustainability, which envisages two projects worth BGN 986.1 million (BGN 457.3 million from the Recovery and Sustainability Mechanism and BGN 528.8 million national co-financing (2022-2025) in pillar Green Bulgaria:

- Fund for promoting the technological and ecological transition of agriculture – BGN 962.2 million (BGN 437.4 million from the Recovery and Sustainability Mechanism and BGN 524.9 million national co-financing);
- Digitisation of processes from the farm to the table – BGN 23.9 million (BGN 19.9 million from the Recovery and Sustainability Mechanism and BGN 3.9 million national co-financing).

Four of the specific objectives of the Strategic Plan for the Development of Agriculture and Rural Areas of the Republic of Bulgaria for the period 2023-2027 are directly aimed at increasing the innovation potential of agricultural holdings and the sectoral innovation system as a whole, including through the implementation of digital and green technologies, improving the interaction and transfer of knowledge and innovations among the participants of the innovation system, increasing the educational level and competencies of those employed in the sector, making the sector attractive for young farmers, modernisation and increasing the competitiveness of agricultural holdings, access to markets.

Innovation potential of the agricultural sector in Bulgaria

Agricultural knowledge and innovation systems encompass all people and organisations (farmers, foresters, farmer and forester organisations and cooperatives, advisors, researchers, businesses, NGOs) that generate, share and use agricultural knowledge and innovation, and interrelated domains such as rural areas, value chains, environment, climate, biodiversity, society, consumers and others.[6]

Box 1. EDUCATION WITH A FOCUS ON AGRIBUSINESS

СОФИЙСКИ УНИВЕРСИТЕТ „СВ. КЛИМЕНТ ОХРИДСКИ" основан 1888 г.

The master's programme Innovations and digital transformation of agribusiness at the Faculty of Economics of Sofia University provides an opportunity for entrepreneurs, public officials at the central and local administration, the non-governmental sector and individual experts employed in the field of the agribusiness sector and related activities to acquire specialised knowledge and skills, integration into sector networks and interactions, and access to specific know-how through meetings with leading professionals from the country and abroad.

The master's programme offers a unique range of courses in the field of European and national sector policies, agri-food systems and supply chains, entrepreneurship and innovation, the application of digital technologies, the protection of intellectual assets, the financing of innovation projects, organic agriculture and sustainable development.

Partners of the programme are the Institute for Agrostrategies and Innovation, AgriHub.BG, Agricultural Academy, Association for the Promotion of Agricultural Cooperation between China and the Countries of Central and Eastern Europe, Organic Farming Foundation BIOSELENA, TechnoLogica and others.

Source: Applied Research and Communications Fund.

[6] Collaborative Working Group on Agricultural Knowledge and Innovation Systems, CWG AKIS.

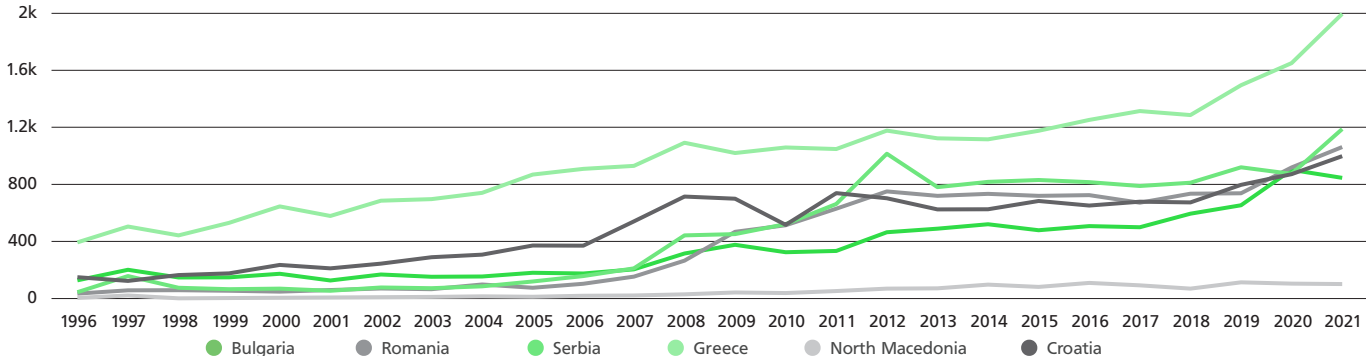
The research organisations in Bulgaria in the agrarian sciences and related biology, ecology, forestry, aquaculture and others include the Agricultural Academy, some of the institutes of the Bulgarian Academy of Sciences (BAS), Trakia University in Stara Zagora, Sofia University, Forestry University, and the medical and some technical universities.

In addition, in Plovdiv there are the Agricultural University, the University of Food Technology, the University of Plovdiv, the Higher School of Agribusiness and Regional Development, the Medical University, the Centre for Plant Systems Biology and Biotechnology. This is also the reason why a major part of the research infrastructure in this area is located in the South Central Planning Region.

The development and spread of innovative practices in agricultural holdings in Bulgaria depends to a very large extent on the development of agricultural science and the potential impact of scientific results – scientific articles, new varieties of plants and breeds of animals, but also citability, recognition on the international scene and interaction with business.

The profiles of the Agricultural Academy and the Agrarian University do not appear in the institutional ranking of Scopus.[7] The inclusion criterion is for the institutions to have published at least 100 works included in the Scopus database in the last year of a given time period.

Figure 4. Publication activity, agricultural and biological sciences, 1996-2021, number of documents



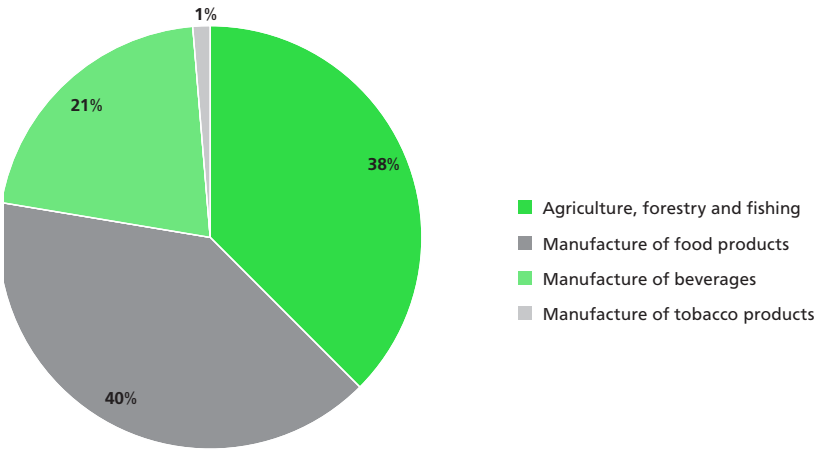
Source: SCImago (2007). SJR — SCImago Journal & Country Rank. Retrieved September 16, 2022, from http://www.scimagojr.com

Bulgaria ranks 58th with a total of 9,305 documents and an H-index of 117 as regards publication activity in the field of agricultural and biological sciences during the period 1996-2021, among 235 countries included in the Scopus database. **The country is in 10th place (out of a total of 23 countries) in the group of Eastern European countries, and in 21st place (out of a total of 28 countries) within the European Union**.

In the period 2001-2021, the Patent Office of Republic of Bulgaria (PORB) has issued a total of 152 patents in the field of the agri-food chain (agri-sector and food industry). Only 7% of them were created by scientific bodies working in this field. The predominant part is the result of research and development by business.

[7] SCImago Institutions Rankings (SIR) is a classification of academic and research-related institutions ranked by a composite indicator that combines three different sets of indicators based on research performance, innovation performance and societal impact as measured by their web visibility.

Figure 5. PATENT ACTIVITY IN THE AGRICULTURAL SECTOR AND THE AGRI-FOOD CHAIN, 2001-2021, %



Source: Own calculations based on data from PORB, 2022. https://www.bpo.bg

Table 4. PATENT ACTIVITY OF RESEARCH ORGANISATIONS IN THE AGRICULTURAL SECTOR AND THE AGRI-FOOD CHAIN IN BULGARIA, 2001-2021

Research organisation	Number of patents
Institute of Soil Science "N. Pushkarov", Sofia	3
Agricultural Institute, Shumen	2
Institute of Animal Science, Kostinbrod	2
Wheat and Sunflower Institute "Dobrudja", General Toshevo	1
National Centre for Agrarian Sciences, Sofia	1
Institute of Cryobiology and Food Technologies, Sofia	1
Agricultural University Plovdiv	1

Source: Own calculations based on data from PORB, 2022. https://www.bpo.bg/

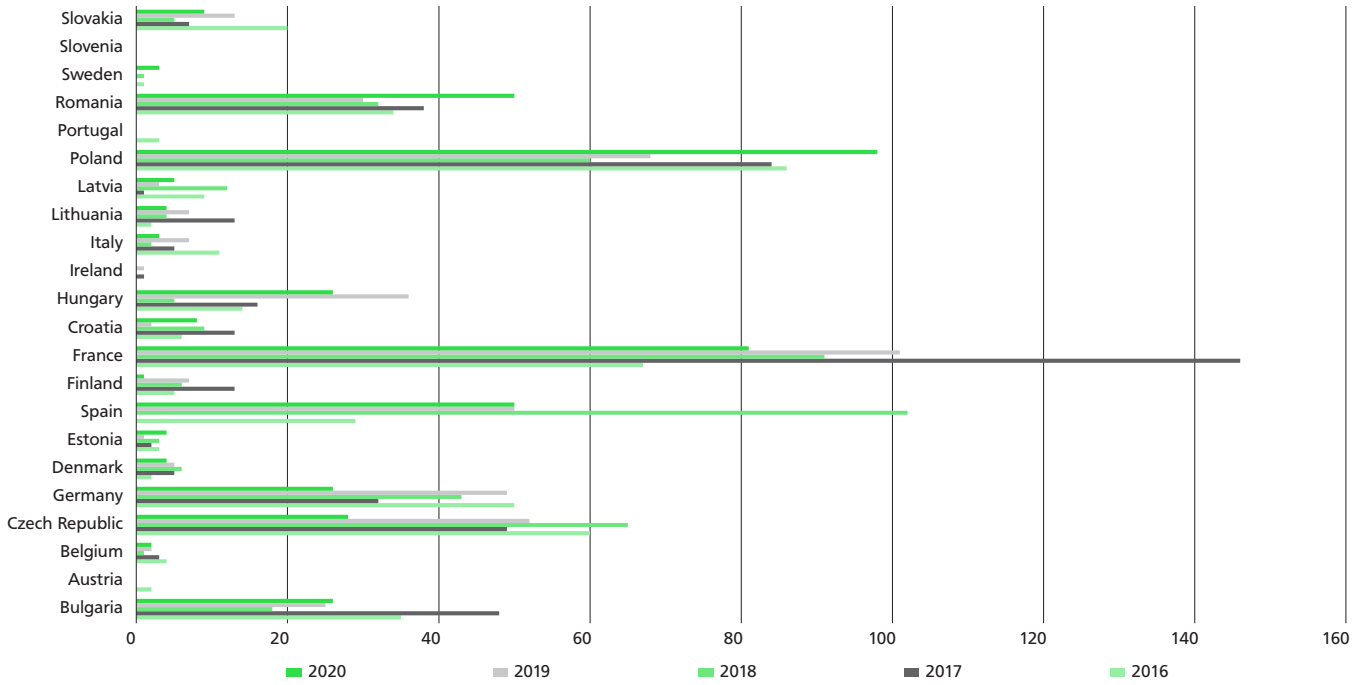
Scientists at the institutes of the Agricultural Academy are involved in four national scientific programmes: Healthy foods for a strong bioeconomy and quality of life (Foods), Environmental protection and reduction of the risk of adverse events and natural disasters (Environment), Reproductive biotechnologies in animal husbandry (Reprobiotech), and Young scientists and post-doctoral researchers.

Table 5. NUMBER OF APPLICATIONS FOR NEW PLANT VARIETIES, BULGARIA, 2016-2020

	Applications	Titles	Expired titles	Titles in force
2016	35	21	13	391
2017	48	24	n/a	n/a
2018	18	47	52	419
2019	25	30	65	384
2020	26	13	103	294

Source: International Union for the Protection of New Varieties of Plants, 2022.

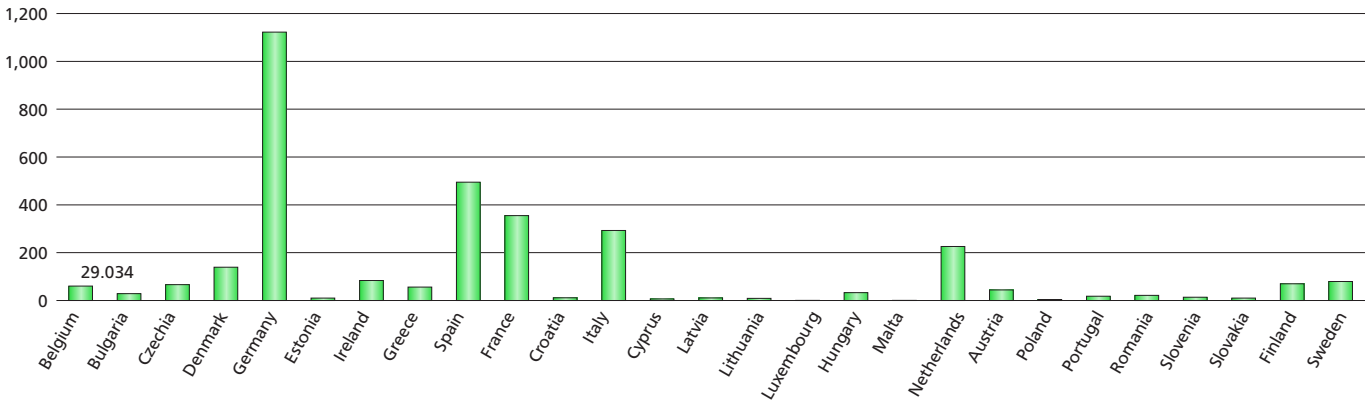
Figure 6. NUMBER OF APPLICATIONS FOR NEW PLANT VARIETIES, 2016-2020



Source: International Union for the Protection of New Varieties of Plants, 2022.

The main area of research of scientific units in the agrarian and related sciences is the creation and protection of new varieties of plants. **In this respect, for the period 2016-2020, Bulgaria is in the eighth place within the European Union, with 152 applications for new varieties of plants submitted.** The country obtained 135 titles (nearly 90% success rate), and the total number of titles in force for the five-year period is 1,488. Leader in Europe is the Netherlands with 3,234 applications for the same period, followed by France (486) and Poland (396).

Figure 7. BUDGETARY EXPENDITURES FOR R&D IN THE AGRICULTURAL SCIENCES, 2021, EUR MILLION

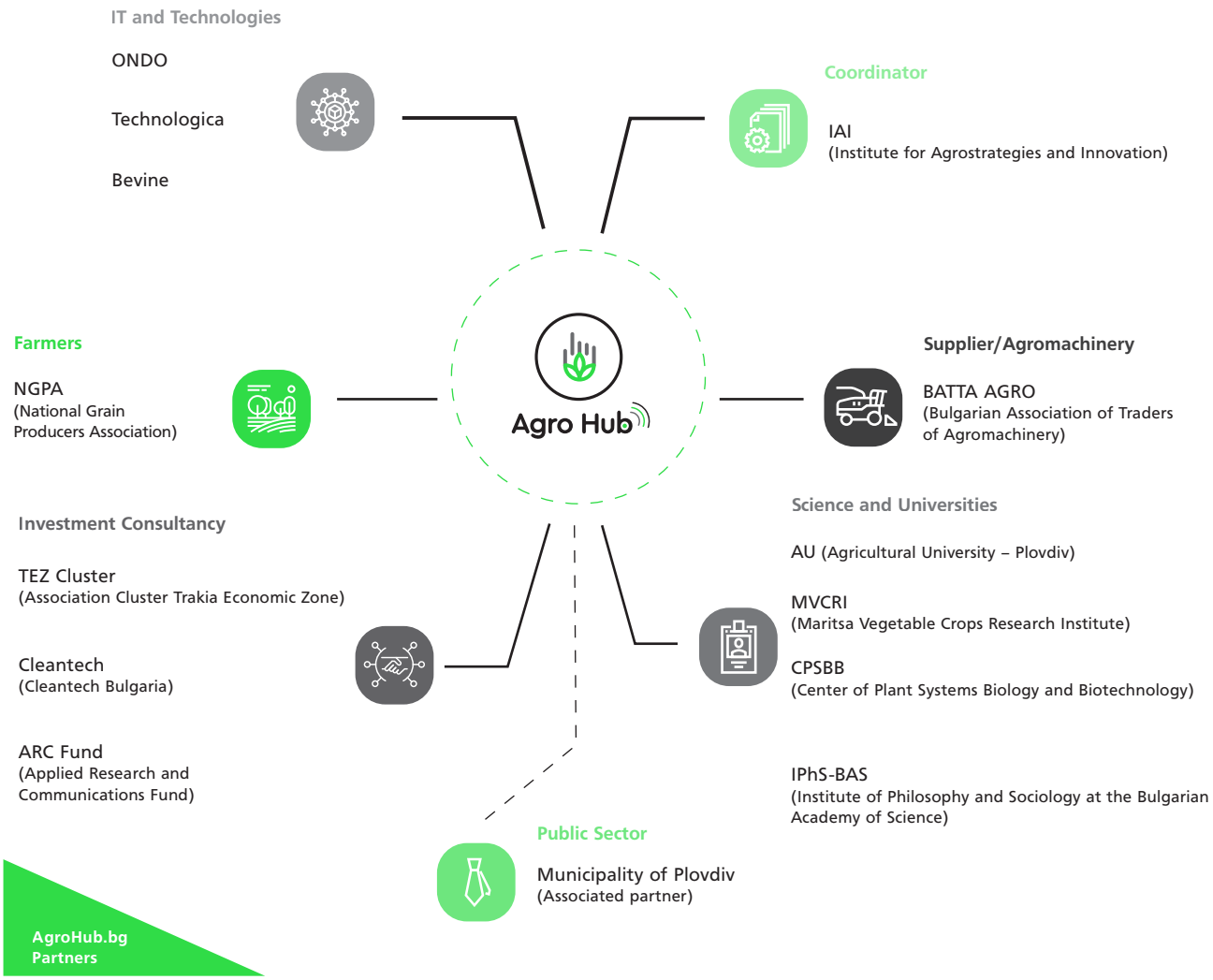


Source: Eurostat, 2022.

Box 2. EUROPEAN DIGITAL INNOVATION HUB IN AGRICULTURE

On November 1, 2022, as part of the implementation of the EU's Digital Europe programme, four European digital innovation hubs (EDIH) started operating in Bulgaria:

- **AgroHub.BG:** AgroDigiRise project, number 101083473. The project consortium of 14 partners concluded the Grant Agreement with the European Commission and as of November 1 this year, the implementation of the project began.
- **REGA, Stara Zagora:** Synergy project for regional green digital transformation of South-East region of Bulgaria: SynGReDiT! It includes 29 partners from the South-East Region: local authorities, business, academia, NGOs.
- **"EDIH in the construction sector",** coordinated by the Bulgarian Construction Chamber, partners with the Chamber of Architects in Bulgaria, Higher Construction School "Lyuben Karavelov", Institute of Mechanics - BAS, "Cleantech Bulgaria" Ltd, Bulgarian Association of Construction Project Management, other leading companies in the construction sector and ICT companies – "Plane" Ltd., "Geostroy" AD, "Baumit Bulgaria" Ltd. and "ESRI Bulgaria" Ltd.
- **Digital innovation hub "Trakia"** focuses its expertise on the artificial intelligence field, high-performance computing, cyber security and key base technologies, with leading expertise in the field of cyber security. EDIH "Trakia" will develop activities on the territory of the South-Central Region with a coordination center in the city Plovdiv.



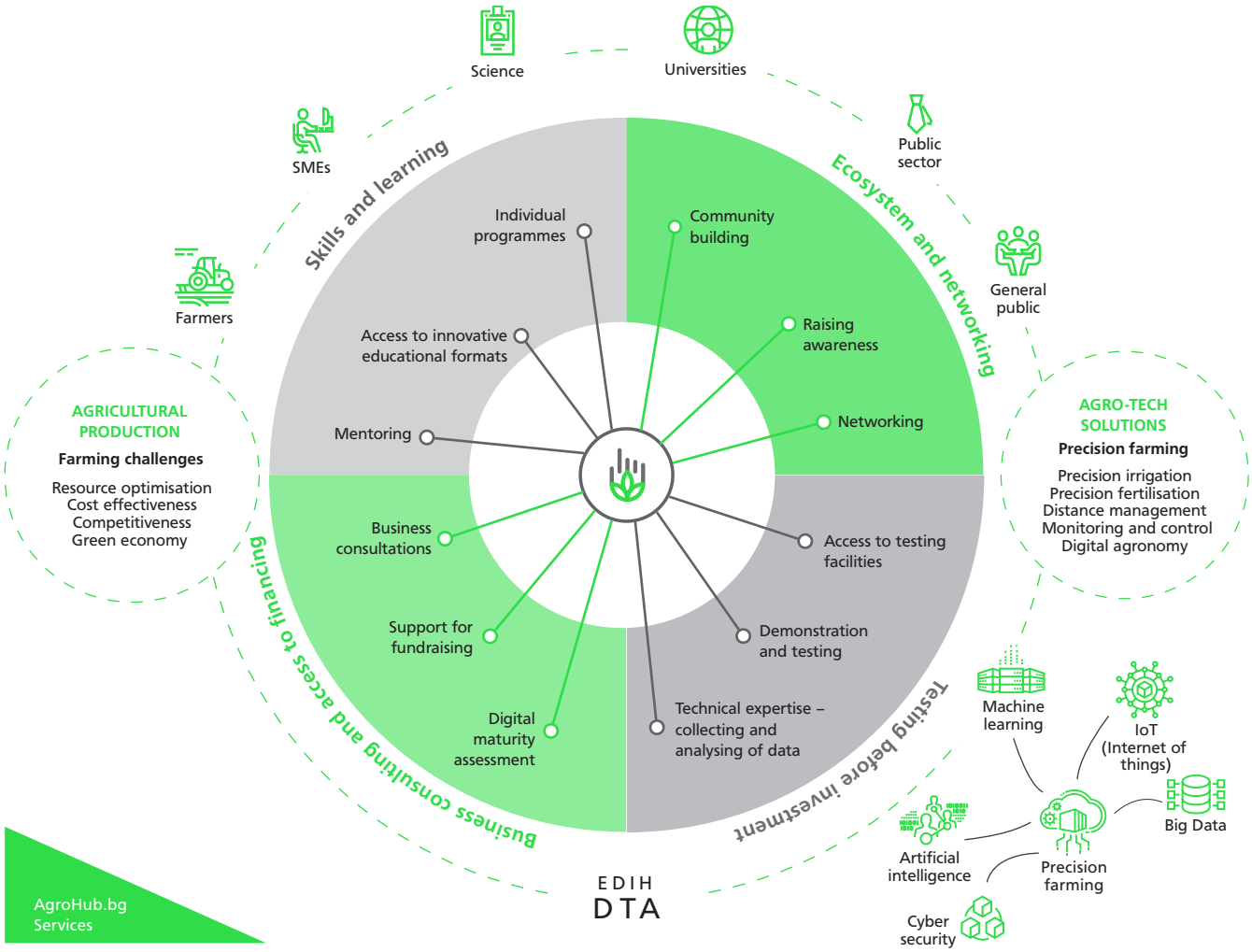
The main goal of the hubs is to stimulate the wide application of advanced digital solutions (including high-performance computing, artificial intelligence, cybersecurity and others) in industry, public organisations and academia.

Box 2. EUROPEAN DIGITAL INNOVATION HUB IN AGRICULTURE (CONTINUED)

The only centre with a direct focus on the agri-sector and agri-food chains is AgroDigiRise. Its activity will be aimed at harnessing the innovative potential of the agrarian sector in the South Central region of Bulgaria and supporting business in its digital and green transformation.

AgroDigiRise services will also be aimed at:

- Development of a dynamic and sustainable innovation ecosystem and acceleration of cross-sectoral cooperation, awareness raising and networking at regional, national and European level.
- Providing access to innovative facilities and services for pre-investment testing – creation and expansion of a network of demo points with a focus on precision farming, access to technical expertise and data.
- Increasing the competences and capabilities of SMEs and the food sector through training for the acquisition of digital skills – development of the digital skills of farmers, SMEs and public administration through custom-made training programs.
- Support of digital and business transformation with consulting and financial services – development of digital maturity in the agricultural sector through technology audits, assessments, consultancy, digitisation and business plans, market analysis, etc.



The participation of research organisations, universities, and local government of the area will allow the hub to analyse, test, adapt and support the implementation of digital solutions tailored to the specific parameters of individual businesses and territories, and the specific needs of producers at regional and national level.

By connecting fragmented digital solution providers and end-users with academia and the public sector, the project will support the achievement of the objectives of the competitiveness, digital and green transition of the economy.

Box 3. WOODEN SPOON: BULGARIAN BIO COSMETICS WITH ROYAL APPROVAL

Since its creation in 2014, the family company Orenda Group (today, Yani Dragov, an innovator in the field of biofoods, is also a partner) has been aiming to provide "the cleanest possible skin care cosmetics." Sylvia Pavlova, the company's co-founder, believes that "unless a skin oil is edible, it shouldn't be applied to the body." Orenda works with edible raw materials and produces baby and child cosmetics, personal and oral hygiene products, skin care, and high-tech natural creams and facial serums.

It sells under its own brand name and also produces for other international and Bulgarian brands.

Orenda Group is an organic innovator. "Typically, it all starts when we look for a specific product but find out that there is no such on the market. We then search for a solution in synergy with all our partners, colleagues and labs," says Ms. Pavlova. The company is planning to release 50 new products in 2013.

In 2022, the company invested nearly BGN 5 million in the construction of new production facilities in the Bozhurishte industrial zone. The first stage of the construction is expected to be complete by the summer of 2023. This investment will allow the company to increase its production capacity 20-fold, to branch into new product types and create 15 new jobs. The factory will have its own testing lab.

Orenda was a winner of the Innovative Enterprise of the Year Award in 2021 in the Market leadership category. WoodenSpoon was recognised in two royal books (*Baby Sussex* and *Her Majesty The Queen: The Official Platinum Jubilee Pageant Commemorative Album*).

Box 4. BEE SMART TECHNOLOGIES: HONEY AND HIGH-TECH

Bee Smart Technologies JSC is the company behind the Pollenity technological brand and creator of the Genuine Honey platform. It was created in 2015 in order to "save the bees through business innovation and new technologies," says Sergey Petrov, co-founder and CEO. The company develops technologies for distant monitoring of beehives. BeeBot is a device which tracks sensors in the hive, while HiveBase is a smart hive scales. They send data to BeeBoard, which aggregates it and analyses the health of the bees.

Through its platform Genuine Honey, the company provides the service Adopt a Beehive. Through a subscription, adopters receive a certain monthly quantity of honey from the respective beekeeper. "In order to establish a sustainable business model and help producers we created an ecosystem equipping them with technology but also helping them with sales at a fair price," says Mr. Petrov. Adopt a Beehive has been operating in Bulgaria for three years and is expanding to Germany, Austria and other European countries.

For the past three years, the company has been working on a large R&D project together with six prestigious European universities titled HIVEOPOLIS. The project will be prototyping advanced technologies for beehives of the future. All developments are made under an open-source code and all data will be public.

The company uses some of its revenue to fund an educational programme at the Beekeeping University, which it has created. In 2021, it enrolled 30 new beekeepers out of 300 applicants. The company provides scholarships to women entrepreneurs in this sector.

On the eve of the 140th anniversary of the establishment of the first research units of the Agricultural Academy and the start of agricultural science in Bulgaria, the Academy reports a number of achievements:

- 16 titles for new plant varieties;
- 22 applications for titles for new plant varieties;
- one patent and one patent application;
- 597 publications in journals indexed in Scopus and Web of Science;
- 1,327 citations in Scopus and Web of Science.

By the end of 2021, the Academy had 482 researchers. Although this is a modest 1% increase on an annual basis, it could mark the end the downward trend in the number of scientists (it is less than half the 2020 number of 1,108).

Innovation potential of the Bulgarian economy

Gross innovation product

The gross innovation product, or the innovativeness of an economy, is assessed by the new products and services introduced, the new technologies created and the scientific outputs. It involves and results from the interaction of the innovation, technological and scientific products of a country. It is a major benchmark for innovation policy because it allows decision-makers to compare the outcome of the innovation system in temporal and geographical terms, as well as to estimate the need for changes in the organisation and resources of the innovation process.

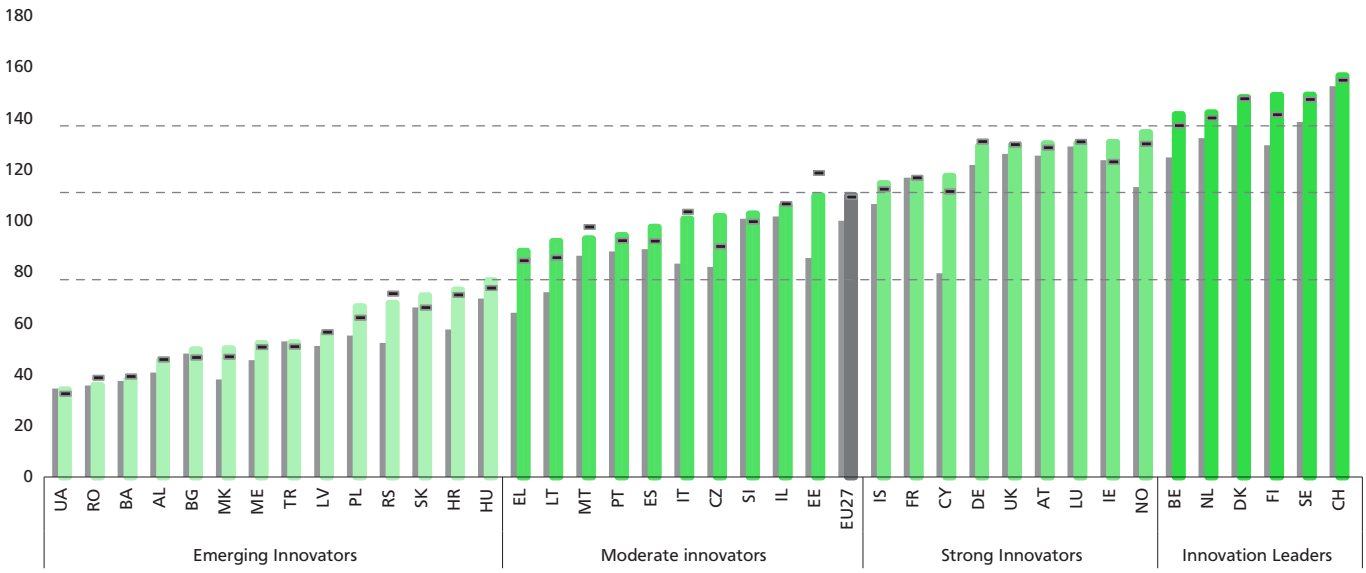
Innovation product

The innovation product results from innovation activity in the form of new and significantly improved processes, products and services based on new and/or adapted existing knowledge and know-how. It is determined by the innovation activity of enterprises in the country and is the most important indicator for assessing the national innovation system. Innovation activity in business and innovation demand by the public, along with the factors which determine these, comprise the innovation potential of the economy – its capacity to develop driven by new knowledge.

Bulgaria is among the weakest innovators

The results of the European Innovation Scoreboard (EIS) in 2022 reflect the impact of the global challenges of the last few years on the European economies and the state in which they start the new financial and programming period in the EU 2021 – 2027. The economic crisis caused by the global Covid-19 pandemic has led to a decline in some of the indicators which are the basis of the EIS's summary Innovation Index. This primarily affected public and private investment in innovation activities. Public investment was very often redirected to the most affected sectors in the

Figure 8. EUROPEAN INNOVATION SCOREBOARD*



* The coloured bars show the state of the member states in 2022 based on the latest data for the 27 indicators of the European Innovation Scoreboard compared to the EU average in 2015. The positions in black on top of them correspond to the same indicator, but for the previous year. The grey bars show the position of the member states in 2015 compared to the EU average in 2015. The dashed lines show the 70%, 100% and 125% threshold values between the groups of countries for 2022 adjusted for growth compared to 2015.

Source: European Innovation Scoreboard, 2022.[8]

[8] The threshold values in the EIS 2021 methodology have been adjusted upwards to reflect the increase in EU efficiency between 2014 and 2021, which explains the higher number of countries in the group of emerging innovators compared to previous years.

form of social payments. In Bulgaria, for example, the government chose to finance the selection of regional innovation centres at the expense of other urgent measures. At best, the diverted funds supported medical research, for example, through the National Science Fund or the national science programmes, but without particular results because of the lack of depth and sustainability of the investments. Private investment in innovation offset operating losses from closed businesses and declines in orders and labour. Along with the indicators of R&D and risk capital expenses, a decrease was also registered in the total volume of exports, which, however, allowed its restructuring in favour of high-tech products and services.

Bulgaria's **overall performance improved** compared to both 2015 (1.5%) and 2021 (3%). However, this **is insufficient to advance its positions in Europe** given the growth of the innovativeness of the European economy by 9.9%. In 2022, Bulgaria is again in the penultimate place among the member states, ahead of only Ukraine, Bosnia and Herzegovina, and Albania. The country's innovation performance is even weaker compared to that of candidate countries – North Macedonia, Montenegro and Serbia – despite the fact that the countries of the Western Balkans have much more limited access to European structural funding, which Bulgaria mainly relies on in the financing of its scientific and innovation policy.

Innovation.bg has repeatedly commented on the country's **lack of progress** on EIS indicators and the need to either find more appropriate tools to measure the innovativeness of the country's economy, or to significantly improve the quality of the innovation policy and its application. The EIS is the official tool chosen by the Bulgarian government as a scale for assessing the innovation potential of the national economy and the progress towards reaching the average European levels in this respect. The fact of **falling behind these levels is a harsh verdict on the innovation policy** and practice of the last financial and programming period 2014-2020. In this respect, an improvement can hardly be expected. At the beginning of the third year of the current programming period, the Innovation Strategy for Smart Specialisation 2021-2027 – the framework document that sets the priorities and thematic areas of impact for the country's innovation policy – has not yet been adopted and is not applied. Given the political instability and overall lack of vision and strategic goals for the development of Bulgaria's science and innovation system, the country can hardly be expected to change its positions in the EIS significantly, such as moving into the moderate group innovators in the next decade.

The actual innovation performance (innovation index) of Bulgaria for 2022 according to the EIS methodology is at **45.2% of the EU average and below the average for the group of emerging innovators (50%).** The country **continues to fall behind** because its performance increase of 1.6 p.p. is well below the EU average of 9.9 p.p.

In the field of innovation, Bulgaria is not distinguished by comparative advantages. The indicator for which the country has slightly better results compared to the EU average is now only one – trademark applications and it can hardly be defined as a competitiveness factor.

Compared to the base year of 2015, the country made progress in the field of innovation results and the achieved impact. There is a growth in innovative SMEs that offer new and/or improved product innovations (close to 70%) and business process innovations (just over 45%).

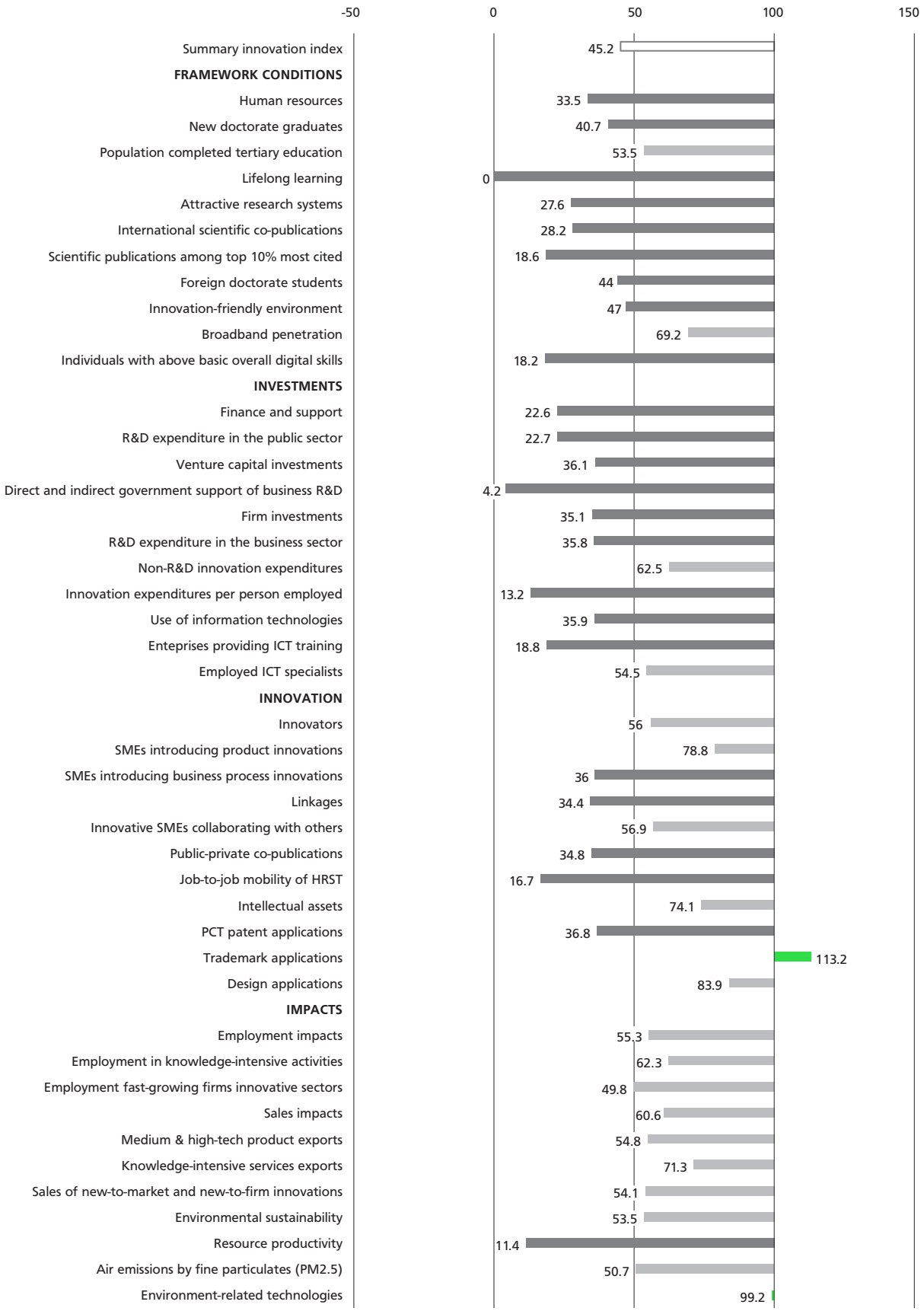
Significant improvement has also been achieved in terms of interaction both within the business sector and between business and the public sector, including collaborative research and publishing. There is no positive change as regards the mobility of highly qualified staff and personnel engaged in R&D, which is partly the result of the lack of stimuli in the regulatory framework.

There is also growth in the export of high-tech products (19%) and knowledge-intensive services (51%), as well as the sale of innovative products (23%). Employment in innovative enterprises is also increasing, respectively the growth of their number.

The main deficiencies, which far outweigh the positives, are in the following areas:

- **In human resources** there has been decline in the number of doctoral students (5%) and virtually **zero levels on the lifelong learning indicator**.
- In terms of **financial resources** there has been a significant drop in risk investments (31%) and investments in non-R&D innovative activities (34%). The growth of business R&D expenses by 15% is supported by a slight increase in public investments (5%), although the distance from the average European levels remains significant for both indicators.
- As regards **digitisation,** the weak improvement in broadband coverage cannot compensate for the double drop in the number of businesses providing ICT training to their employees (below 19% of the EU average). There is no progress in terms of employed ICT specialists and the number of the population with digital skills above the basic level (only 18% of the average levels for the EU). While these factors are of decisive importance for the success of the digital transformation of the economy and the improvement

Figure 9. INNOVATION POTENTIAL OF BULGARIA, SHARE OF EU-27 AVERAGE LEVELS, %, 2022



Source: European Innovation Scoreboard, 2022.

of the business environment, Bulgaria is at one of the lowest levels in the EU.

- There has been a significant drop in all indicators related to **sustainable development and impact on the environment,** resulting in an even more unfavourable positioning of the country by these indicators in Europe.

Innovation infrastructure, but no institutions and market

Bulgaria holds more advanced innovation positions in a number of rankings by less technological indicators, which are more strongly influenced by the general economic performance of the country than by the long-term innovation factors of the EIS. In 2022, such differences with the EIS suggest that there needs to be a serious **reconsideration of the best way to monitor the status and prospects for the Bulgarian innovation system**. One option is the introduction of an ongoing, annual assessment based on market studies and research of innovation performance, similar to the approaches proposed by *Innovation.bg*. However, it should be noted that the **lack of institutions and tools for the formation and management of the national innovation system** can hardly be masked with appropriate measurement tools.

Bulgaria maintains its position in the ranking of the Global Innovation Index (GII) and is 35th in the company of a total of 132 countries[9]. After 2013, this is the best performance of the country according to the methodology of the World Intellectual Property Organization (WIPO), which covers 81 indicators distributed in seven pillars and two sub-indices – 1) innovation resources, which include data of the business environment, markets, the human, financial and intellectual resources invested in R&D and innovation; and 2) innovation results presented in the form of new knowledge, technological assets, entrepreneurial activity and market expansion, development of ICT and creative industries.

Together with Romania, the countries of the Western Balkans and the former Soviet republics, Bulgaria remains in the group of upper middle-income countries and ranks second only after China (11th position in the general ranking) in this group.

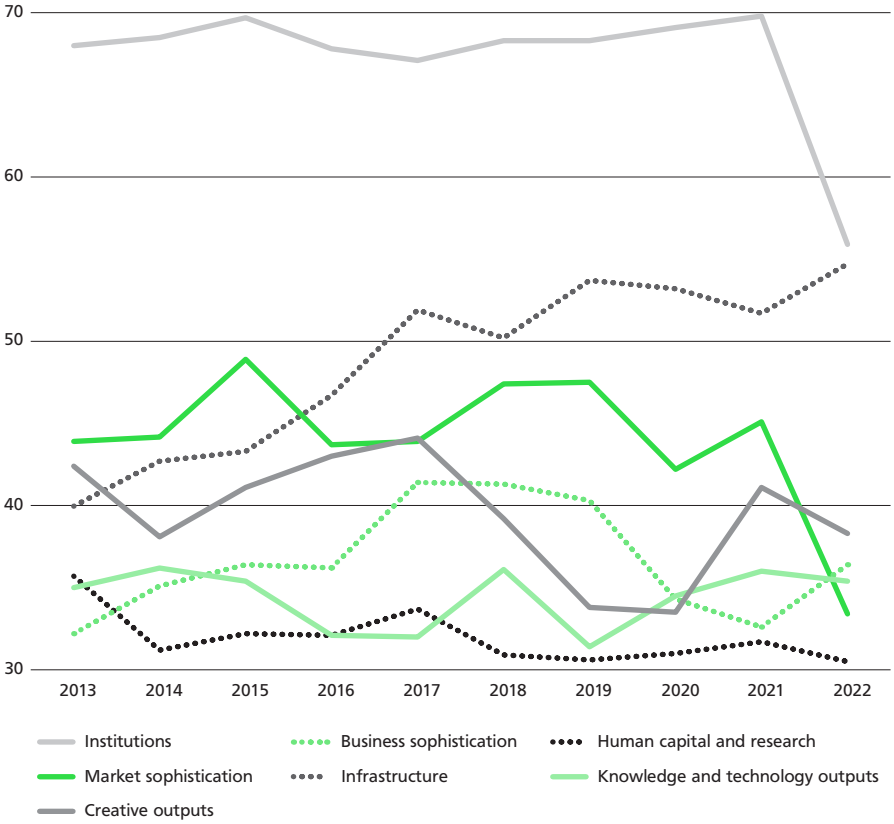
According to the methodology of the GII, **Bulgaria ranks 20th within the EU and 23rd among the European countries represented in the ranking**. With a weaker innovation performance are Poland (38), Lithuania (39), Latvia (41), Croatia (42), Greece (44), Slovakia (46) and Romania (49).

The main advantages of the country are in the following areas:

- creativity – regardless of the decrease of 3 points compared to the previous year, some of the indicators for intellectual property, products of the creative industries, online activity, and mobile applications fall into the group;
- knowledge and technology results – despite weaker positions compared to last year, indicators of industrial property, high-tech sectors and knowledge diffusion are included here.

In contrast to almost all groups of indicators in which Bulgaria has declined, an **area of almost continuous improvement over the last ten years is infrastructure**. This includes indicators of access and use of ICT and e-government, public infrastructure and environmental sustainability.

Figure 10. GLOBAL INNOVATION INDEX, 2013-2022, RESULTS FOR BULGARIA BY MAIN GROUPS OF INDICATORS



Source: Global Innovation Index 2022: What is the future of innovation driven growth?

[9] Global Innovation Index 2022: What is the future of innovation driven growth?

The most drastic drop in indicators is in the "Institutions" group, including business support policies and entrepreneurial culture. **A long-term negative effect is also expected as a result of the deterioration of the country's performance in the human resources indicators** (primarily graduates in STEM fields, positions of Bulgarian universities in international rankings, number of researchers, spending on education), **market environment** (primarily venture capital and microcredit), **business environment** (employment in high-tech sectors, innovation interaction and application of new technological knowledge).

Technological product

The technological product (protected and unprotected new technological knowledge) is the result of creative activities of various participants in the innovation process. It has unique characteristics and economic significance which make it attractive as an object of transfer. The analysis of application and patent activities, as well as the attitudes of Bulgarian and foreign persons in this field make it possible to assess an essential aspect of the innovation system operation and to seek ways of improving it.

In 2021, the latest full year for which data is available, there were 179 patents issued by the Patent Office of the Republic of Bulgaria (PORB) to Bulgarian applicants, which was at the level of the pre-crisis year 2019, but there was a slump of 17% compared to 2020. **The trend of the last four years of relatively high patent activity** of nearly 190 registered patents on average per year continues. However, for the period 2001-2021, the total number of companies holding patents in Bulgaria is 390, i.e. **only 0.1% of active non-financial enterprises register successful inventions**.

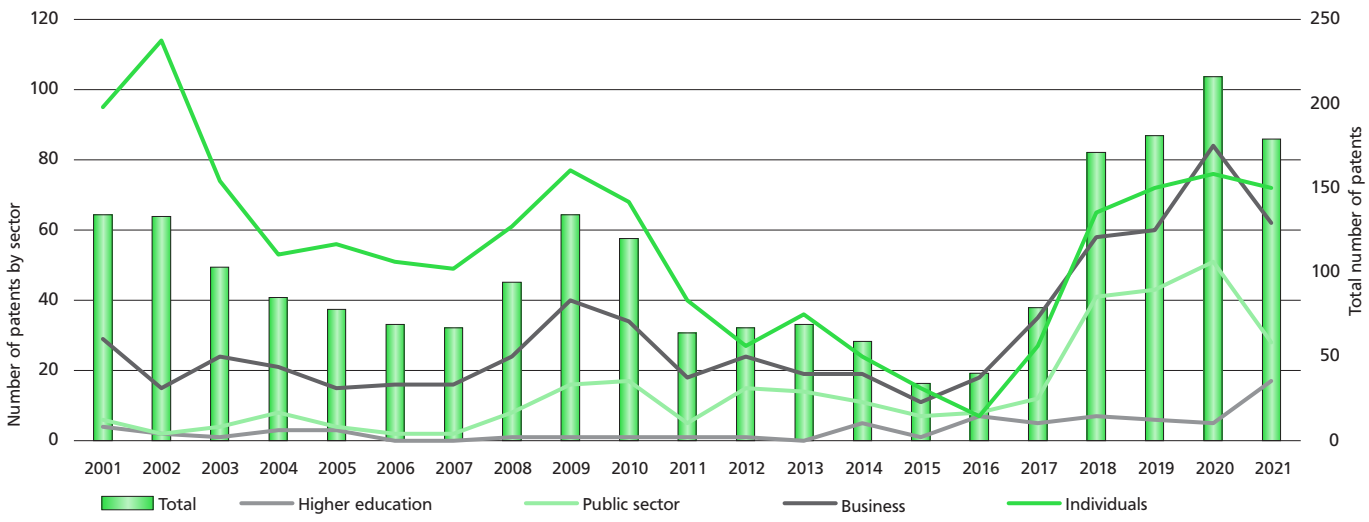
The only institutional sector with an increase in successfully registered patents is higher education – 17, which is an increase of more than three times on an annual basis. There are seven universities with registered patents, which makes 2021 the most successful year for the sector. **The leader is the Technical University Sofia** with nine patents, followed by the Technical University Varna and the Southwestern University with two patents each.

The trend is opposite in the rest of the publicly funded bodies. Among these, most patents (28) were registered by the institutes of the Bulgarian Academy of Sciences (BAS) but the number is a drop of nearly 50% compared to the previous year. **The Institute of Systems Engineering and Robotics holds the leading position** – 16 patents for 2021 or 93 for the period after 2001 (which is 1/3 of the total number of patents of the Academy).

Outside BAS, only **the Institute of Animal Science in Kostinbrod** (part of the Agricultural Academy) added a patent to its assets. It was the second for the Institute after 2019, which is all that has been registered by the Academy for the last five-year period.

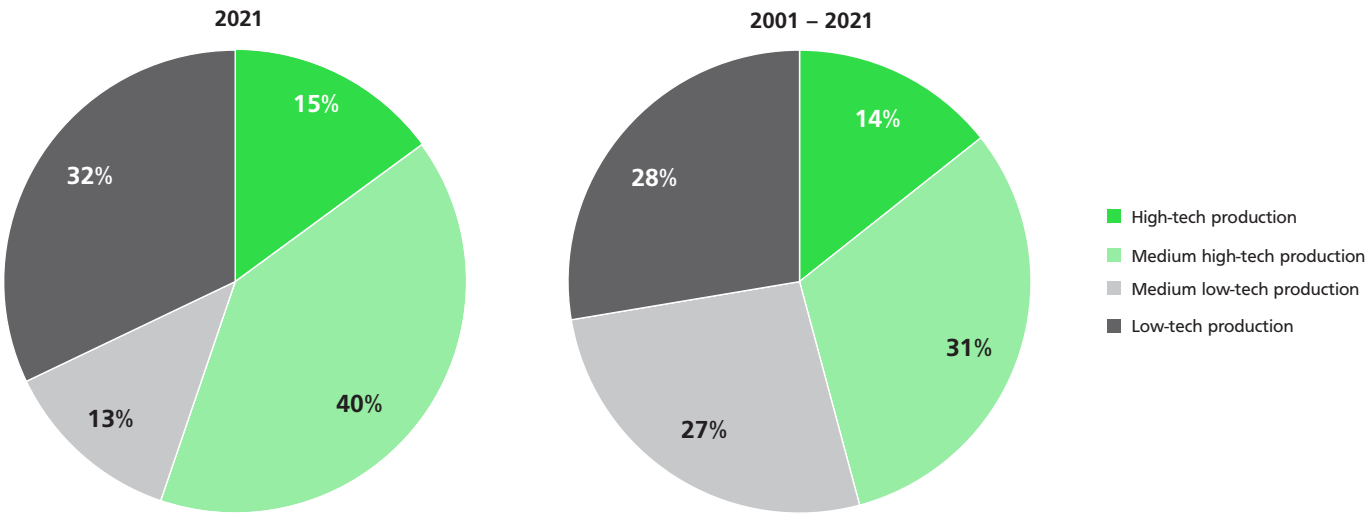
The decline in the number of registered patents of the business sector is slightly over 25% on an annual basis and ends the upward trend since 2015. PORB has issued a total of 62 patents to 56 Bulgarian companies, three of which are validated European patents. Almost 60% of the registered patents belong to companies from the city of Sofia. Compared to the numbers for the period 2001-

Figure 11. PATENT ACTIVITY OF BULGARIAN PATENT HOLDERS ON THE TERRITORY OF BULGARIA, 2001 – 2021, NUMBER



Source: Own calculations based on data from PORB, 2022. https://www.bpo.bg/

Figure 12. Patent activity of Bulgarian patent holders on the territory of Bulgaria by technological level, %



Source: Own calculations based on data from PORB, 2022. https://www.bpo.bg/

2021, this is an increase of the concentration of the patent activity by business in the capital city.

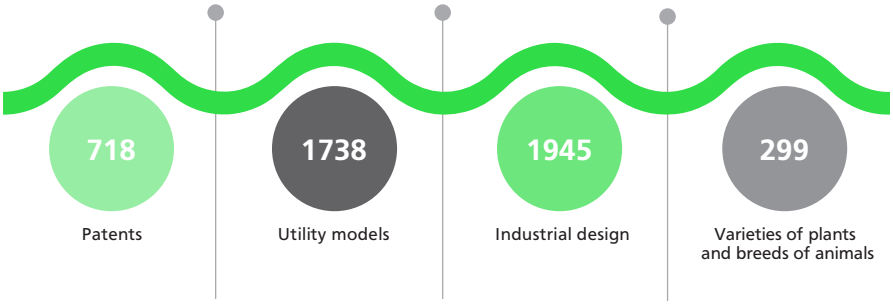
In 2021, **over half of the patent activity of Bulgarian patent holders on the territory of the country was concentrated in high-tech and medium-high-tech industries**[10]. Since 2001, this trend has been increasingly pronounced. The technological field which has the largest share of patents of Bulgarian inventors is **"Human and veterinary medicine, hygiene, dentistry and medicines" – nearly 9% of all patents** for the period under study.

Bulgaria attracts foreign patent interest almost exclusively from the European Union. Patents registered nationally to foreign patent holders are below 1%. In 2021, out of a total of 2,027 foreign patents with effect on the territory of the country, 14 patents from seven countries received registration by the PORB; half are of Danish origin.

In 2021, there was a decline of applicant activity by nearly 60% in patent applications and by 40% in utility model applications. Traditionally, interest in utility models (222 applications) has been stronger than in patents (171 applications) due to the simpler and less resource-intensive procedure. This also reflects the lower degree of technological novelty of the inventions, as well as the resulting more limited period of monopoly rights provided by law. As a result, the patent success rate in 2021 was 64% (the ratio of registered patents to filed applications) and is significantly lower than the utility model success rate of over 90%.

Despite the drop in applicant and patent activity over the past year, the number of industrial property objects in Bulgaria is growing. The most pronounced growth is in utility models – by more than 30%, followed far behind by the number of new varieties of plants and breeds of animals (3%) and industrial design (1%). An exception is the number of registered patents, where there is a drop of just over 7% on an annual basis.

Figure 13. Objects of industrial property protected on the territory of Bulgaria, 2021



Source: PORB, 2022. https://www.bpo.bg/

[10] According to Eurostat's methodology high-tech includes manufacture of basic pharmaceutical products and pharmaceutical preparations and manufacture of computer, electronic and optical products, while medium-high-tech covers manufacture of chemicals and chemical products, electrical equipment, machinery, motor vehicles, etc.

Table 6. TOP-15 TECHNOLOGY FIELDS OF BULGARIAN PATENT ACTIVITY IN BULGARIA, 2001-2021, NUMBER OF PATENTS, %*

No	IPC class	Designation	Total	%
1	A61	Human and veterinary medicine, hygiene, dentistry, medicines	**192**	8.8
2	H01	Basic elements of electrical equipment: cables, wires, insulators, resistors, magnets, detectors, transformers, switches, resonators and others	**177**	8.1
3	G01	Measurements of physical quantities	**147**	6.8
4	H02	Production, conversion and distribution of electrical energy, electrical machines, generators, motors, control and regulation	**77**	3.5
5	E04	Ground construction, elements of building structures, building materials	**75**	3.4
6	A01	Agriculture, forestry, animal husbandry, hunting, fishing, pesticides, herbicides, disinfectants	**57**	2.6
7	A23	Food and food products, processing, milk, oils, coffee, tea, chocolate, confectionery	**55**	2.5
8	B01	Methods and devices for physical and chemical processes – melting, casting, mixing. Equipment	**50**	2.3
9	F16	Units and details of machines, methods and devices ensuring the operation of machines and installations, thermal insulation	**50**	2.3
10	F42	Ammunition, explosives, pyrotechnics	**46**	2.1
11	G06	Calculators and computing machines	**41**	1.9
12	B60	Vehicles	**40**	1.8
13	B64	Aeronautics, aviation; cosmonautics	**37**	1.7
14	C07	Organic chemistry: general methods, acyclic, carbocyclic, heterocyclic compounds, sugar, steroids, proteins	**36**	1.7
15	F03	Hydraulic machines and motors, wind, spring, gravity and other types of motors	**36**	1.7

* Class according to the main sections of the IPC: A – Human needs; C – Technological processes; transportation; C – Chemistry and metallurgy; D – Textiles and paper; E – Construction; mining; F – Mechanics; lighting; heating; engines and pumps; weapons and ammunition; G – Physics; H – Electricity.

Source: Own calculations based on data from PORB, 2022. https://www.bpo.bg/

During the period 2001-2020, **Bulgarian inventors registered patents in 50 foreign offices**. The **greatest interest is in the US market**, where Bulgarian legal entities and individuals own 555 patents. In 2020 alone, the US Patent and Trademark Office issued 57 patents with Bulgarian participation, which is just under half of the patent activity of Bulgarian inventors abroad for the year, and represents a 19-fold increase compared to the beginning of the period.

In terms of interest from Bulgarian patent holders, the US is followed by the countries of the European Union. The number of patents received by the European Patent Office is 154, in addition to another 47 patents received from the patent offices of 12 member countries. Of these, 13 patents are registered in Germany, and eight patents each in France and Italy.

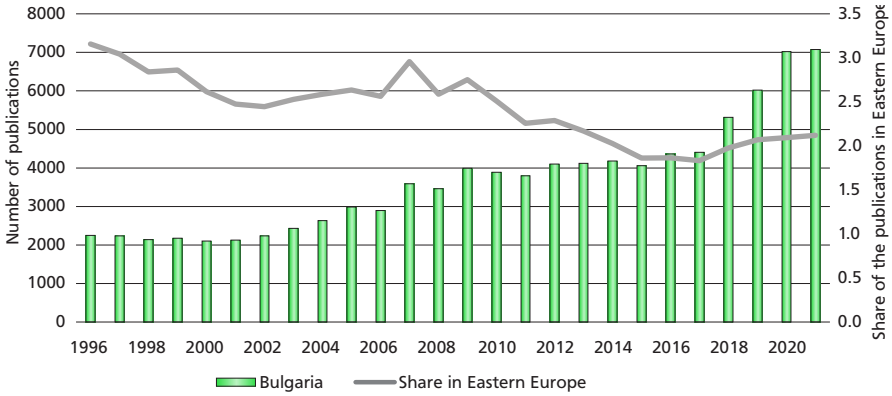
Bulgarian interest in the Asian markets is constant – the total number of patents registered in China amounted to 46 for the period, with another 38 issued by the Eurasian Patent Organization. After the US and China, the top five national patent offices include Russia (34), Japan (33) and Ukraine (28).

The patent activity of Bulgarian patent holders abroad also includes the protection of useful models or the so-called "small inventions". During the period 2001-2020, 18 national patent offices registered a total of 104 utility

models with Bulgarian participation. A third of them cover the territory of Germany, with another 15% and 10% in Russia and Ukraine.

The Western Balkans are not of particular interest for Bulgarian inventors. Only five patents (three in North Macedonia and two in Serbia) and one utility model (Serbia) complete the country's portfolio for the region.

Figure 14. PUBLICATION ACTIVITY IN THE SCOPUS DATABASE, 1996 – 2021



Source: SCImago (2007). SJR — SCImago Journal & Country Rank. Retrieved November 10, 2022.

Research product

New scientific knowledge is an important condition for enhanced innovation activity in the country. The analysis of the dynamics and structure of the process of research creation reveals the potential of Bulgaria to successfully fit in the global scientific networks, its comparative advantages in various fields of knowledge and its ability to compete successfully on the market for intellectual products.

As of the end of 2021, the number of scientific publications of Bulgarian organisations in the Scopus database amounted to nearly 10,000 documents, which corresponds to an average of just over 13 citations per document and a total H-index[11] of 305 units. This ranks Bulgaria in **56th place internationally** (242 countries), in **22nd place within the EU28,** and in **11th place among Eastern European** countries (23 countries). The country's share in scientific production is respectively 0.19% at the global level, 0.65% at the EU28 level and 2.32% at the regional level, with all three indicators showing a **decline over the last year**, although the number of scientific documents suffered a slight increase (below 1%).

Medicine remains the most popular field in the publication activity of scientific organisations in Bulgaria. The number of documents for the period under review is nearly 22,000 (1,320 from 2021) with an H-index of 200 and an average number of citations per publication of 16.34. However, the number of publications for the last year is falling, as is the share within the international scientific production. **The loss of international positions** is most significant in relation to Eastern Europe – from nearly 5% of Bulgarian scientific publications in 1996 to 2% in 2021. This is happening despite the continuous increase in funding and the number of people employed in R&D in the field of medicine for the past five years.

The main runner-up remains the scientific field **"Physics and Astronomy"**. The total number of documents for the period 1996-2021 is slightly over 23,000 (1,040 in 2021) with a total H-index of 175 and an average number of citations per article of 17. The share of Bulgarian scientific publications in the field within the EU remains relatively unchanged, albeit with significant fluctuations over the years. There has been a decline, however, in the contributions to the development of physics and astronomy at the international and regional level.

Engineering sciences retain their third place in the scientific production of the country – 921 publications from 2021, or a total of nearly 17 thousand for the period with an average number of citations of 7.66 and H-index 116. There is again a decrease in the number of publications, together with a lower share in the scientific output at international, European and regional level.

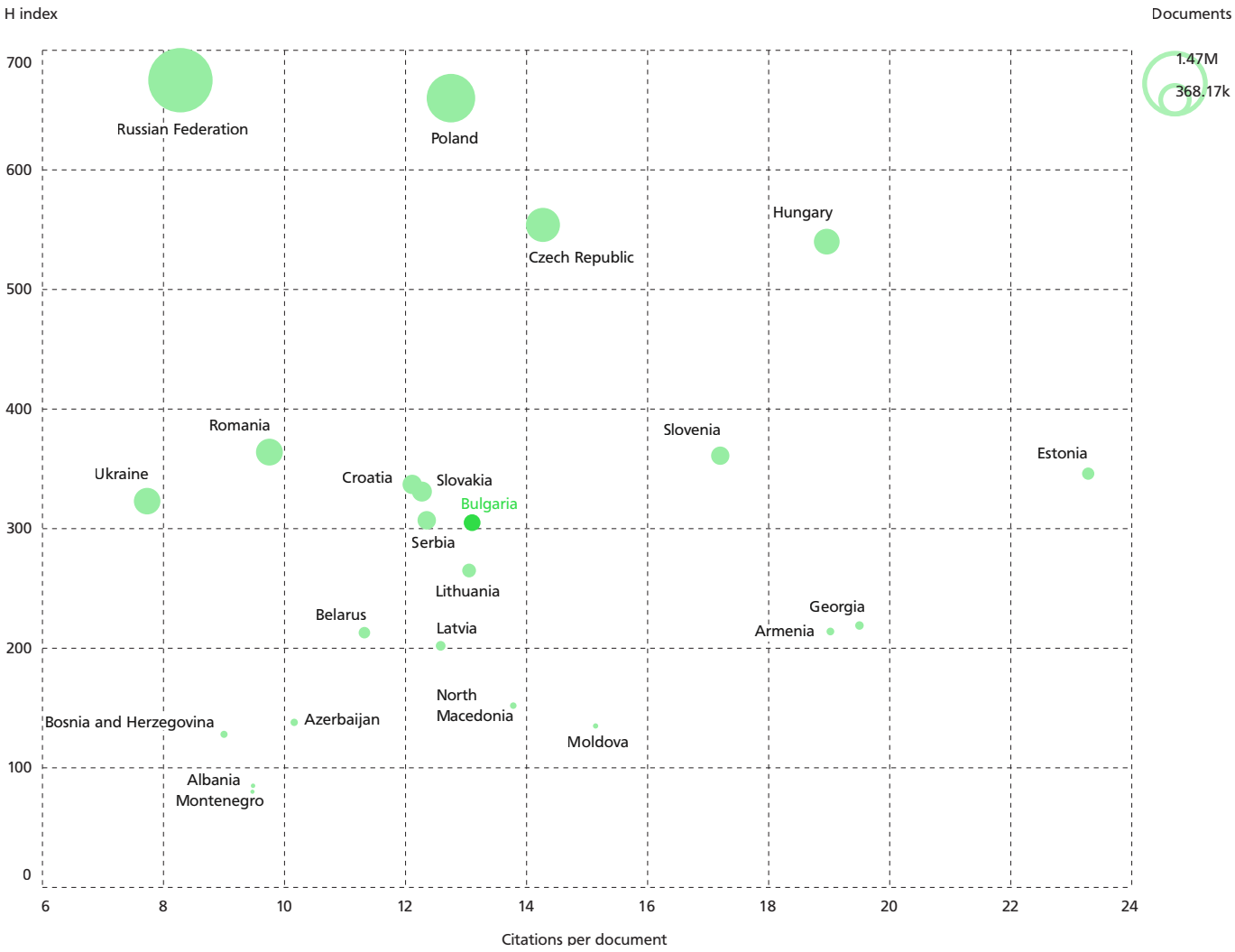
The number of Bulgarian journals indexed in Scopus is growing and reached 56 in 2021. Of these, eight fall into Q1[12] (first quartile), where the most authoritative scientific journals are represented; another 13 are in Q2.

The SCImago institutional ranking includes research organisations (academic bodies, the business sector and NGOs) ranked on the basis of a composite indicator made up of three indicators: scientific research,

[11] The scientometric indicator **h-index** is known as the Hirsch index after the California physicist Jorge E. Hirsch, who launched its use in 2005. It evaluates both the productivity and the importance of the publications made by a certain scientist, group or institution. The value of the h-index is determined based on the most cited publications: among them, those h in number that have been cited at least h times are counted. The H-index is the only number that fits this definition.

[12] Q1, Q2, Q3 and Q4 denote the four quartiles into which Scopus groups scientific journals according to their rank (SCImago Journal Rank, SJR), with Q1 being the highest-ranked journals in which the most the authoritative journals are represented, and Q4 is for the lowest-ranked journals. Quartile (Q) is a bibliometric indicator for classifying scientific journals that ranks them against the SJR metric related to the subject area, quality, and reputation of the publication, and this determines the weight of citations accordingly.

Figure 15. Publication activity in the Scopus database, Eastern Europe, 1996-2021



Source: SCImago (2007). SJR — SCImago Journal & Country Rank. Retrieved November 10, 2022.

results of innovation activity and social impact, measured by their online visibility[13]. The 2022 edition of the ranking includes 23 research organisations and universities from Bulgaria, unchanged from the previous year[14]. BAS participates in the ranking both through the overall data for the Academy and through the independent presence of eight institutes that are part of it. In addition, 14 Bulgarian universities are already in SCImago Lab (a total of 7,409 organisations worldwide), nine of which are research universities. An exception is the Medical University, Pleven, which became a research university in 2022 (together with the Trakia University and the University of Rousse), but is not included in the institutional ranking of Scopus.

The ranking of universities in Scopus is somewhat different than the criteria used to assign the "research" designation to a university used by the methodology of the Ministry of Education and Science, introduced in the Law on Higher Education in 2020.[15] It takes into account more diverse indicators, including funding from participation in international and national research projects, contracts with business, development of the academic staff, social and economic impact of the research.

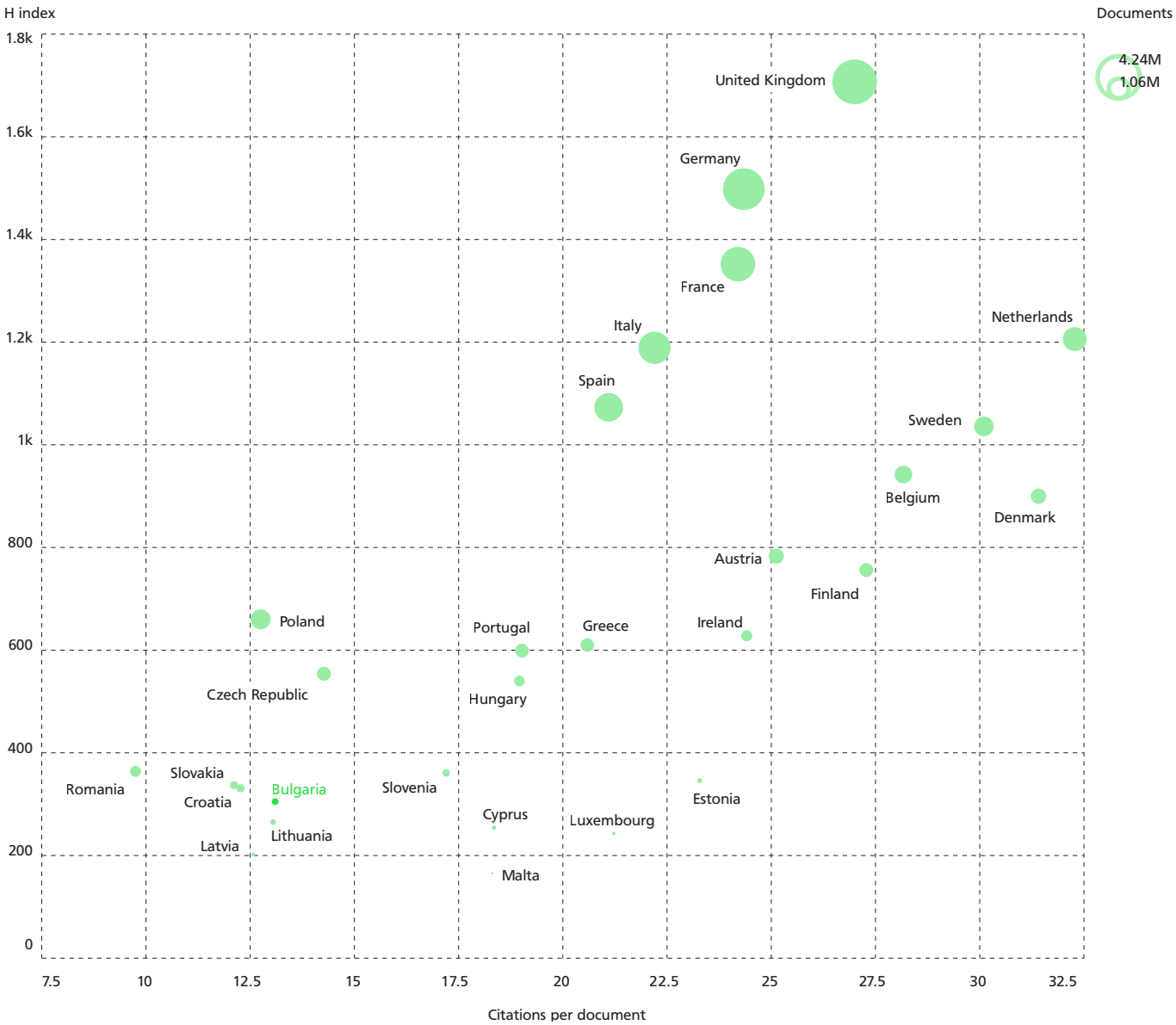
In 2022, Trakia University leads among Bulgarian higher education

[13] SCImago Institutions Rankings (SIR) is a product of SCImago Lab and uses data from the Scopus database.

[14] According to the methodology, the ranking includes institutions that have at least one hundred publications in the Scopus database in the last year of the period under review.

[15] The status of a research university is given for a significant contribution to the development of important public areas through high results in research. The first ranking was based on data for the period 2017-2020, collected within the framework of the annual assessment of scientific activity according to the Act for the Promotion of Scientific Research. The procedure is annual and a list of research universities is updated by November 1 each year.

Figure 16. Publication activity in the Scopus database, EU, 1996-2021



Source: SCImago (2007). SJR — SCImago Journal & Country Rank. Retrieved November 10, 2022.

institutions, with the highest rating in terms of research potential, followed by the University of Forestry and the University of Chemical Technology and Metallurgy. As regards innovation, the medical universities in Sofia and Plovdiv, and the Chemical Technology and Metallurgy University share the leading positions. According to the Scopus methodology, in this category the potential of the research units is determined entirely by the patent activity (by their own researchers or by outsiders) resulting from the scientific product they have created. The University of Sofia has the best performance in the field of social impact, while in terms of research activity and innovation potential it ranks seventh and fifth, respectively, among Bulgarian universities.

Entrepreneurship and innovation networks

The European Commission and national governments put in motion a number of tools to alleviate the impact of the Covid-19 crisis on business and primarily on entrepreneurs and SMEs. The relatively small number of bankruptcies so far is due to the comprehensive measures and the mix of traditional and innovative approaches in improving access to financing (grants, debt and equity financing, tax holidays, etc.).

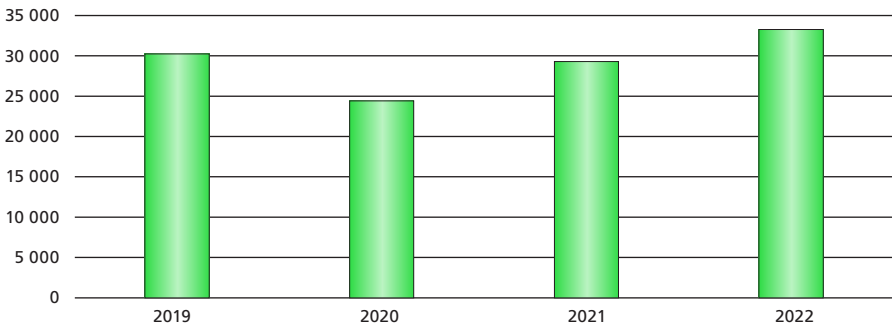
By the estimate of *Innovation.bg 2020,* at the beginning of the Covid pandemic, 11% of individuals in Bulgaria were entrepreneurs. Following a drop in the number of newly registered companies in 2020 and the slow recovery in 2021, in 2022 **14% more companies were registered as compared to before the pandemic.** Individual entrepreneurship is stronger than corporate, as well as among Bulgarian individuals vs foreign. Around 30% of the companies incorporated in the first ten months of 2022 are wholly owned or are partnerships of Bulgarian citizens. While surveys usually underestimate the level of entrepreneurship, data from the Commercial Register about newly registered legal persons (the basic indicator of entrepreneurial activity) show much higher levels.

Almost 80% of new incorporations are sole ownership private limited companies and 4% are sole proprietorships. These options are to be expected from entrepreneurs in an **unpredictable legal environment and slow administration of justice** as they fear that any disputes with partners could block or destroy a business. This kind of bias towards full control deprives of the opportunities provided by bringing together experts from various fields, which could give the new company a competitive edge.

Entrepreneurship is most dynamic in the largest cities and their provinces (oblast) – Sofia, Plovdiv, Varna, and Bourgas. It is also notably high in Blagoevgrad province, which is probably partly due to the presence of two large universities – AUBG and the Southwestern University – but also to Greek entrepreneurship, which keeps up even after the initial migration of Greek companies to Bulgaria during the 2007-2009 crisis. Newly registered Greek companies in Blagoevgrad province in 2022 are around 14-15%.

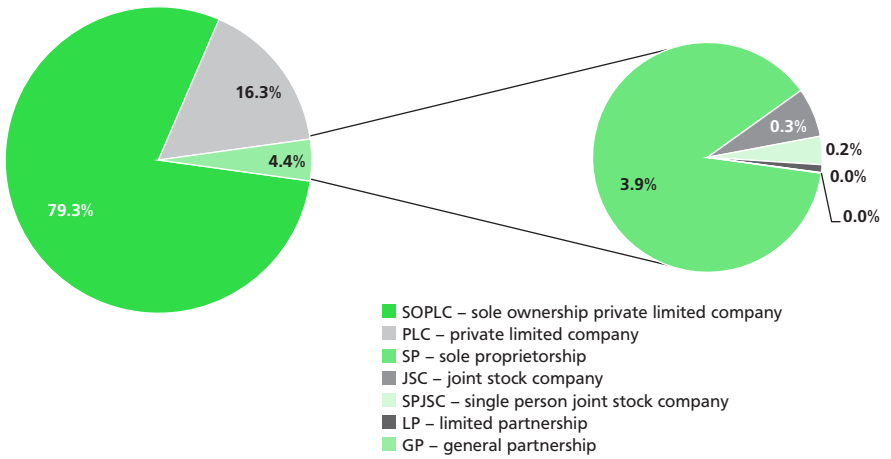
Regional entrepreneurial differences exist with respect to the number of new incorporations and to the initial capital of companies. The average size of initial capital is highest in Sofia province (around BGN 30,000), this owing mostly to the relatively small number of new companies and the

Figure 17. NEW COMPANY REGISTRATIONS, JANUARY 1-NOVEMBER 11



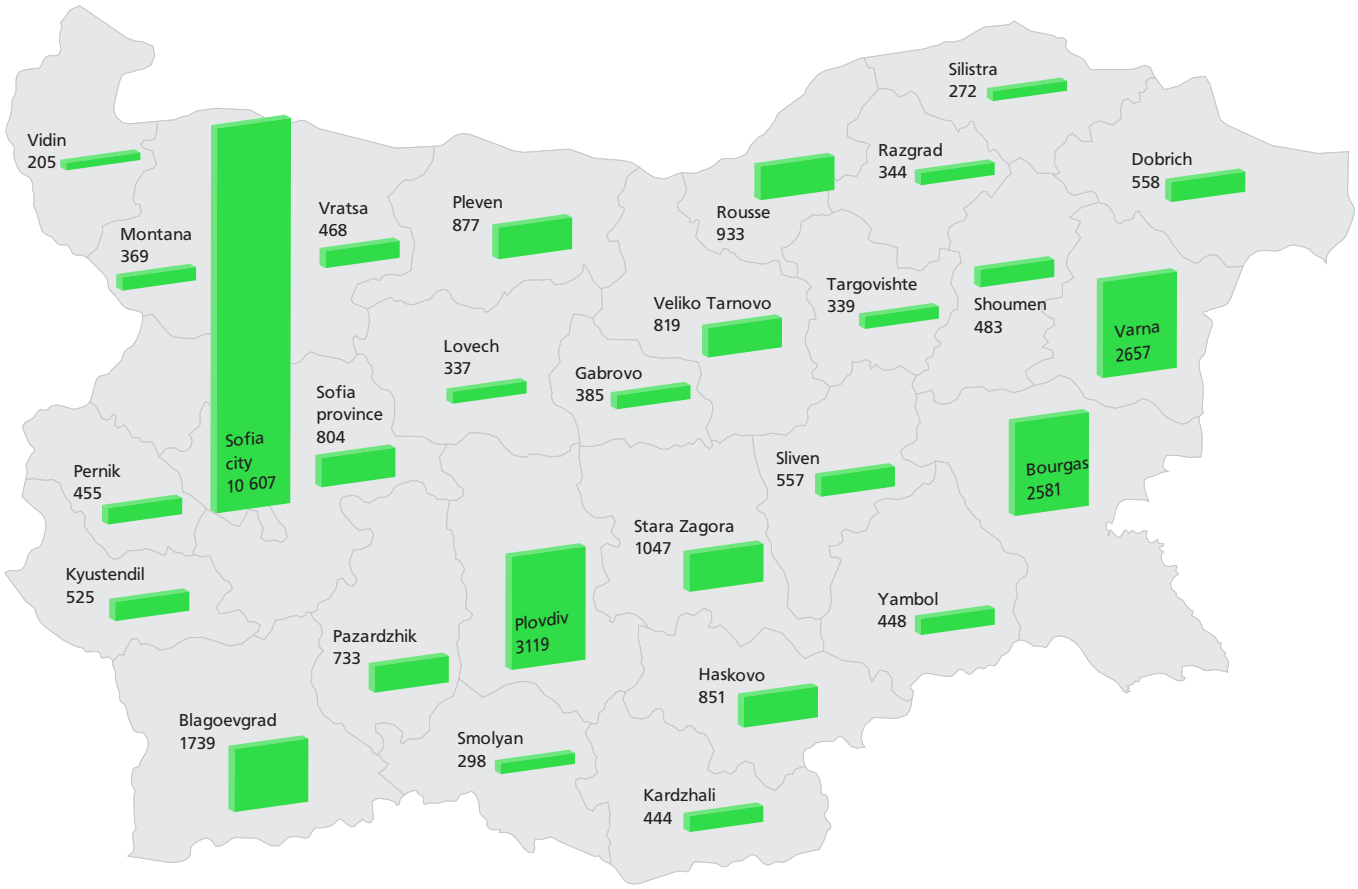
Source: APIS.

Figure 18. NEW COMPANY REGISTRATIONS BY COMPANY TYPE, JANUARY 1- NOVEMBER 11



Source: APIS.

Figure 19. NUMBER OF NEWLY REGISTERED COMPANIES BY PROVINCE



Source: APIS, 2022.

fact that more production facilities are registered there. Sofia province is followed by Sofia city with BGN 20,000, Sliven with BGN 14,000, Varna with BGN 12,000, and Veliko Tarnovo with BGN 10,000. Sliven is ahead of bigger cities because of its **concentration of investment in renewable energy facilities** and the related in-kind contributions of land and buildings.

As a result of the availability of EU funding after 2007 the **Bulgarian startup**[16] **ecosystem developed rapidly.** According to dealroom.co Bulgaria has 1,600 startups, compared to Greece with 1,700 and Romania with 2,800. Bulgaria has, however, the highest number of newly created jobs in startups (per 100,000 population) – 80, while Greece has 60 and Romania 45. Bulgarian startups attract foreign talent, some of whom later decide to start their own business. The country has 20% of the market for startup jobs in Southeast Europe[17] and has a high potential for growth, especially if the government makes it easier for foreign students to enrol in Bulgarian universities[18].

Startup financing in Bulgaria seems more accessible than the average European and is **twice as accessible compared to the rest of the region**[19]. Newly created Bulgarian companies are valued at around USD 5.6 billion, with the most highly valued ones being Gtmhub, Dronamics and Payhawk,

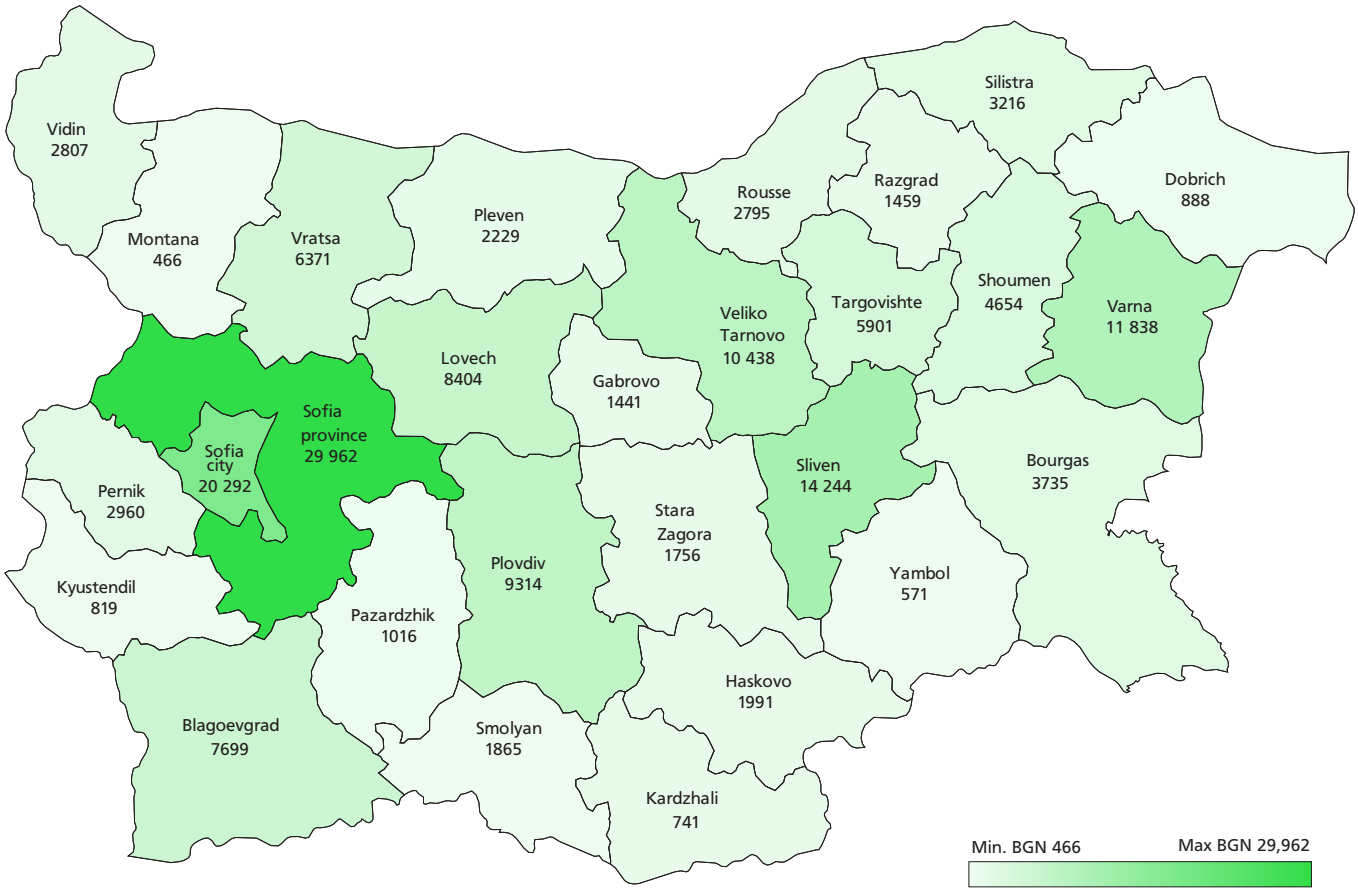
[16] In this case, a startup is not just a new company but such with a potential for rapid growth and capacity to attract multimillion investment allowing its products to become internationally competitive.

[17] SEE Report 2022-November.

[18] Currently, it takes between 9 and 18 months from the moment of application to the arrival of a non-EU student in Bulgaria. In some cases, only obtaining a visa could take up to five months. This preceded by complex interactions among the university, the National Centre for Information and Documentation, the student's university and back along the chain, recognition within the university, clearance from the Ministry of Education and approval from the Ministry of Foreign Affairs even before the student applies for a visa.

[19] SEE Report 2022-November, p. 6.

Figure 20. Average size of capital in newly incorporated companies, by province, 2022



Source: APIS, 2022.

the first Bulgarian unicorn[20]. In some sense the Bulgarian branch of eMag could also be classified as a unicorn. Having a number of fast-growing companies around the country has a direct positive effect within the country. Such companies create opportunities for growth within an ecosystem (such as the advancement of retailers in eMag) and help the development of suppliers (for example STAMH[21], which constructs fully automated warehouses for eMag).

Data about investment in newly created companies confirm the forecast of *Innovation.bg* 2020 that innovative Bulgarian companies **will keep investing in innovation even during the crisis.** The downside is that the such continued invest is only fuelled by the cycle of EU funding and not the market investment cycle. The decline in 2022 confirms this finding, although Russia's war in Ukraine also contributes to high investment insecurity.

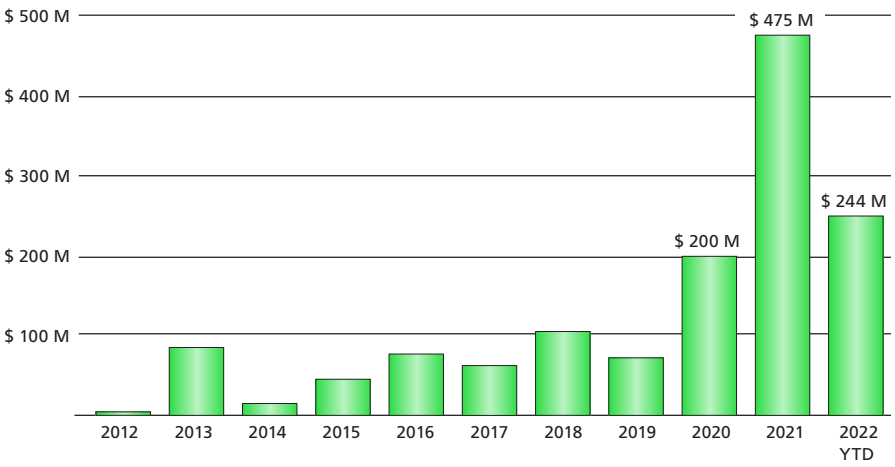
It is somewhat encouraging that few Bulgarian startups are involved in cryptocurrencies (with the possible exception of Nexo) because the turmoil on this market, especially with the collapse of FTX, will have an effect on employment in this sector in Bulgaria.

Another company established in Bulgaria, which is being watched by investors as **a potential unicorn** is Hyperscience. Nexo was also on this list but because of FTX investors will exercise much more caution. It is expected that the period between the creation of a company and the recognition of a unicorn status through investment will keep shrinking with each year. It remains to be seen whether unicorns and other successful smaller innovative companies will manage to establish additional linkages to the local market. For now, the biggest demand is for **horizontal linkages** to universities for the obvious reason of **access to students.** Still, research cooperation with a university is also becoming a popular consideration when choosing Bulgaria as location for opening a company office.

[20] A unicorn is a privately held startup company valued at over USD1 billion.

[21] STAMH Ltd. is an award winner of the Innovative Enterprise of the Year Award in 2020 in the Market leadership category.

Figure 21. INVESTMENT IN BULGARIAN STARTUP COMPANIES, USD



Source: SEE Report 2022-November.

Encouragingly, the first generation of entrepreneurs who successfully sold their companies are becoming **business angels and risk investors** with respect to younger colleagues. Although a precise measure of the multiplication effect of the initial investments in Launchub and Eleven is hard to make, they were definitely a reason for entry of other funds which broadened their portfolios.

For the dynamic development of the startup ecosystem to continue it **needs a broad base of potential entrepreneurs among high school and university students.** Planning one's entrepreneurial career well (and a consequent corporate one) is a key to the success of a company and for not having unreasonable expectations early on. Such attitudes are typically created not by traditional teaching but through experience and experimentation, and meetings with young and successful entrepreneurs in an international environment. In this regard projects such as Erasmus for Young Entrepreneurs[22] and "Innovative tools for capacity building of youth organisations promoting careers of young people" (YouthCap)[23] are indispensable for support of entrepreneurship through **soft measures and knowledge transfer,** suitable for more modest entrepreneurs who will engage in moderate innovations without aiming for a startup or unicorn status.

Growth models other than those based on external financing (with the expectation of re-selling several times) and borrowed capital should also be considered when deciding on a source of initial funding of market entry. A number of innovative Bulgarian companies, such as Datex, Euro Games Technology, Mechatronica, do not borrow but plan their investment only on expected revenue. Instead of outsourcing (as was the trend until recently), they insource, **integrate vertically and rely on self-sufficiency.** In some sense, the pandemic justified these strategies since all those who relied on more complex supply chains faced serious logistical problems.

Bulgaria is also facing its first wave of **exists by the founding owners of a number of companies**. The better part of the first wave of entrepreneurs of the 1990s are already of retirement age and are facing the problem of legacy. The absence of an established market for ownership of active enterprises as well as mechanisms for financing of this kind of transactions pose a risk of loss of valuations in the forthcoming exits and successions.

[22] Five institutions in Bulgaria implement this pan-European project: Sofia University (Faculty of Economics), Bulgarian Chamber of Commerce and Industry, Foundation Cluster Information and Communication Technologies, Bcause and Champions Factory. Erasmus entrepreneurs: business exchange in Bulgaria.

[23] YOUthCAP | Center for research and analysis.

Investment and financing of innovation

Spending on research and innovation is a measure of the investment in the creation, use and dissemination of new knowledge in the public and business sectors. It is considered an indirect indicator of the innovation capacity of the national economies. A high ratio of R&D financing to GDP is a factor fostering dynamic economic growth and competitiveness.

R&D spending

The growth of GDP in 2021 (BGN 139.012 billion at current prices), increasing inflation and the revision of the data by the National Statistical Institute (NSI) worsened the picture of the funding for scientific research, technological development and innovation in Bulgaria. For the first time, **R&D investment crossed the threshold of BGN 1 billion**, marking an annual increase of BGN 50 million, but **its share in GDP fell to 0.77% in 2021.**

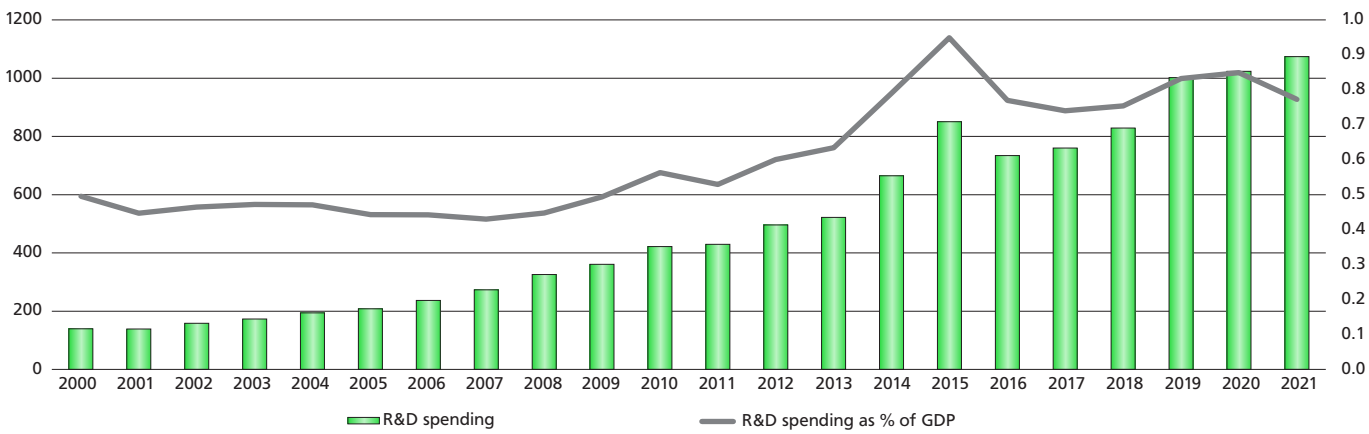
All three main institutional sectors are increasing R&D investment:

- **Nearly 66% of R&D spending in 2021 was made by business.** The budget of the sector "Enterprises" for R&D increased by 2% (a little over BGN 16 million) to a level of BGN 707 million, which constitutes a share of 0.51% of GDP (0.06 p.p. below the previous year's level).
- **The increase in investments of the public sector in R&D is significantly higher** – 10% on an annual basis (or nearly BGN 28 million) to the level of BGN 291 million. This equals a minimal annual decrease of 0.01 p. p. of the sector's share in GDP to 0.21%.
- **The higher education sector also registered a double-digit growth in funds for R&D – just over 11%** to a level of BGN 69 million. The sector's contribution to R&D funding as a share of GDP remains at the same negligible low level of 0.05%.
- For the first time since 2017, **non-profit organisations reduced their R&D spending by nearly 10%.**

The increase in R&D spending in 2021 in the business sector is almost entirely due to investment by large enterprises with more than 250 employees. In fact, as the size of enterprises increases, so do their R&D expenses. In 2021, large enterprises, which accounted for just under 7% of all active enterprises in the year, provided 57% of business R&D spending.

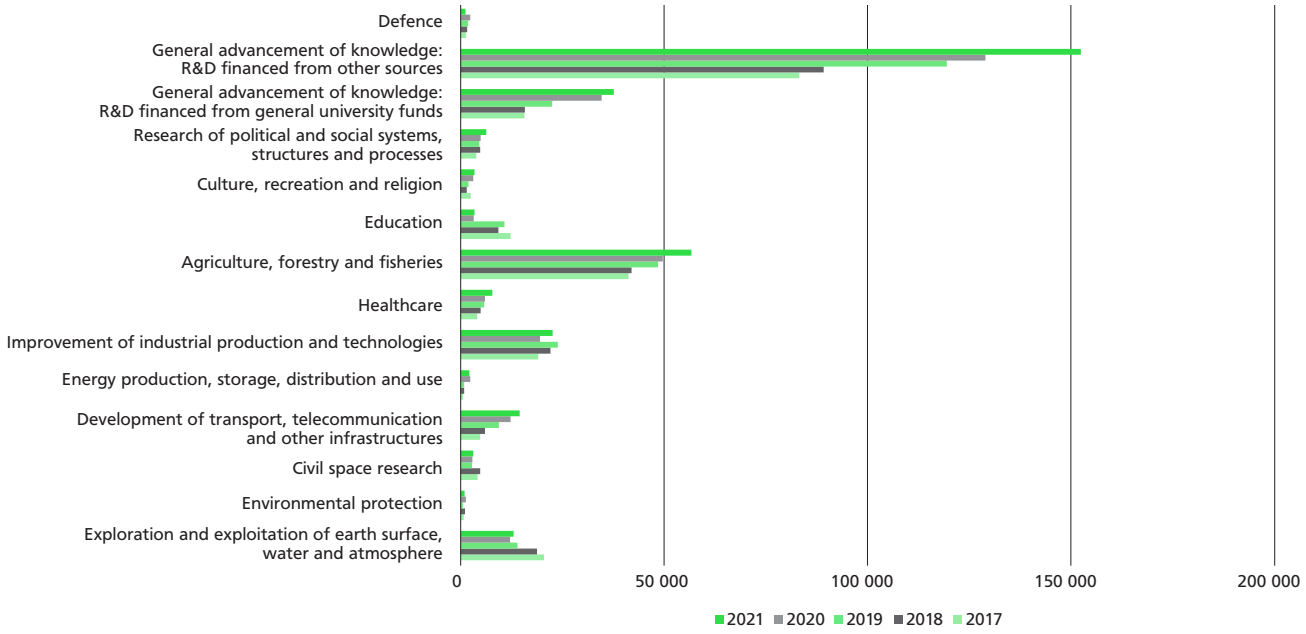
The analysis of the **industry structure of business spending** on R&D has remained relatively unchanged over the past few years. Most investments were made in **the ICT sector** (or as it is formally known, "Creation and dissemination of information and creative products; telecommunications") – 37%, or BGN 263 million. This is slightly higher than in the "Professional activities and scientific research" sectors (33%, BGN 236 million) and much higher than the spending of all subsectors of "Manufacturing industry", taken together (25%, BGN 179 million). The growth

Figure 22. R&D SPENDING IN BULGARIA, 2000-2020



Source: NSI, 2022.

Figure 23. PUBLIC R&D EXPENDITURES BY SOCIO-ECONOMIC OBJECTIVE, BGN THOUSAND



Source: NSI, 2022.

of the sector "Creation and dissemination of information and creative products; Telecommunications" began in 2016 when it levelled with "Manufacturing" and began to overtake "Professional activities and research". It is indicative of the state of the educational sector that such an economically important sector is in the next to last place in terms of R&D spending with 0.04% (BGN 0.283 million), only ahead of the enterprises in "Agriculture, forestry and fisheries" by 0.02%, while also dropping by nearly 40% on an annual basis.

There have been only slight changes in the structure of **R&D spending by scientific field** compared to the previous year. **Technical sciences maintain their leading role** with a 52% share of the total funding, relying almost entirely on corporate funds – nearly 89% compared to 7.5% provided by the public sector, and just over 3% of the budget of technical and technological higher schools. **Medical (19%) and natural (18%) sciences** are relatively equal, although in the first case the focus is entirely coming from business (87%, including growth compared to the previous year), while in the second case it is mainly due to the contribution of the public sector (74%). The budget for **agricultural sciences** is almost entirely provided by the public sector (93% of the total amount of funds in this scientific area). An additional 5% is provided by business, while higher education institutions with a focus on agrarian sciences manage to generate a share of only 2%.

Changes in the distribution of R&D spending by regions of the country are also negligible. The **increase in the concentration of innovation potential in the South West Planning Region continues** (6% growth). Two regions – **South East and South Central regions – had a decrease** in the funding of research and innovation, by 1% and 5%, respectively. Sector "Enterprises" is the leader in all regions of the country with a predominant share of investments in R&D. **Business influence is strongest in the North Central Planning Region** (92%). At the other extreme is the North East region, where the shares of business and the public sector are more equal, 43% and 35%, respectively. As a result of the strong positions of innovative businesses and public sector institutions (including BAS and AA) in the South West Planning Region, the share of higher education is the weakest here – only 4% of all R&D spending in the region despite the clustering of a large number of higher schools. This is indicative of the predominant educational rather than research nature of Bulgarian universities.

The three main institutional sectors (enterprises, public sector and higher education) have different profiles regarding the **sources of funding** for their research and innovation activities. The main sources of funding for **business R&D** are two – **funds from abroad** (primarily European structural funding that reaches enterprises through operational programmes and foreign investments aimed at R&D&I[24]) (55%) and **own funds** (including internal resources made available as a

[24] *Innovation.bg 2021: Building Innovation Recovery and Resilience in Bulgaria*, Applied Research and Communications Fund, 2021.

result of attracted external project financing) (45%). The public sector as a source of funding plays a very small role here, mainly through the national co-financing under operational programmes and through the National Innovation Fund, which relies entirely on funds from the state budget and work commissioned by government institutions and public science bodies. **Higher education institutions** have the most diversified portfolio of R&D funding sources – 51% from the public sector (including through the national science programmes, the National Science Fund and the intra-university funds for research provided by the state budget), 34% from abroad (primarily project funding from participation in international research consortia) and 15% from business as commissioned research. **The public sector remains almost completely closed in on itself**. In it, 83% of R&D spending is provided by the state budget, 9% by business, and only 8% is attracted external funding from participation in international and European projects. The composition of funding sources shows **the lack of an integrated national innovation system** in the country. Government funding from European funds is the main source and determines the nature of the innovation ecosystem. In this sense, **the lack of a national innovation policy supported by a programme budget** for innovation development allocated on a competitive basis is one of the essential impediments in the development of the national innovation system.

In 2021, the total amount of **budget R&D spending by socio-economic objective** (according to the Nomenclature for the analysis and comparison of scientific programmes and budgets; NABS 2007) was just over BGN 326 million, which is an annual growth of 15%. The biggest increase is in healthcare development – nearly 32%, which makes sense given the Covid crisis and the funding to address it through the national science programmes and the National Science Fund.

As in previous years, with the largest share in this budget (47%) is the R&D spending of the BAS institutes, financed under the title "General development of knowledge: R&D financed from other sources" – BGN 152.5 million (growth of 18% on an annual basis). According to the NSI methodology, this item also includes the annual membership fee from the budget to international scientific organisations, as well as payments from the budget related to Bulgaria's participation in bilateral and multilateral research programmes.

The amount allocated to the Agricultural Academy (AA) is BGN 57 million. The subsidy of the AA was increased in 2021 by over 17%, reflecting the increase in the salaries of the academic staff at the Academy – a result of the recommendations made by this report in the past. Along with the funds provided by the state budget, the AA reports project funding from European framework programmes for scientific research and innovation (BGN 915 thousand) and from national programmes (BGN 2,493 thousand).

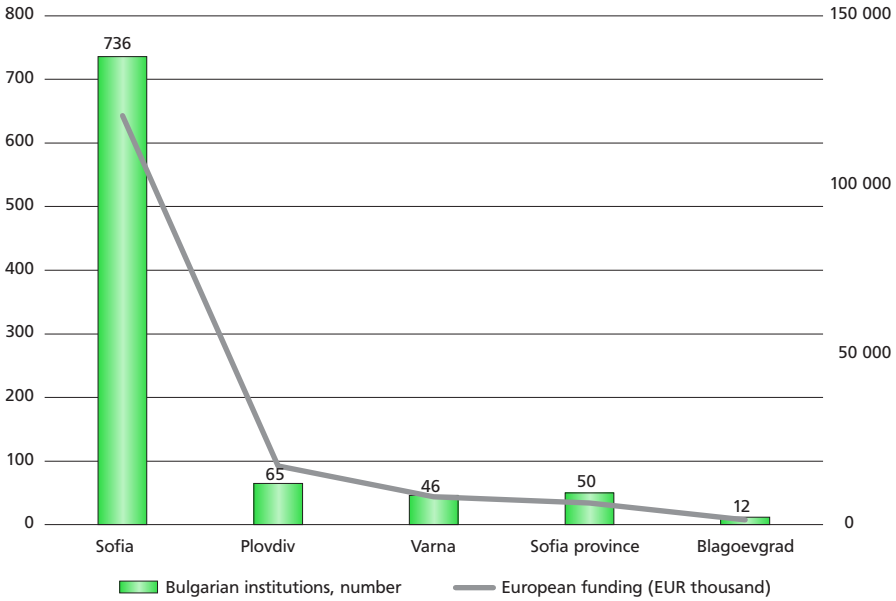
Participation of Bulgaria in Horizon 2020

Since the launch of the Horizon 2020 framework programme of the EU, the Bulgarian organisations which implemented coordination or partner projects funded by it received a total of **EUR 161.9 million** (0.24% of the programme budget) within 664 grant agreements (1.87% of all contracts). **The success rate** of the projects with Bulgarian participation is 11.14%, **close to the EU average** of 11.95%.

Bulgarian participants in the work of Horizon 2020 research consortia number 995[25] and represent 21 of the country's regions. The highest concentration of participants and attracted funding is in the city of Sofia – 736 organisations that received EUR 120 million – followed by Plovdiv, Varna, Sofia region and Blagoevgrad.

In terms of funding received from Horizon 2020, **business performs best** (306 organisations, 32.3% of the funding), followed by scientific organisations (230, 29.1%) and higher and

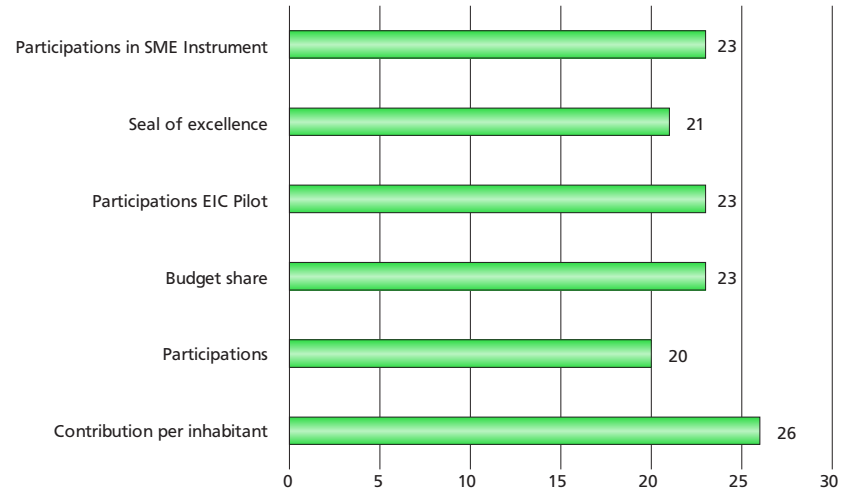
Figure 24. Participation of Bulgarian organisations in Horizon 2020 (NUTS 3)



Source: https://webgate.ec.europa.eu/

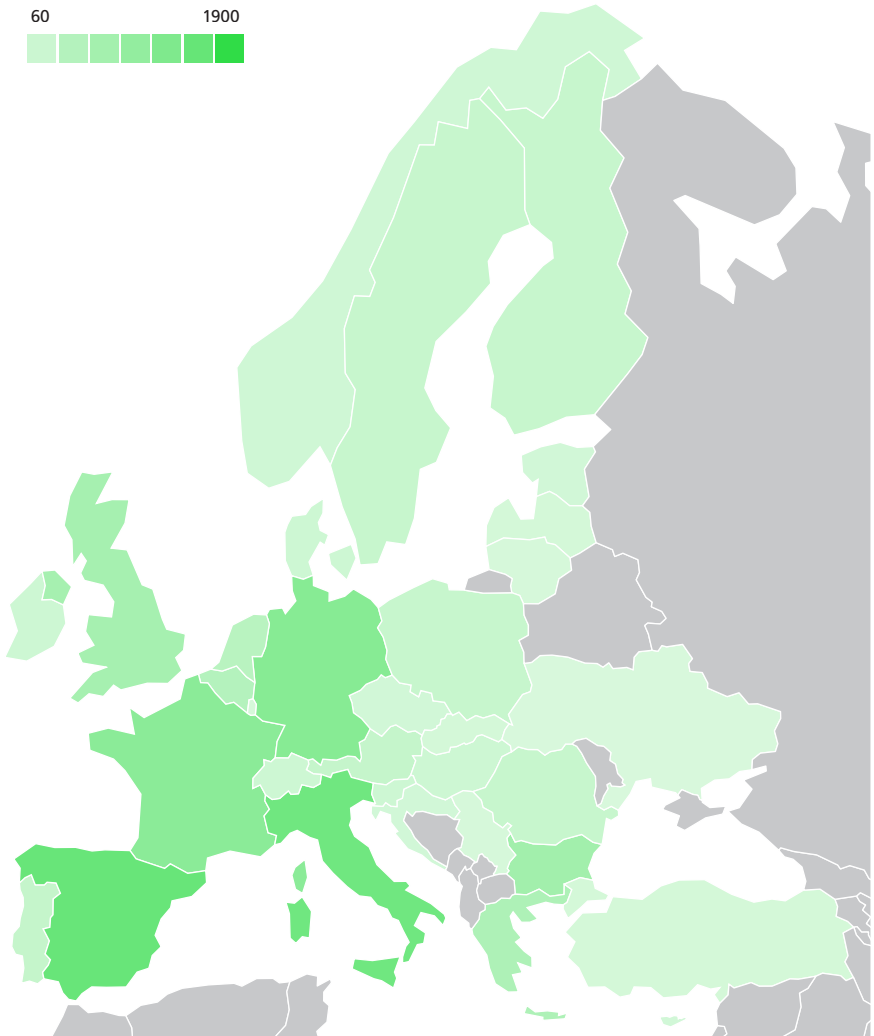
[25] An organisation participating in N projects counts as N times.

Figure 25. Ranking of Bulgaria in Horizon 2020, EU-28



Source: https://webgate.ec.europa.eu/

Figure 26. Intensity of partnerships of Bulgarian organisations on projects under Horizon 2020, Europe



Source: https://webgate.ec.europa.eu/

secondary schools (184, 25.3%). With nearly 7% of the attracted funding, public institutions rank fourth.

Bulgarian organisations have participated in Horizon 2020 projects in partnerships with organisations from 91 countries. The largest number of partners is from Spain, Italy and Germany, followed by France, UK and Greece.

Building on their experience in previous European framework programmes, Bulgarian organisations had **a strong start in projects under the Horizon Europe programme**. As of November 2022, there are 148 participations and **the success rate is already 20.41%**. Eighty-six grant agreements were signed raising EUR 18.7 million.

The five best performers from Bulgaria in terms of attracted funding include the companies Sirma (EUR 2.15 million) and Pensoft Publishers (EUR 1.32 million), together with Sofia University (EUR 668.76 thousand), the Center for the Study of Democracy (EUR 624.38 thousand) and the Medical University, Sofia (EUR 566.53 thousand).

At the end of 2022, the operational programmes for the period 2021-2027, which are also the main tools for achieving the goals of the Innovation Strategy for Smart Specialisation (in a working version too), are still to be approved. Despite the political instability in the country, the national instruments – the National Science Fund and the National Innovation Fund – continue their work. The lack of a policy framework and comprehensive vision for innovative development of the country, as well as national resources for their realisation, puts the Bulgarian economy in **serious danger of long-term technological underdevelopment and growth slowdown**.

Human capital for innovation

Staff engaged in R&D together with those employed in scientific and technological activities comprise the human resources directly responsible for the creation, application and dissemination of new knowledge in the area of technologies. The indicator of employment in high-tech sectors characterises the country's specialisation in sectors with a high level of innovation.

Staff engaged in R&D

In 2021, the personnel engaged in R&D in Bulgaria amounted to **34.6 thousand people**, two-thirds of whom are in the category of researchers – professionals engaged in the creation of new knowledge through research, improvement and development of concepts, theories, models, technical equipment, software and operating methods. The number of researchers remained unchanged on an annual basis, ending the almost continuous growth trend since 2000. The ratio of researchers to other R&D personnel saw a minimal change of 5 p.p. in favour of the researchers.

In 2021, almost half of R&D personnel worked in the enterprises (46%) where 66% of R&D spending was made. The latter is almost entirely directed to cover current costs, including wages. This makes the professional career of highly qualified staff in the business sector more attractive compared to government-funded research units.

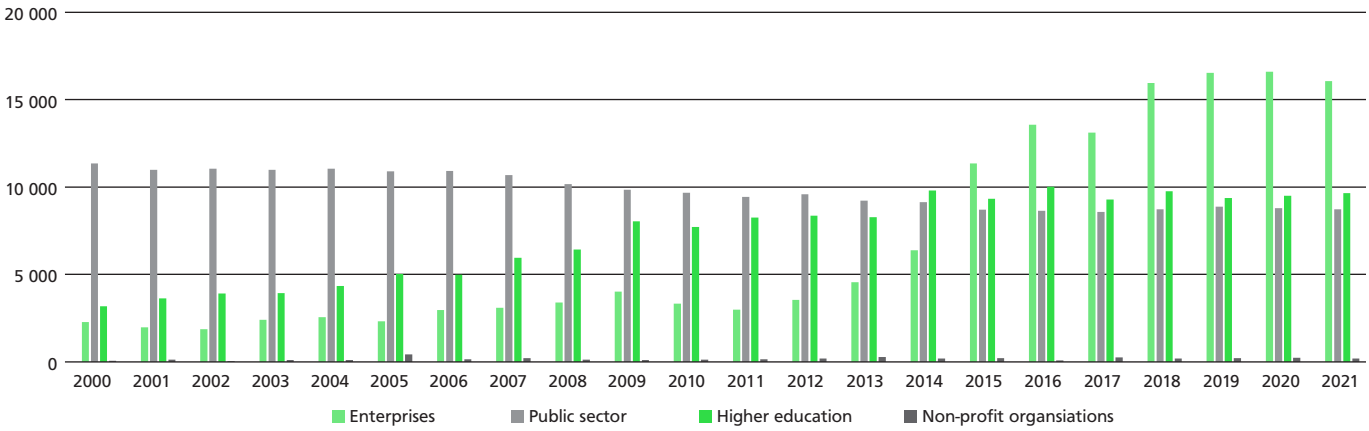
Half of the personnel engaged in R&D in the business sector belong to the group of large enterprises (more than 250 employees). For the last 20 years, they had a growth of 7 p.p., consolidating their position as a major employer of research staff in the business sector. There are **significant differences in the group of small enterprises** (10-49 employees), which **doubled their share within the business sector** as regards the number of staff engaged in R&D to 17%. The trend is opposite for **medium-sized enterprises** (50-249 employees) – their share has **almost halved** from 41% in 2000 to 23% in 2021.

Divergences in the positions of small and medium-sized enterprises in terms of their role as employers of highly qualified staff follow changes in the general structure of the business sector by size of enterprises. The number of small enterprises increased more than 12 times during the period, while the number of medium-sized enterprises increased 3 times. In addition, the profile of small businesses is changing in favour of sectors such as ICT, fintech and knowledge-intensive services.

The leading role of business in providing employment for R&D staff determines **the focus on technical sciences of nearly 40% of researchers**.

The second largest employer of 28% of researchers is higher education, which includes 52 accredited public and private higher education institutions. The sector has **only 6% of the**

Figure 27. STAFF ENGAGED IN R&D, BY INSTITUTIONAL SECTOR, NUMBER



Source: NSI, 2022.

funding for R&D in the country, 20% of which is used for investment purposes.

The organisations of the public sector, including above all BAS institutes (47 units), the AA (21 units), the Military Medical Academy and the other research units and hospitals funded by the government budget, **employ 25% of the staff engaged in R&D**. They have a relevant share of the national expenditure of R&D (27%). Publicly funded research units spend less than 10% of their funds on acquiring fixed assets.

The higher share of capital investment for R&D in higher education and the public sector is provided by the national science programmes, the Research Infrastructure Roadmap, the centres of excellence and the competence centres, in which the publicly funded units are the main participants. The first stages of the mentioned projects were related precisely to the procurement of the necessary research structures.

Despite the lower remuneration of research work in the higher education sector, academic researchers have a more favourable demographic compared to the organisations of the public sector. After 2000, universities in the country have enjoyed increased interest from researchers in the age groups between 25 and 65 years. Staff engaged in R&D is mostly between the ages of 45-54 and 35-44, with a share of 28% and 26% respectively. In the public sector, the share of employed persons under the age of 34 has significantly decreased – in total, their number has halved since 2000. The biggest increase (by 18%) was in the number of R&D staff over 65 years of age.

After 2014, the number of academic personnel in universities alternated between decline and increase (within 5-10% on an annual basis) but remained practically unchanged in absolute terms – 8,509 researchers in 2021 (4 more compared to 2014).

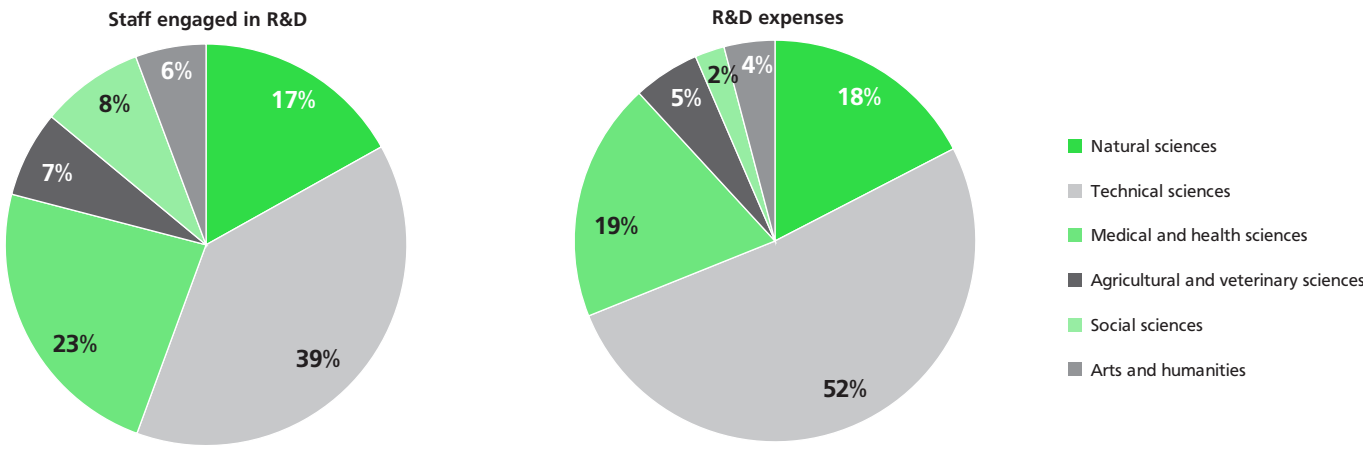
Skills and competencies for innovation

Despite the series of policy documents and reforms in the field of human resources in Bulgaria the challenges remain extremely serious and the country continues to fall behind global developments.

An important indicator of the potential of the economy to develop and implement innovations based on locally developed or imported new technological knowledge are the university graduates in the scientific and technological fields of education26. In the last 5 years, however, there has been a downward trend in their number and as a share among all graduates.

The demographic collapse and the negative migration balance led to a decline in the number of secondary school graduates. Combined with the propensity of Bulgarian students for applying to foreign universities, in 2021 this caused a fall of 20% (compared to 2017) in the number of bachelor's graduates (a total of 23,269 people). There has also been a drop in the numbers for scientific and technological fields of education, in most cases more serious compared to the general decline of those who received a bachelor's degree. These fields include:

Figure 28. RESEARCH AND DEVELOPMENT ACTIVITY BY FIELD OF SCIENCE, 2021, %



Source: NSI, 2022.

[26] Scientific and technological fields of education according to the International Standard Classification of Education (ISCED97) are: natural sciences (ISCED42); physical sciences (ISCED44); mathematical sciences and statistics (ISCED46); informatics (ISCED48); technical and engineering sciences (ISCED52); manufacturing and processing sciences (ISCED54); architecture and construction (ISCED58).

- environment – a decrease of 43% over the last 5 years;
- physical, chemical and Earth sciences (-28%);
- mathematics and statistics (-32%);
- technical sciences and technical professions (-19%);
- mining and production technologies (-20%);
- architecture and construction (-45%).

The only exception is the ICT field, where there was a growth of 17%.

In the field of agriculture, the decrease has been within 8%, together with 55% for fisheries and 72% for forestry. Such a decline in the inflow of highly educated specialists **will significantly impede the processes of green and digital transformation** of the sector, as discussed in the section on agriculture in this report.

Bulgarian students show preference towards business, administration and law (52% growth), security (29%) and healthcare (8%), despite the efforts of the Ministry of Education and Science for structural reforms.

The picture for master's degree graduates is similar. There has been an increase in the numbers of doctoral students in mathematics and statistics by 28% and in environmental studies by 11%; for all other scientific and technological fields of education the decline is considerable. Apparently, increased funding for the various educational fields as the only impact factor fails to solve existing problems.

Along with the deterioration of the profile of the cohort of university graduates who would engage in the development and application of technological innovations, there is also **a high level of de-skilling of the adult population**.

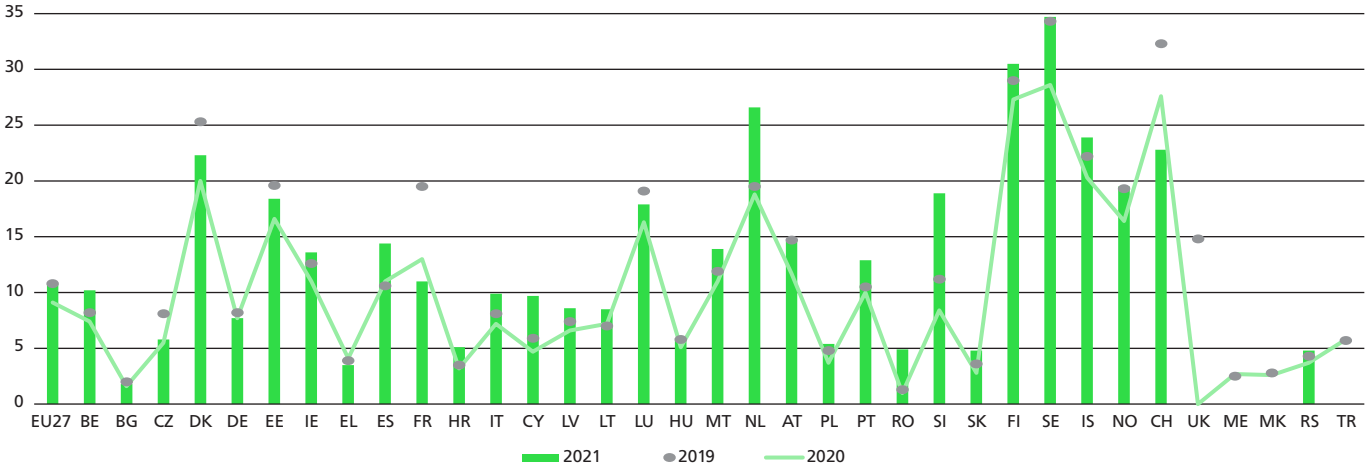
The participation of adults in formal, non-formal and informal learning[27] is an important factor when it comes to the adoption of Industry 4.0 and Industry 5.0 technologies.

The proportion of 25 to 64-year-olds in the EU who participated in education or training in the last four weeks of 2021 was 10.8% (an increase of 1.7 p.p. higher on an annual basis). It is believed that this increase could be related to the economic recovery after the Covid-19 pandemic, which also led to more active participation in various forms of education.

The share of the population in the EU involved in adult learning is higher among women (11.6% in 2021) than among men (10.1%), which is true for all EU member states, with the exception of Romania, Cyprus, Germany and Greece.

Sweden, Finland and the Netherlands stand out with significantly higher shares of the adult population participating in lifelong learning during the study period. All three countries have a share of over 25%. In contrast, **Greece and Bulgaria report adult education levels below 4**%. The data for Bulgaria condemn the country to maintain its position as a laggard within the EU in terms of indicators of innovation potential (see the "Innovation product" section) and readiness to develop competitive advantages based on new technologies.

Figure 29. Participation in education and training, last 4 weeks of 2021, % of population aged 25-64



Source: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Adult_learning_statistics.

[27] **Formal education**: a hierarchically structured, chronologically graded education system, passing from primary school through university and including, in addition to general academic training, a variety of specialised programmes for regular technical and vocational training. **Non-formal education** refers to lifelong learning in which each individual acquires attitudes, values, skills and knowledge from everyday experiences and the educational influences and resources in his or her environment. **Informal education** is any organised educational activity outside the established formal system, which is towards the generation of knowledge and skills.

Information and communication technologies in the light of artificial intelligence

Information and communication technologies (ICT) continue to be a significant factor in the innovation of enterprises and the growth of economies. The notion of ICT has significantly changed since the first report *Inovation.bg 2004*. Automation moved smoothly from machines through production processes and reached the cognitive abilities of the enterprise's personnel or its customers. Artificial intelligence (AI) is transitioning very quickly from a special technology to a general-purpose one – widely affordable in price and available for use, embedded in a variety of other software provided as a service.

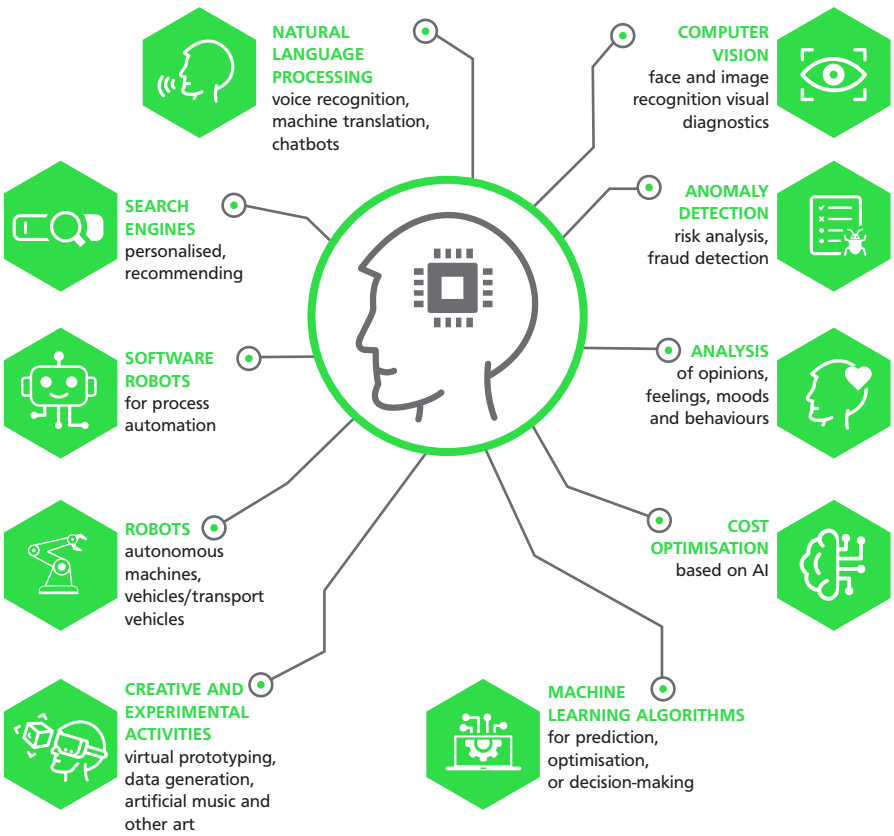
AI: The new integrating metaphor for ICT

The measurement of ICT by their innovation life cycle in enterprises and households is always accompanied by variable definitions, blurring of understandings and contradictions in data and interpretations even in methodologically close studies. *Innovation.bg* reports have focused the attention of public institutions on this problem earlier (diffusion of computers and the internet, specific access technologies, such as dial-up and broadband internet, as well as the continued underestimation of R&D in business). Artificial intelligence is no exception in this regard.

Innovation.bg 2021 cited data from the first pan-European study on technologies based on artificial intelligence, assigned by the European Commission to a consortium including the Belgian consulting company Ipsos and the International Centre for Innovation, Technology and Education Studies at the Free University of Brussels[28]. According to that data, 54% of enterprises in Bulgaria use at least one of 10 AI technologies, with an average for Europe of 42%, which places the country in the top three positions in Europe. Almost a third (31%) of enterprises in Bulgaria used at least two technologies, compared to an average for Europe of 25% (or 8th place on the continent).

At the same time of the Ipsos survey, Eurostat conducted its annual Community Survey on the use of ICT and

Figure 30. Range of AI technologies in the Ipsos study



Source: Applied Research and Communications Fund

[28] Ipsos and iCite, (2020), *European Enterprise survey on the use of technologies based on artificial intelligence.*

e-commerce. The differences in the results are between 6 and 10 times (7% on average for the EU and 5% for Bulgaria)[29]. Such major differences can hardly be explained only by the fact that the Ipsos sample includes also micro-enterprises (fewer than 10 people), while Eurostat examines only small and medium-sized enterprises (10 and more employees). As the publication of the Eurostat Institutional Survey data is usually delayed for too long, the Ipsos data took hold, thus supporting the analyses of a rapid penetration of artificial intelligence across Europe. In EU's Digital Agenda[30] database, there is only data on the use of AI technologies for 2021 – 3.29% for Bulgaria and 7.91% for the EU, which are comparable to those of Eurostat from 2020.

The difference in numbers is mostly due to the methodology and definition of what artificial intelligence is. Ipsos research defines it as "technology that tries to automate one or more (human) cognitive functions or processes. It provides predictions, recommendations or decisions to achieve specific objectives. It does so by continuously learning about its environment or results from its actions"[31]. According to the researchers, 10 varieties of artificial intelligence best fit this definition:

- Natural language processing (speech recognition, machine translation, chatbots);
- Visual diagnostics, face or image recognition (computer vision).
- Fraud detection or risk analysis (anomaly detection).
- Analysis of emotions or behaviours (sentiment analysis).
- Forecasting, price optimisation and decision-making using machine learning algorithms.
- Process or equipment optimisation using AI.
- Recommendation and personalisation engines using AI to produce customised recommendations, via matching algorithms or information retrieval.
- Process automation using AI, including warehouse automation or robotics process automation.
- Autonomous machines, such as smart and autonomous robots or vehicles.
- Creative and experimentation activities, such as virtual prototyping, data generation, artificial music or painting.

In each of these niches in Bulgaria there are at least two of the following four types of companies:

- A large international (global) company that has outsourced part of its operations related to AI in the country, cooperates with universities and is ready to finance joint projects. Perhaps the most significant company to this effect is Schwartz IT[32]. Most likely, in this segment of the market, the model of the entry of fintech companies will be repeated, since there is practically no global fintech company without an office in Bulgaria. *Innovation.bg* also expects the entry of startup companies from Europe with the aim of accessing human resources, but also to be in a rapidly developing ecosystem of other AI companies and academia. One such company is Lattice Flow, which awarded as the best AI startup in Switzerland[33].
- An established Bulgarian company with unique technology and a wide portfolio of clients. Such are Ontotext (Sirma), Sensika and Milara International, Identrix (A Data Pro). This group also includes Bulgarian companies that have attracted significant funding and have become "foreign", such as HyperScience.
- A startup company that aims to solve an important technological problem by R&D. About 15% of the startups in Sofia[34] work in AI. According to data from the Artificial Intelligence Cluster, 40% of those employed in the sector in 2021 are engaged in R&D, which is a significant increase compared to the 29% in 2020.
- A diffusion hub, i.e. a company that implements AI technologies (exclusively or as embedded in some other solution) in many other local companies. Such are the companies for process automation, cloud services related to the creation of online stores, chatbots, etc. As in the past with process innovations, the determining factor for the growth of applications are external suppliers, because it cannot yet be expected that companies will be able to adopt AI technologies on their own.

According to the annual report on the state of AI in Bulgaria, in 2021, developers of AI applications generated EUR 25.7 million, which represents a growth of 17.3% compared to 2020 and 35% compared to 2019. This estimate is conservative even if international companies and diffusion hubs are excluded.

[29] Artificial intelligence in EU enterprises – Products Eurostat News – Eurostat.

[30] Analyse one indicator and compare breakdowns — Digital Scoreboard – Data & Indicators.

[31] Ipsos and iCite, (2020), pp. 21-22).

[32] The IT company of the Kaufland and Lidl group. It is the main sponsor of the master's program Artificial Intelligence for Business and Finance of the Faculty of Economics at Sofia University.

[33] One of the founders of the company is Prof. Martin Vechev from ETH, Zurich, and its arrival is connected with INSAIT. The founders Martin Vechev and Petar Tsankov are serial entrepreneurs with several successful exits from similar companies.

[34] Sofia Business Guide (2020). This percentage appears in many reports and speeches and for different years, referring to all startups, but most likely only refer to those between 600 and 700 which participated in some of the venture funding rounds in 2019.

The parallel study by Eurostat starts from a slightly different definition of AI. The assumption is that these are systems with intelligent autonomous behaviour towards a given goal, receiving information from the environment and adapting to it. In this form, AI was not presented to the respondents in the survey, but was constructed according to the responses about the use of four types of AI:

- Chat service where virtual bots/ agents (computer generated, animated and based on artificial intelligence) serve the customer.
- Machine learning algorithms for pattern detection in automated task performance.
- Generation, recognition and processing of natural language to analyse big data.
- Use of software robots and robots performing services in a complex and dynamic environment in an interactive mode with people, objects or devices, excluding industrial automation robots.

Thus defined, AI is much narrower in scope and content. For example, according to the broader definition, rule-based chatbots, which are the most common, are easily perceived as applicable, while in the second option, they are not considered artificial intelligence.

About 5% of Bulgarian enterprises use exactly one of the four technologies of artificial intelligence. The Eurostat/NSI sample did not include enterprises using more than one at the same time. Two percent use chatbots, software robots or robotic services and 1% use machine learning algorithms.

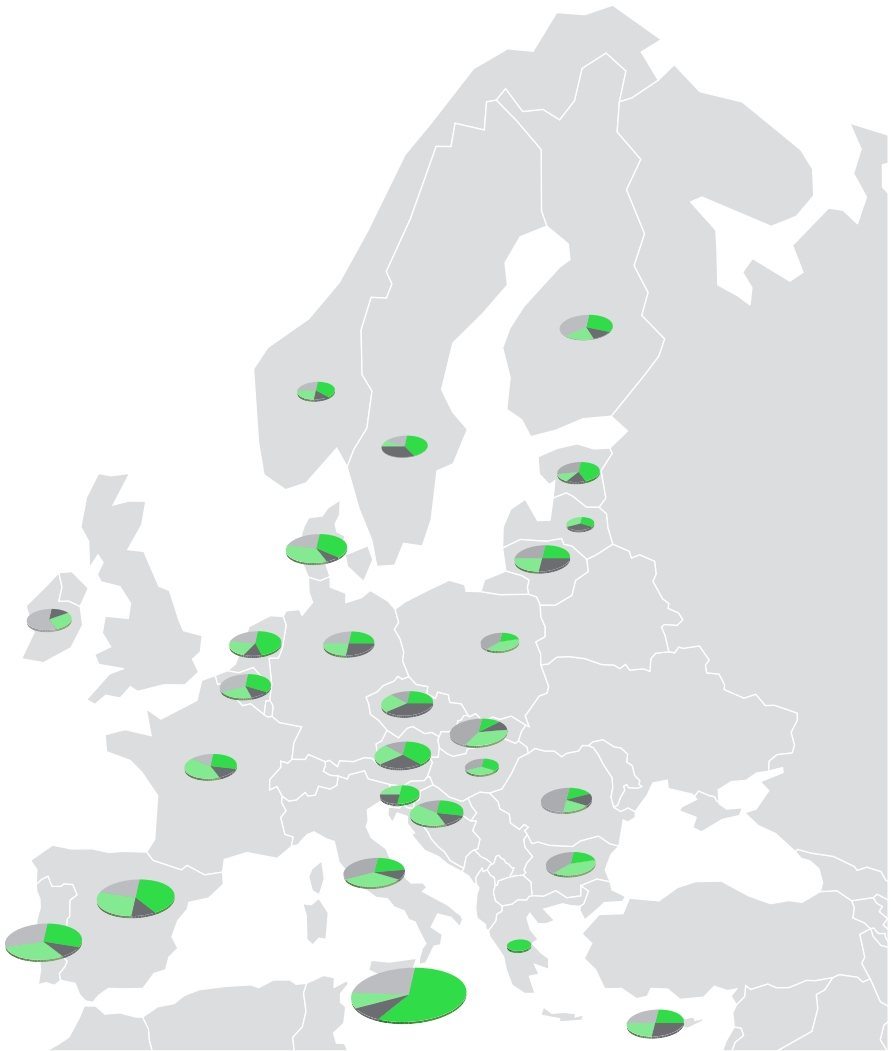
In reality, however, some of the most interesting and cost-effective applications of artificial intelligence are precisely the joint, coordinated use of different types of AI. For example, with the help of algorithms for modelling big data of communications between customers and the service centre (real chats, emails, recorded conversations to be recognised and become text) typical user scenarios can be derived (the so-called topic modelling), sentiments can be diagnosed and chatbot models can be created to handle a large portion of inquiries, thereby optimising the call centre.

Typically, this type of innovation is created in networks of organisations rather than intra-company, as they require very different competencies. In one such case, for example, the dissertation of a doctoral student at the Faculty of Economics of the University of Sofia University led to the creation of a chat-bot in a large bank[35].

Intensity of use of accompanying technologies

Artificial intelligence technologies cannot be used without reliable and secure **cloud technologies**. Although

Figure 31. USE OF ARTIFICIAL INTELLIGENCE IN ENTERPRISES*



* The size of the circle indicates the share o f firms that use at least one of four AI technologies

Source: Eurostat, 2022.

[35] Hristova, Gloria (2022) "Automated system for online communication with customers through machine self-learning and natural language processing – structure, construction and business applications", Dissertation towards gaining the degree "Doctor" in Economics, Faculty of Economics, Sofia University "St. Kliment Ohridski".

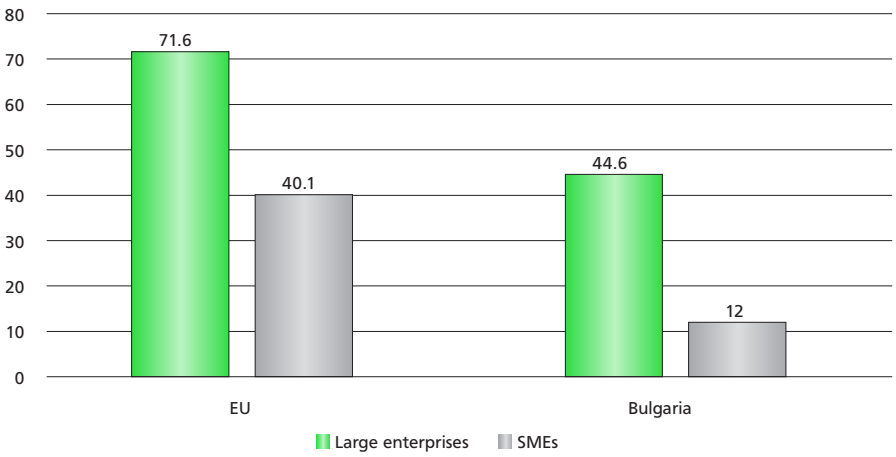
cloud services and virtualisation are widely available in Bulgaria – provided by both foreign companies such as VMware and Bulgarian ones such as Siteground, Scala Hosting and Superhosting – only 12.8% of SMEs claim that they use cloud services, compared to 41% in Europe. In this regard, the distance between SMEs and large companies in Bulgaria is considerable.

In Bulgaria, cloud services are most often used in the service sector (business process outsourcing), unlike in the other EU countries where they are mainly used in industry. Another divergence is in the sophisticated use of cloud services, which is associated with higher security. Only 10% of Bulgarian enterprises use sophisticated cloud services, compared to 34% on average in the European Union. This puts businesses (and government) at risk of cyber-attacks and being blocked for a long time, as happened with the Bulgarian Post in the first half of 2022. The war between Russia and Ukraine and the targeting of the European economy by Russian hacker groups puts under threat the cybersecurity of all economically significant enterprises.

Cloud services are the tool of transformation of software products into a service, but also of the transformation of data from the consumption of a product or a service into knowledge, and from there again into a service. Big data analytics cannot happen without cloud services, smart houses and smart cars cannot work without cloud services, etc.

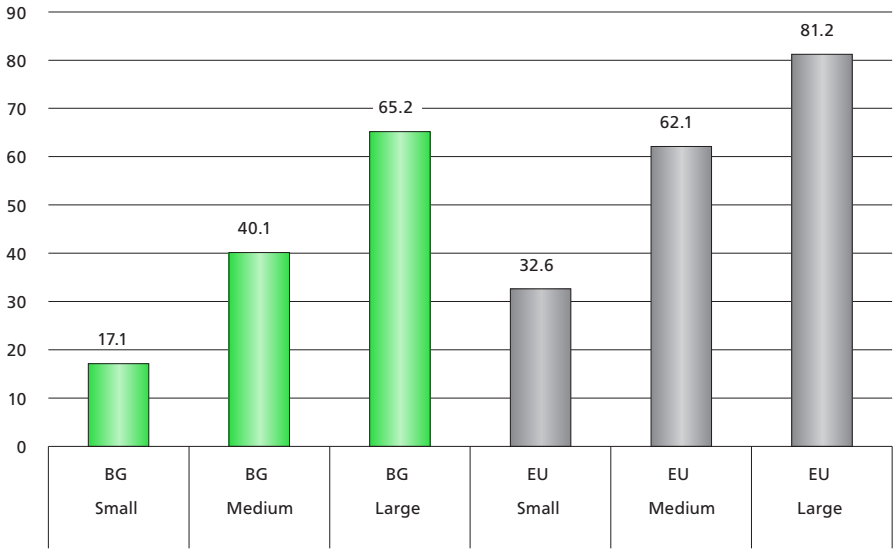
An important condition for the use of modern methods of analysis (machine learning) and AI in general in decision-making is that the enterprise be internally integrated in terms of information – to use an enterprise resource planning system (ERP), including the internet of things, and customer relations

Figure 32. USE OF CLOUD SERVICES



Source: Digital Scoreboard, 2022.

Figure 33. SHARE OF ENTERPRISES THAT HAVE CONNECTED THEIR INTERNAL PROCESSES TO ERP



Source: Digital Scoreboard, 2022

management (CRM), incl. managing knowledge about them across all access channels to be able to generate coherent big data.

In terms of ERP use, Bulgarian enterprises are seriously behind European ones (21.8% vs 38.1%). The problem is even bigger in smaller enterprises. Taking into account that foreign enterprises and those integrated in production chains are usually linked to their parent companies using ERP, it is likely that an even smaller proportion of domestic enterprises use ERP, resulting in a loss of comparative advantages.

As can be expected, the share of users of CRM is about half of those using ERP (11.2% use CRM in Bulgaria compared to 19.5% for the EU). The reason is that a significant proportion of enterprises with ERP are in the B2B segment, not the B2C segment (where CRM is relevant).

With the rapid development of the fintech industry, payment terminals (e.g. Phyre) easily acquire CRM functionalities. The Payment Services Directive (PSD2) requires banks and other financial institutions that manage payment accounts for customers to provide third-party services with access to those accounts. This made possible the development of a payment system that bypasses the few major global credit card operators and has instant payments. Fintech companies can thus begin to offer a host of non-banking services related to customer relationship management.

E-commerce

The share of enterprises that sell online (and generate at least 1% of turnover through online channels) is increasing and reached 10.5% in 2021. This share seems small, but the data shows that for Romania the share is 12%, and for Germany and Austria – about 20%. Nearly a fifth (19%) of large businesses sell online. On average, 6.19% of the turnover of Bulgarian enterprises is generated online. Large enterprises generate 10% of their turnover from online sales, and small and medium-sized enterprises – about 4%. According to the Bulgarian e-commerce association, e-commerce turnover has reached 2.5% of GDP[37].

The majority of payments are still in cash, as small retailers find card payment fees too high. In addition, between 7% and 20% of orders remain unclaimed or are with the wrong address[38], further increasing transaction costs.

NSI/Eurostat data related to internet use are traditionally underestimated[39]. According to them, only 33% of all individuals have ordered online in the last year, which seems too low. A more realistic estimate is 42-44%, according to the data of the Bulgarian e-commerce association. The share of people who sell online (P2P; usually used items or art) is also increasing – 8%.

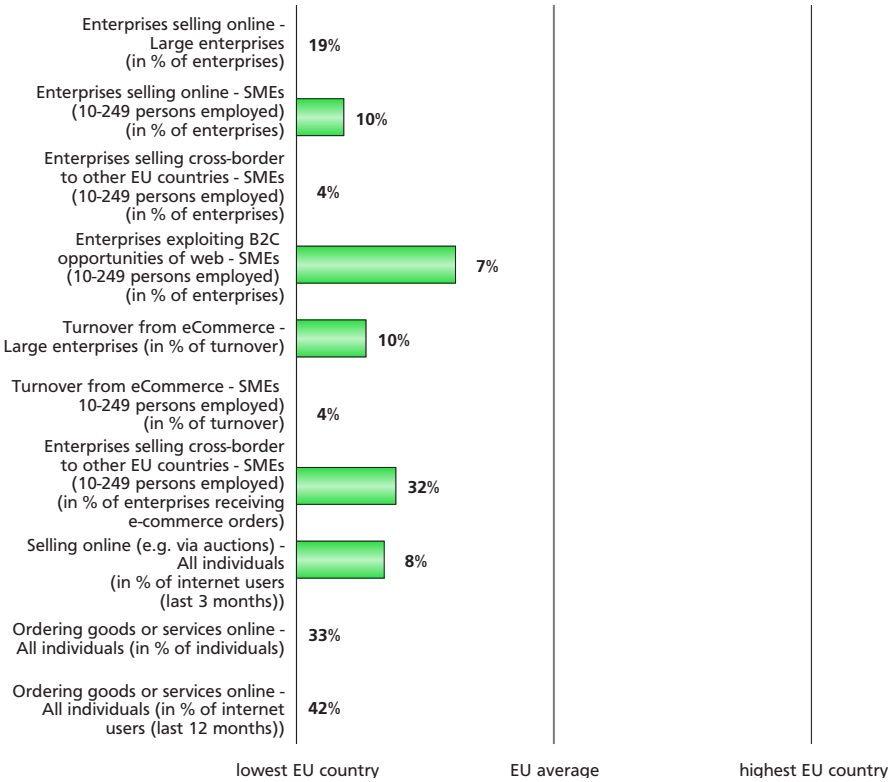
An important development last year was the increased share (almost a third – 32%) of small and medium-sized enterprises that sell online not only in Bulgaria, but also in other countries of the European Union. This shows a significant internationalisation of businesses that are online.

Box 5. INSAIT[36]

The Institute for Computer Science, Artificial Intelligence and Technology (INSAIT) at Sofia University was created at the initiative and under the guidance of Prof. Martin Vechev from ETH, Zurich in order to promote Sofia and Bulgaria as a location for AI rivalling Zurich, San Francisco and Tel Aviv. The Institute is funded on a public-private basis, involving the governments of Bulgaria and Switzerland, large international technological companies and leading Bulgarian companies. INSAIT will host post-graduate students working on the latest unsolved problems of science related to quantum computers and their programming, AI, technology transfer and entrepreneurship. Some of the startups from Zurich are relocating to Sofia Tech Park.

Source: Applied Research and Communications Fund

Figure 34. E-COMMERCE PROFILE OF BULGARIA



Source: Digital Scoreboard, 2022.

[36] Insight.ai

[37] European E -commerce report 2022, pp. 81-82.

[38] Ibid.

[39] Historically, this is due to the sampling methodology (households, not CATI), which does not capture active young people who use the internet.

By comparison, less than 5% of all businesses in the economy export.

The expansion of online exports is driven by a number of factors – apart from the availability of a competitive product and the availability of logistics – from courier services and payment on delivery to VAT facilitation for sellers. The need to register in each country where sales are made and to pay for accounting and other services increases transaction costs in a way that makes it unaffordable for small businesses to physically relocate. Following the adoption of changes throughout the European Union, which allowed eMag-type platforms (marketplace) to carry out overall administration, rather than individually for retailers, smaller companies have increased their cross-border trade.

Box 6. GAMIFICATION OF 11235 LTD.

Gamification refers to the use of elements of game playing in other areas of activity. As early as the 1960s, manager training included role-playing, board games, and later computer simulations in order to enhance engagement of staff, get quick feedback and make it enjoyable. Gamification is now popular worldwide and is applied in diverse fields, from marketing to recruitment. ICT and AI are key tools for the implementation of gamification projects.

In 2022, one of the notable such projects was carried out by 11235 Ltd. (a private company named after the first five Fibonacci numbers) in the customer service centre of Postbank. It involves an IT system where personnel log in with individual passwords and offers competitions, awards, missions, etc. The system relies on gamified behaviour but also uses data from the actual work assignments of the staff in order to motivate them to carry these out more effectively. There are also trainings and nominations related to the values of the company.

Similar games are implemented in various large companies – from Amazon to Bayer – while in Bulgaria gamifications are introduced by foreign companies, such as Coca-Cola, OMV and others.

Source: Applied Research and Communications Fund.

The development of e-commerce in Bulgaria is driven by several factors: a) eMag and Olx (which are part of the same group, but represent two different verticals – B2C and C2C, as well as some of their specialised fashion stores); b) large chains of household appliances, consumer electronics, and furniture; c) order and delivery of food in the top 5 cities in Bulgaria; and d) ordering from Chinese online portals.n important development last year was the increased share (almost a third – 32%) of small and medium-sized enterprises that sell online not only in Bulgaria, but also in other countries of the European Union. This shows a significant internationalisation of businesses that are online. By comparison, less than 5% of all businesses in the economy export.

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There are 5,000 merchants actively working[40] in eMag, where both traffic and sales continue to grow. There are over 2 million active products on the platform and 1.4 million orders (one order can include more than one product). About a third of eMag sellers (29%) doubled their income in the last year.

E-commerce is an area where artificial intelligence is widespread, but is often invisible to both consumers and store owners. Any content management system and e-store building – such as WordPress, Magento, Drupal, Joomla, etc. – has in its ecosystem plugins based on artificial intelligence – chatbots, spam comment diagnostic systems, recommendation systems, image search optimisation, analytics and user behaviour prediction systems, etc.

[40] A careful assessment of the market is needed, including the Facebook profiles of small shop, but it is very likely that the share of SMEs selling online in a given segment is well over 10%.

LITERATURE

Applied Research and Communications Fund, 2021, *Innovation.bg 2021*: *Building Innovation Recovery and Resilience in Bulgaria*.

Bernhardt, H.; Bozkurt, M.; Brunsch, R.; Colangelo, E.; Herrmann, A.; Horstmann, J.; Kraft, M.; Marquering, J.; Steckel, T.; Tapken, H.; et al., "Challenges for Agriculture through Industry 4.0," *Agronomy 2021*, 11, 1935, https://doi.org/10.3390/agronomy11101935.

EuroCommerce, *European E -commerce report 2022*.

European Parliament, *Precision agriculture and the future of farming in Europe*, Scientific Foresight Study, Brussels, 2016, ISBN 978-92-846-0475-3, doi: 10.2861/020809 .

Eurostat, 2021, Artificial intelligence in EU enterprises - Products Eurostat News.

Goode, L. et al., *Agriculture's connected future: How technology can yield new growth*, McKinsey Center for Advanced Connectivity and Agriculture Practice, October 2020.

Hristova, Gloria (2022) "Automated system for online communication with customers through machine self-learning and natural language processing - structure, construction and business applications", Dissertation towards gaining the degree "Doctor" in Economics, Faculty of Economics, Sofia University "St. Kliment Ohridski".

Ipsos and iCite, (2020), *European Enterprise survey on the use of technologies based on artificial intelligence*.

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Applied Research and Communications Fund
5 Alexander Zhendov St., 1113 Sofia, Bulgaria
tel. +359 2 973 3000
arc@online.bg
www.arcfund.net

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