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High-tech in Central Europe. The importance of the high-technology sector in the decade between the crises

Summary

The role of the Central European high-tech sector is minor in comparison to that of the dominant countries in the world, or even in the European Union. Among the hundreds of unicorns – start-ups valued at a billion dollars or more – at the end of September 2021, only four were based in Central Europe, and in the list of the thousand companies in the EU that spend most on R&D, only six were from this region. This concerns Central Europe as eleven EU member states, i.e. Bulgaria, Croatia, Estonia, Lithuania, Latvia, Poland, the Czech Republic, Romania, Slovakia, Slovenia and Hungary.

Despite the small number of specific success stories, the high-technology sector in the Central European countries has acquired new significance during the decade preceding the ranking mentioned above in 2021, i.e. between the global financial crisis and the pandemic crisis.

- Firstly, the value of high-tech goods traded increased significantly. Total exports rose from less than 40 bn to 90 bn EUR, and imports went from 51 bn to 109 bn EUR. The share of high-tech goods in total Central European trade also increased – on average to 11% in exports and 13% in imports.
- Secondly, employment in high-tech services and industries increased. Total employment in the high-tech[1] industry rose from 2.5m do 3.1m and in high-tech services, from 0.8m to 14m. At the same time the share of employees in the high-technology sector in total Central European employment increased – from 5.5% to 6.8% in industry, and from 1.9% to 3% in services.

However, from the point of view of the importance of the high-tech sector in the national economies, Central European countries are characterised by considerable

[1] The data concerning employment in high-tech also includes the medium high-tech category.

differences. The regional leader in the high-technology sector is the Czech Republic – a highly industrialised economy with a developed manufacturing base for electronics and computer equipment and whose value of high-tech export goods at the end of the analysed period was nearly 31bn EUR, i.e. 18% of Czech exports. Hungary and Estonia can also be said to have a relatively high share of high-tech goods in their exports – 16% and 12% respectively. Latvia is also worth mentioning, which in the analysed period advanced, with a result of 11%, to the group of leading Central European high-tech exporters and importers, almost from the very bottom of the EU ranking in this area. These countries are also characterised by a relatively large share of high-tech in employment – in the case of industry, it was highest in the Czech Republic, and in the case of services, Estonia came out on top.

At the same time there are countries in Central Europe where the high-technology sector is far less significant. The share of high-tech goods was lowest in Slovenia and Bulgaria, both located in the south of the region, where it did not exceed 6%. The share was also low in Romania and Croatia. In the context of the Central European eleven, Poland and Lithuania were lower in terms of the importance of their high technology sector, and even second from bottom – in the case of the share of high-tech employees in the industry in Lithuania and in the services category in Poland.

It should be pointed out that in total the Central European countries import far more high-tech goods than they export. In most of these countries, there was a high negative balance in the trade of high-tech goods throughout the analysis period. The exceptions were Hungary, Lithuania and the Czech Republic, which in certain years recorded a surplus of high-technology export goods over imports.

“The impact of high-tech products on people’s everyday lives is immeasurable. High-tech products keep people safer and healthier, enable them to be more productive at home and on the job, and afford a higher standard of living”.

AeA (formerly the American Electronics Association)

Introduction

The shift towards the high-technology (high-tech) sector is an exceptionally important and far-reaching economic phenomenon. Technology is perceived as a key instrument for building a competitive advantage for enterprises, and it is the main catalyst for contemporary structural changes in economies. Policy in the field of technological development is also a core part of European Union strategy – this has been the case since the signing of the first community treaties and the establishment of the European research framework programmes in the 1980s[2]. The largest programme of this type in the past decade was Horizon 2020, which was realised in 2014-2020 and had a budget approaching 80 bn EUR. It is being succeeded by Horizon Europe for 2021-2027, with a planned budget of over 95 bn EUR[3], equivalent to the GDP of Slovakia in 2020. The aim of these programmes is to reinforce the research area and the science and technology base of the EU, and to consequently increase European capabilities in the scope of innovation and competitiveness. It is also reducing the differences in this field among individual member states. And those differences still remain significant. This is demonstrated clearly by the list of the thousand companies in the EU with the highest expenditure on R&D[4]. In 2020 there were only six companies on that list from the entire region in Central Europe that comprises Bulgaria, Croatia, Estonia, Lithuania,

[2] While the EU founder states were taking a technological leap forward and formulating the first regulations in this field, most of the Central European states analysed here were still *stuck* in a command economy. In their case that leap happened after the economic transformation, which had a major impact on the economic growth of those countries, see B. Jóźwik, *Transformacja i rozwój gospodarczy w państwach Europy Środkowej i Wschodniej* (*Economic Transformation and Development in Central and Eastern European Countries*), "Rocznik Instytutu Europy Środkowo-Wschodniej" 2016, no. 4(5), p. 49-66.

[3] European Commission, "Horizon Europe", https://ec.europa.eu/info/funding-tenders/find-funding/eu-funding-programmes/horizon-europe_pl [16.09.2021].

[4] The study covered the 27 states of the European Union, and the United Kingdom. European Commission, *The 2020 EU Industrial R&D Investment Scoreboard*, 2021, https://iri.jrc.ec.europa.eu/scoreboard/2020-eu-industrial-rd-investment-scoreboard [16.09.2021].

Latvia, Poland, the Czech Republic, Romania, Slovakia, Slovenia and Hungary. Those companies were the Polish CD Projekt and Asseco Poland, the Slovenian Krka and Gorenje, the Czech CEZ and the Hungarian Richter Gedeon. For comparison, the list includes 280 British, 212 German and 113 French companies. The situation is similar when it comes to technology start-ups valued at a billion dollars or more, known as unicorns. At the end of September 2021, there were 848 such companies worldwide, but only four had their headquarters in Central Europe. These were Bolt in Estonia, Vinted in Lithuania, Rohlik in the Czech Republic and Infobip in Croatia[5].

The aim of this study is to determine the significance of the high-technology sector in Central European countries in the decade preceding these comparisons, which was the decade between the global financial crisis and the crisis caused by the COVID-19 pandemic. It should be pointed out in the introduction that there is no single measure which would precisely and completely reflect the importance of the high-tech sector in the economy. However, there are many which may be combined to make such an assessment. These are presented in this study and divided into two main parts.

The first covers foreign trade in high-tech goods. The foreign expansion of high technology is one of the major factors affecting the competitiveness of economies on international markets. Therefore the following indicators will be analysed: the values of exports and imports, the balance of foreign trade in high-tech goods, the share of such goods in total exports and imports of particular countries in Central Europe, and the export and import structure divided into

[5] Immediately after completion of work on this publication, reports appeared that a Polish company had joined the list for the first time – DocPlanner. However, it was not officially included on the CB Insights *Global Unicorn Club* list: *Private Companies Valued at $1B+ (as of September 30th, 2021)*, https://www.cbinsights.com/research-unicorn-companies [20.10.2021].

individual groups of those goods. In this part, the analysis will be conducted in line with the product approach, based on Eurostat data from the Comext database.

The second part will be devoted to employment in high-tech industries and services. In this case, the analysis will cover such indicators: the number of employees in high technology industries and services and their share of total employment in particular economies. The analysis in this section will be conducted in line with the sectoral approach, based on Eurostat data from the Labour Force Survey. In the case of industry, data will be presented for two groups of high technology – high-tech and medium high-tech.

The above data for the Central European countries sometimes refer to data for the EU as represented by the EU-28, since that was the membership of the EU during most of the period in question, i.e. from 1 July 2013 to 31 January 2020, or the EU-15, i.e. the states of the "Old Union"[6], forming the EU before the accession of new states on 1 May 2004, which due to the level of economic development constitute a natural point of reference for the studied countries. In addition, the study attempts to indicate which Central European states are leaders in terms of high technology.

[6] These are: Austria, Belgium, Denmark, Finland, France, Greece, Spain, the Netherlands, Ireland, Luxembourg, Germany, Portugal, Sweden, the UK and Italy.

1. High technology – definition and specificity

"… Western Europe, with its dense population and its high technology…". This sentence contained the first mention of the expression high technology. It was found in an article encouraging the use of nuclear power in Western Europe in the pages of *The New York Times* in 1958[7]. This newspaper, and more precisely Robert Metz's regular column Market Place, is also considered to have popularised the term. This was where the abbreviated form "high-tech", commonly used today, was first recorded[8].

Despite the significant role played by high technology in the contemporary economy, and the multitude of literature in this area, no single, universally accepted definition has yet been developed. It is generally assumed that high-tech refers to the newest available technology, the so-called cutting edge, while high-tech companies are those using it. To better identify it, the literature points out certain specific features which differentiate high-tech firms from others. The features most often cited are as follows: high spending on R&D[9], a high degree of innovativeness[10] and a reliance on knowledge, and extensive use of modern information technology[11]. These features, however, require that a measurable value be indicated, enabling a given company to be identified as high-tech or not. Determining such rigid limits poses difficulties, which complicated the creation of a comprehensive classification. Moreover, "the specific nature (and appeal) of this

[7] *Atomic Power for Europe*, "The New York Times", February 4, 1958, p. 17.
[8] Polish literature on the subject currently uses both the English name and numerous translated forms. More: M. Ratajczak-Mrozek, *Specyfika przedsiębiorstw zaawansowanych technologii (high-tech)* (*The specificity of high-tech enterprises*), "Przegląd Organizacji" 2011, no. 2, pp. 26-29.
[9] Y. Baruch, *High technology organization what it is, what it isn´t*, "International Journal of Technology Management" 1997, no. 13(2), pp. 179-195.
[10] N. O´Regan, M. A. Sims, *Identifying high technology small firms: A sector analysis,* "Technovation" 2008, no. 28,
pp. 408-423.
[11] A. Zarzewska-Bielawska, *The strategic dilemmas of innovative enterprises: proposals for high technology sectors*, "R+D Management" 2012, no. 42(5), pp. 303-314.

concept is that it is dynamic in time"[12], which makes it even more difficult to determine which company is, and which is not, high technology. There have been attempts made for many years to systematise this area of the economy, and certain solutions have been found, although they are not perfect.

The most popular of the current taxonomies are methods of differentiating high technology according to the field of economic activity – the sectoral approach, and according to the products manufactured – the product approach. In both cases, the factor determining a specific level of high technology is the intensity of R&D spending. This intensity is the ratio of expenditure on R&D activities (directly and indirectly in investment products and semi-finished products) compared to the value of production or of added value.

The methods differ in the method of categorisation. According to the **product approach**, products are categorised to a determined level of high technology based on the SITC (Standard International Trade Classification), which was developed by the United Nations and is used in foreign trade statistics. A list of products categorised as high-tech according to this approach is shown in Table 1.

Table 1. Classification of high-tech – product approach

Product group	Products
Aerospace	aeroplane motors, helicopters, aeroplanes and other aircraft, mechanically propelled (other than helicopters), spacecraft (including satellites) and spacecraft launch vehicles, propellers and rotors and parts thereof, undercarriages and parts thereof, direction-finding compasses; other navigational instruments and appliances
Computers – office machines	multifunction office machines capable of connecting to a computer or a network, other office machines capable of connecting to computer or a network

[12] A. Skala, *Nowa metoda identyfikacji przedsiębiorstw wysokiej technologii na przykładzie Warszawy* (*A New Method for the Identification of High-Technology Companies, using Warsaw as an Example*), "Modern Management Review", vol. 19, 2014, no. 21(2), pp. 109-127.

Electronics – telecommunications	sound recording or reproduction apparatus operated by coins, bank cards, video apparatus, telecommunications equipment, electrical boards and consoles, optical fibre cables, microwave tubes, other valves and tubes, semiconductor devices, electronic integrated circuits, piezoelectric crystals, optical media, semiconductor media
Pharmacy	antibiotics, hormones and their derivatives, glycosides, glands, antisera, vaccines, medicaments containing antibiotics or derivatives thereof, medicaments containing hormones or other products of subgroup
Scientific instruments	electrodiagnostic apparatus for medicine or surgery and radiological apparatus, optical instruments and apparatus, dental drill engines, measuring instruments and apparatus, photographic cameras, cinematographic cameras, contact lenses, optical fibres, orthopaedic appliances, excluding 899.65, 899.69
Electrical machinery	electrical capacitors, fixed, variable or adjustable, electrical machines, having individual functions, electric sound or visual signalling apparatus
Non-electrical machinery	gas turbines, parts for gas turbines, nuclear reactors and parts thereof and fuel elements, machinery and apparatus for isotope separation, machining-tools for working any kind of materials by removing excess material using a laser or other beam of light or photons, by ultrasound, electroerosion, electrochemical, using electron beams, ion beams or plasma arcs; lathes, drills, knee-type and other milling machines, grinders, sharpeners, bending machines, machines for straightening or straighteners for metal sheets, mechanical shears, machines for piercing and cutting – digitally controlled, machines and instruments for friction welding, partly or wholly automatic, machines and instruments for arc-welding metals
Chemistry	selenium, tellurium, phosphorus, arsenic and borium, silicon, calcium, strontium and barium, other inorganic alkali, radioactive materials, synthetic and organic dyes and colourants, ethylene polyteraphthalate, insecticides, disinfectants
Armaments	arms and ammunition

Source: Eurostat, *Aggregation of products by SITC Rev. 4*, https://ec.europa.eu/eurostat/cache/metadata/Annexes/htec_esms_an5.pdf [18.09.2021].

According to the sectoral approach, companies are categorised by their level of technological advancement based on the area of the economy they belong to according to the NACE (Nomenclature statistique des Activités économiques dans la Communauté Européenne) statistical classification of businesses in the European Union[13]. This approach additionally differentiates technologically

[13] In this approach, the division is made according to the following scheme: R&D intensity over 7% – *high technology*, between 2.5-7% – *medium-high technology*, between 1–2.5% – *medium-low technology*, below 1% – *low-technology*.

advanced services, which consist of some knowledge-based services[14]. The list of economic activities categorised as high-tech according to the sectoral approach is included
in Table 2.

Table 2. Classification of high-tech – sectoral approach

Sector	Economic Activity
Industry	**High technology** • manufacture of basic pharmaceutical substances, and medicines and other pharmaceutical products • manufacture of computers, electronic and optical products • production of aircraft, spacecraft and similar machines **Medium high technology*** • manufacture of chemicals and chemical products • manufacture of arms and ammunition • manufacture of electrical devices • manufacture of machinery and equipment • manufacture of motor vehicles, trailers and semi-trailers • manufacture of other transport equipment • manufacture of medical devices, instruments and products
Services	• motion picture, video and television programme production, sound recording and music, publishing activities • programming and broadcasting activities • telecommunications • computer programming • consultancy and related activities • information service activities • scientific research and development

* The medium high-tech category was also taken into account because it includes certain economic activities which would have been considered high-tech using the product approach.

Source: Eurostat, *Aggregations of manufacturing based on NACE Rev. 2*, https://ec.europa.eu/eurostat/cache/metadata/Annexes/htec_esms_an3.pdf [18.09.2021].

It should be pointed out that both methods of distinguishing high-tech products and sectors have certain limitations. New technology crosses the boundaries

[14] The basic division of services based on knowledge-based criteria is into *knowledge-intensive* services, which also include technologically advanced services and those which are *less knowledge-intensive*.

according to traditional product or sectoral classifications[15]. In the case of the first classification, some products considered collectively to be manufactured by a company from the high-tech sector may not make use of the latest technological achievements, and vice versa – they may be used by manufacturing companies from traditional sectors. The situation is similar in the case of the other classification: some companies which claim to belong to a sector considered high-tech may, in reality, not possess the previously mentioned features of high-tech companies, and vice versa – enterprises from other sectors may fulfill them.

In spite of methodological difficulties, companies operating within the high-tech sector remain a vital object of interest for economists and national and international institutions. This is for several reasons[16]. Firstly, they are a source of innovation, particularly technological innovation, which as a result increases the level of innovation in the entire economy, supports the creation of new markets and more productive use of resources[17]. Secondly, they are highly productive and stimulate export growth, which contributes to economic growth and the improvement of a country's competitiveness on regional markets[18]. Thirdly, they are characterised by a high growth dynamic and additionally generate new products and processes, which contributes to an increase in employment[19], with the jobs in question usually being highly paid. As a result, their business contributes to

[15] J. Korpus, Ł. Banach, *Przedsiębiorstwa z sektora wysokich technologii w erze gospodarki cyfrowej* (*High-tech enterprises in the digital economy era*), "Ekonomika i Organizacja Przedsiębiorstwa" 2017, no. 3, pp. 132-140.
[16] M. Lawrence, *High-tech industries drive global economic activity*, "National Science Foundation" 1998, no. 7(20), pp. 319-322.
[17] S. Sandu, B. Ciocanel, *Impact of R&D and Innovation on High-tech Export*, "Procedia Economics and Finance" 2014, no. 15, pp. 80-90.
[18] Y. Meral, *High technology export and high technology export impact on growth*, "Bussecon Review of Finance & Banking" 2019, no. 1(1), pp. 26-31.
[19] V. Van Roy, D. Vértesy, M. Vivarelli*, Technology and employment: Mass unemployment or job creation? Empirical evidence from European patenting firms*, "Research Policy" 2019, no. 47(9), pp. 1762-1776; T. Białowąs, P. Pasierbiak, M. Wojas, *Structural changes and technological progress as factors of labour market developments in the V4 countries in 2004–2018*, "Problemy Zarządzania" 2019, no. 17(6), pp. 11-30.

increasing prosperity in the economy, and not only by the aforementioned wealth creation. This was expressed well by the AeA (formerly The American Electronics Association), an association of technology companies, which stated that "[h]igh-tech products keep people safer and healthier, enable them to be more productive at home and on the job, and afford a higher standard of living"[20].

[20] M.F. Kazimierczak, J. James, W.T. Archey, *We are still losing the competitive advantage: Now is the time to act*, American Electronics Association, Washington 2007.

2. The importance of the high-tech sector in foreign trade in Central European countries[21]

High technology increased in importance in the international trade of Central European states in the decade between the global financial crisis and the crisis caused by the COVID-19 pandemic. Starting with exports of high-tech goods – their value has more than doubled in the eleven Central European countries, from less than 40 bn EUR in 2009 to almost 90 bn EUR in 2018.[22] The largest part of the amount at the end of the analysed period is attributable to the Czech Republic, whose exports in high-tech goods amounted to almost 31 bn EUR in 2018. The next places are occupied by the region's largest economy, i.e. Poland – just under 19 bn EUR, and Hungary – nearly 17bn euro. The exports of technologically advanced goods from other countries in the region did not exceed several billion euros. Importantly, however, all Central European countries in the analysed period significantly increased exports in this area: to the smallest extent, by a quarter – Hungary; double – Croatia, Slovenia, Romania and the Czech Republic; triple – Bulgaria, Slovakia, Lithuania, Poland and Estonia; and Latvia – four times (see Table 3).

Table 3. Exports of high-tech goods from Central European countries during 2009–18 (in bn EUR)

Country	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2018 /2009 %
Bulgaria	0.5	0.6	0.8	0.8	0.9	0.9	1.0	1.2	1.5	1.7	**212.0**
Croatia	0.6	0.6	0.6	0.7	0.8	0.7	0.8	1.2	1.3	1.2	**107.9**
Czech Republic	12.3	16.1	19.2	19.7	18.4	20.2	22.1	22.1	25.9	30.6	**147.8**
Estonia	0.5	0.9	1.8	1.8	1.8	2.0	1.8	1.9	1.5	1.7	**269.8**
Lithuania	0.7	0.9	1.1	1.3	1.4	1.6	1.7	1.8	2.1	2.2	**225.5**
Latvia	0.3	0.3	0.6	0.7	0.9	1.1	1.2	1.1	1.3	1.5	**406.5**

[21] In this section the analysis will be conducted in line with the product method based on Eurostat data from the Comext database.
[22] Latest available data.

Poland	5.6	7.3	7.0	8.6	10.3	13.1	15.2	15.7	17.5	18.5	**231.6**
Romania	2.4	3.7	4.0	2.8	2.8	3.4	4.0	4.8	5.0	5.7	**136.8**
Slovakia	2.4	3.2	3.8	5.2	6.2	6.4	6.8	6.8	7.9	7.7	**225.4**
Slovenia	1.0	1.2	1.3	1.3	1.4	1.4	1.7	1.7	1.9	2.2	**109.9**
Hungary	13.2	15.7	16.9	14.0	13.2	12.1	13.7	14.7	16.1	16.6	**25.5**
Central Europe	39.5	50.6	57.1	56.8	58.1	62.8	70.0	72.9	82.0	89.4	**126.6**

Source: Own elaboration based on Eurostat data.

At the same time, the Central European countries succeeded in improving their position in the export of high-tech goods compared with the other EU states. While in 2009 they were only responsible for 8.7% of the combined exports of high-tech goods by the EU-28 member states, in 2018 this had risen to 11.4%. Meanwhile in the case of total EU high-tech exports beyond the EU-28, the Central European states were responsible for 5.6% and 6% for the same two years respectively. It should be pointed out here that Central Europe's exports of high-tech goods is rather small when considered nominally against the background of those EU states, which dominate this field. The value of technologically advanced goods exported by Germany alone is over twice that of the eleven countries in the region combined, at almost 200 bn EUR in 2018.

As for imports of high-tech goods – their value also increased during the period in question from all the Central European countries, from 51bn in 2009 to 109 bn in 2018. The largest importer of high technology, as well as the largest exporter, is the Czech Republic, which imported over 31bn EUR of high-tech goods, then Poland with 26bn, Hungary with almost 17 bn and Slovakia importing 11bn euro. Also similar to the case of exports, all the Central European countries significantly increased their imports of technologically advanced goods during that period: again to a small extent, by half – Hungary and Croatia; by more than three quarters – Slovenia; more than double – Poland, Bulgaria, Romania, the Czech Republic and

Slovakia; Estonia – almost three times; Lithuania – more than three times; and – again the most – Latvia – almost four times (see Table 4).

Table 4. Imports of high-tech goods from Central European countries during 2009–18 (in bn euro)

Country	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2018 /2009 %
Bulgaria	1.2	1.4	1.8	2.3	1.8	2.0	2.2	2.3	2.4	2.7	**119.0**
Croatia	1.4	1.3	1.2	1.3	1.4	1.3	1.6	2.1	1.9	2.1	**52.7**
Czech Republic	13.1	18.2	19.0	18.6	17.8	19.8	23.7	22.2	26.7	31.5	**140.8**
Estonia	0.6	1.1	1.9	1.9	1.9	2.0	1.9	2.0	1.7	1.8	**189.2**
Lithuania	0.7	0.9	1.1	1.3	1.4	1.6	1.9	1.9	2.3	2.3	**216.1**
Latvia	0.5	0.7	1.0	1.0	1.1	1.3	1.6	1.4	2.1	2.5	**391.0**
Poland	12.6	15.6	15.4	16.3	16.9	19.0	22.4	22.5	25.0	26.4	**109.6**
Romania	4.2	5.7	5.9	5.2	5.6	5.9	6.8	7.5	8.5	9.3	**121.1**
Slovakia	4.2	5.4	7.3	9.2	10.2	10.3	11.4	11.7	11.4	11.4	**169.4**
Slovenia	1.4	1.7	1.7	1.6	1.6	1.8	1.9	2.0	2.2	2.6	**78.9**
Hungary	11.1	13.5	13.9	13.0	12.7	11.8	13.7	14.4	15.7	16.7	**51.2**
Central Europe	51.0	65.4	70.3	71.6	72.4	76.9	88.9	89.8	99.8	109.1	**113.9**

Source: Own elaboration based on Eurostat data.

There was also an increase in the share of Central European states in the EU's imports of technologically advanced goods. In 2009, imports of high-tech goods by the eleven Central European countries accounted for 10.9% of total imports of that category of goods by all the EU-28 member states, rising to 14% in 2018. In the case of imports of high-tech from outside the EU-28, the analogous figures were 9.4% and 10.6%.

However, the comparison of Central European exports and imports of high-tech goods shows a negative balance in trade in these goods. Despite the fact that in 2009 it amounted to 11.5bn euro, and in 2018 almost 19.7bn euro, taking relative measures into account – in 2009, imports of high-tech goods were higher than exports by 29%, and in 2018 by only 22%. During the period studied, however, most

of the countries in the region had a negative balance of trade in high-tech, i.e. they imported more technologically advanced goods than they exported. The exceptions were Hungary in 2009–2014 and 2016–2017, Lithuania in 2010–2011 and the Czech Republic in 2011–2014 – see Table 5. In Hungary, the competitive advantage manifested in the surplus of exports over imports was particularly high in the case of scientific and research equipment, as well as computers and office machines. In the Czech Republic, there was also a positive balance of trade in computers and office machines, as well as in electrical and non-electrical machines, armaments and aviation equipment, and in Lithuania, in chemicals. In the case of other countries, the positive balance for most of the analysed period was recorded only in aviation equipment in Poland, electronic and telecommunications equipment and research and development equipment in Estonia, and pharmaceuticals in Slovenia – more data in Table 16 in the statistical annex.

Table 5. High-tech trade balance in 2009-18 (in bn EUR)

Country	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Bulgaria	-0.69	-0.79	-1.07	-1.47	-0.91	-1.10	-1.14	-1.02	-0.95	-1.00
Croatia	-0.78	-0.67	-0.67	-0.56	-0.65	-0.66	-0.78	-0.86	-0.58	-0.88
Czech Republic	-0.74	-2.07	0.22	1.06	0.63	0.41	-1.53	-0.05	-0.84	-0.91
Estonia	-0.17	-0.23	-0.11	-0.16	-0.06	-0.07	-0.07	-0.11	-0.16	-0.13
Lithuania	-0.03	0.06	0.03	0.08	0.02	-0.03	-0.17	-0.16	-0.17	-0.03
Latvia	-0.21	-0.33	-0.34	-0.26	-0.24	-0.29	-0.41	-0.33	-0.75	-0.97
Poland	-7.03	-8.32	-8.44	-7.68	-6.64	-5.93	-7.17	-6.82	-7.51	-7.92
Romania	-1.81	-2.03	-1.94	-2.38	-2.82	-2.50	-2.81	-2.72	-3.52	-3.62
Slovakia	-1.86	-2.14	-3.49	-4.03	-3.94	-3.86	-4.56	-4.89	-3.50	-3.69
Slovenia	-0.41	-0.52	-0.38	-0.30	-0.22	-0.31	-0.24	-0.26	-0.29	-0.41
Hungary	2.17	2.18	2.99	0.93	0.47	0.29	-0.05	0.27	0.41	-0.12
Central Europe	-11.5	-14.9	-13.2	-14.8	-14.4	-14.0	-18.9	-16.9	-17.9	-19.7

Source: Own elaboration based on Eurostat data.

The analysis so far has focused primarily trade in high-tech by individual countries in terms of its value. This approach, although significant, is somewhat inaccurate due to the different potential of the compared economies. For example, in 2018 the GDP of the largest economy in Central Europe, Poland, was 19 times larger than that of the smallest, Estonia. Therefore, an analysis is needed to show which part of the exports and imports of individual economies are high-tech goods.

Starting with aggregated data covering all eleven analysed countries, the share of high-tech goods exports in total exports from Central European countries increased during the analysed period from 10.7% to 11.4%, and in the case of imports – from 12.9% to 13.6%. However, the share in both exports and imports remained lower on average in Central Europe when compared with the states of the so-called Old Union, the EU-15, where the equivalent growth was from 14% to 14.9% in exports, and from 14% to 14.5% in imports. It should be mentioned that there are clear differences between different economies in both groups analysed. In the EU-15 group, the countries with the highest share of high technology in their exports are Ireland, with 35% at the end of the period studied and the Netherlands and France, with 21%, but the group also includes Portugal, where the figure was 4%, Greece with 5% and Spain with 6%. In general, the indices were much higher in the north of the continent, and lower in the south. For the Central European region, the average highest share of high-tech among goods exported during the period studied was in Hungary, the Czech Republic, Estonia and Latvia – see Table 6, which contributes to their relatively high position in this regard among the remaining EU states – see Table 7. These are also the only Central European countries where high-tech goods at the end of the analysed period accounted for more than 10% of industrial production intended for export – the Czech Republic achieved the highest value, almost 18%. At the same time, however, there are economies in the region such as Slovenia and Bulgaria, in which this share did not exceed 6% at that time.

Table 6. High-tech in export goods in the Central European countries in 2009-18 (% of total exports)

Country	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2018 /2009 %
Bulgaria	4.6	4.1	3.7	3.8	4	3.9	4.4	5.1	5.4	5.9	**28.3**
Croatia	7.6	7	5.8	7.2	7.9	6.6	7.1	9.7	9.2	8.1	**6.6**
Czech Republic	15.2	16.1	16.4	16.1	15.1	15.3	15.5	15	16.1	17.8	**17.1**
Estonia	6.9	10.4	14.8	14.1	14.9	16.3	15.5	15.6	12	11.5	**66.7**
Lithuania	5.8	6	5.6	5.8	5.8	6.6	7.6	7.8	8.1	7.9	**36.2**
Latvia	5.3	4.8	6.7	6.4	8	9.7	11	10.2	10.6	11.2	**111.3**
Poland	5.7	6	5.1	6	6.7	7.9	8.5	8.5	8.4	8.4	**47.4**
Romania	8.2	9.8	8.8	6.3	5.6	6.4	7.3	8.3	7.9	8.4	**2.4**
Slovakia	5.9	6.6	6.6	8.2	9.6	9.9	10	9.7	10.5	9.6	**62.7**
Slovenia	5.5	5.3	5.3	5.2	5.5	5.4	5.9	5.7	5.6	5.8	**5.5**
Hungary	22.2	21.8	20.9	17.3	16.3	14.5	15.4	15.9	16	15.6	**-29.7**
Central Europe	10.7	11.0	10.7	10.2	10.1	10.4	10.9	11.0	11.2	11.4	**7.1**

Source: Own elaboration based on Eurostat data.

Table 7. The position of Central European states in terms of share of high-tech in total export goods compared to the EU-28 in 2009–18

Country	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Bulgaria	27	27	27	26	26	26	27	26	26	24
Croatia	18	18	21	18	18	20	21	17	17	19
Czech Republic	9	9	8	8	9	8	8	10	6	5
Estonia	19	13	10	10	10	6	7	7	10	10
Lithuania	22	21	22	23	22	21	19	20	19	20
Latvia	25	25	18	19	17	15	13	14	12	12
Poland	23	22	24	22	19	17	18	18	18	17
Romania	16	15	15	21	23	22	20	19	20	18
Slovakia	21	19	19	16	14	13	17	16	13	14
Slovenia	24	24	23	24	24	23	24	25	25	25
Hungary	3	3	4	7	7	9	9	6	7	7

Source: Own elaboration based on Eurostat data.

In the ranking of countries with the largest share of high-tech goods among imports in the EU-15, Ireland came top with 37% during the period studied, followed by the Netherlands with 21% and the UK with 16.5%. In Central Europe it was the Czech Republic, Hungary, Slovakia and Estonia – see Table 8, which again contributed to their relatively high positions in this regard compared to the other EU states – see Table 9. In this case, they are also the only Central European countries where high-tech goods accounted for more than 15% of imports at the end of the analysed period – and here again the highest value was achieved by the Czech Republic, over 20%. The countries with the lowest share of high-tech imports are Lithuania and Slovenia, where it did not exceed 8%.

Table 8. High-tech in imports in the Central European countries in 2009-18 (% of total imports)

Country	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2018 /2009 %
Bulgaria	7.2	7.5	7.8	8.9	6.9	7.5	8.2	8.6	8.1	8.3	**15.3**
Croatia	8.9	8.5	7.5	7.7	8.4	7.8	8.6	10.5	8.6	8.7	**-2.2**
Czech Republic	17.4	19	17.4	16.9	16.4	17	18.6	17.1	18.5	20.2	**16.1**
Estonia	8.5	12.4	15.1	13.7	13.6	14.8	14.3	14.5	11.6	11.1	**30.6**
Lithuania	5.5	5	4.8	5.1	5.4	6.3	7.5	7.8	8.1	7.4	**34.5**
Latvia	7.1	7.6	8.3	7.2	8.3	10.2	12.3	11.2	13.8	15.1	**112.7**
Poland	11.8	11.6	10.2	10.5	10.8	11.3	12.6	12.5	12.1	11.7	**-0.8**
Romania	10.8	12.2	10.8	9.6	10.1	10	10.8	11.1	11.2	11.2	**3.7**
Slovakia	10.6	10.9	12.7	15.3	16.5	16.7	17.2	17.1	15.5	14.3	**34.9**
Slovenia	7.6	7.4	6.7	6.4	6.5	6.9	7.2	7.1	6.9	7.2	**-5.3**
Hungary	19.8	20.3	18.8	17.6	16.9	14.9	16.5	17	16.5	16.2	**-18.2**
Central Europe	12.9	13.5	12.6	12.5	12.5	12.7	13.9	13.7	13.5	13.6	**5.3**

Source: Own elaboration based on Eurostat data.

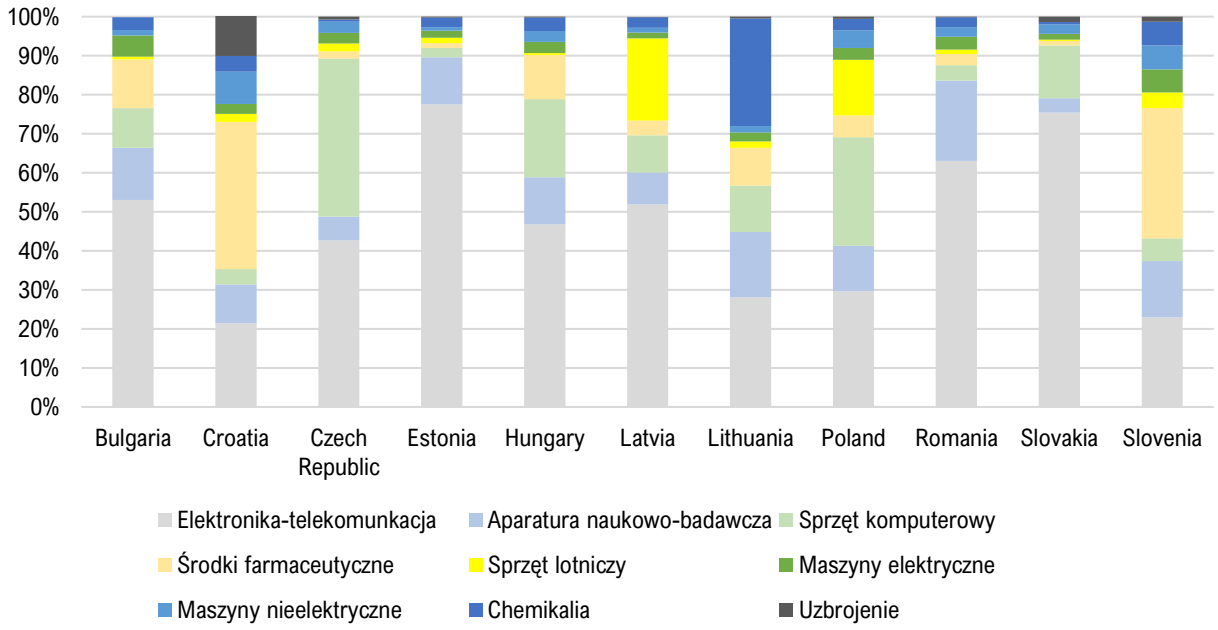
Table 9. The position of Central European states in terms of share of high-tech in total imports compared to the EU-28 in 2009–18

Country	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Bulgaria	25	26	21	19	24	24	23	24	24	24
Croatia	22	22	25	22	20	22	22	19	23	23
Czech Republic	6	5	4	4	8	5	4	5	3	3
Estonia	23	11	7	12	11	10	11	11	15	15
Lithuania	28	28	28	28	28	27	26	26	25	26
Latvia	27	25	19	24	21	16	15	17	10	7
Poland	13	14	16	15	15	14	14	14	13	13
Romania	15	12	14	17	16	17	18	18	18	14
Slovakia	16	19	12	7	7	6	6	6	6	9
Slovenia	24	27	27	26	26	25	27	28	28	27
Hungary	4	3	3	3	4	8	8	7	5	5

Source: Own elaboration based on Eurostat data.

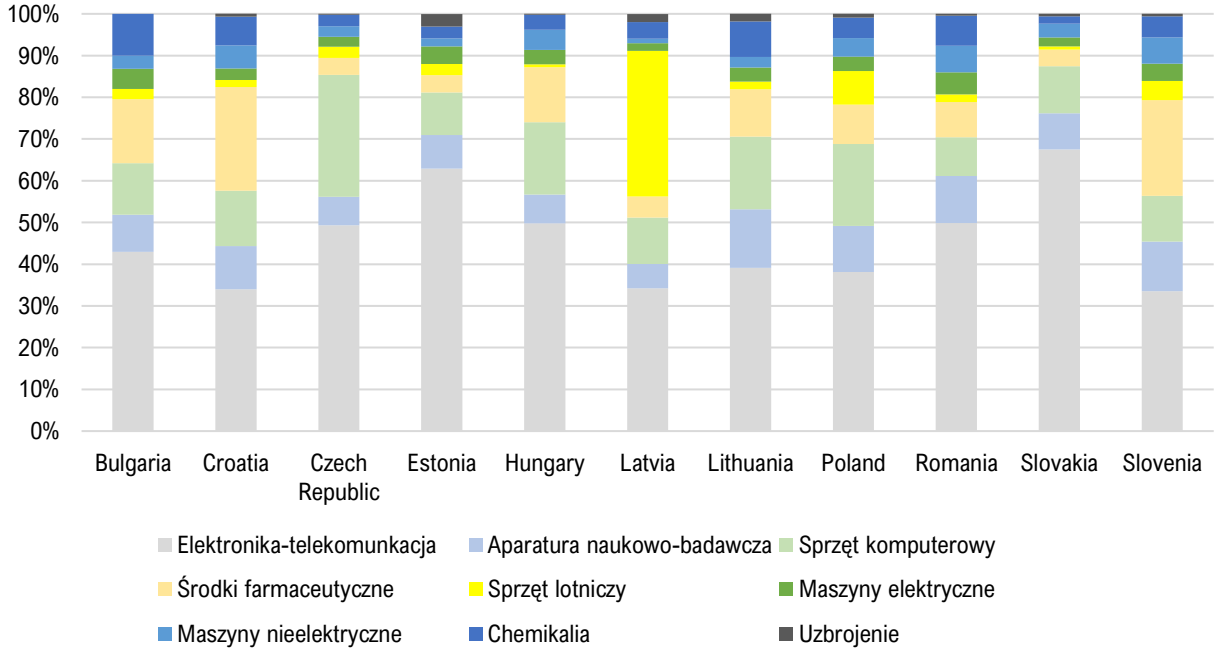
At the same time, it should be mentioned that the structure of trade in high-tech goods shows clear variations between individual countries. The structure of imports and exports is presented in detail in Figure 1 and 2.

Figure 1. Structure of high-tech exports from Central Europe in 2018.



Source: Own elaboration based on Eurostat data.

Figure 2. Structure of high-tech imports from Central Europe in 2018.



Source: Own elaboration based on Eurostat data.

In nine of the eleven countries analysed, electronics and telecommunications were dominant at the end of the period. However, it should be mentioned that in Estonia this dominance resulted from the share of these products in high-tech exports at the level of 78% and in Lithuania only 28%. In contrast, pharmaceuticals were the dominant high-tech exports in Slovenia and Croatia.

3. The importance of the high-tech sector in employment in Central European countries

The analysed decade also brought an increase in the importance of advanced technologies in employment, both in industry and services. Starting with an analysis of the high-tech[23] industry: the number of employees in 2009 in the eleven states of the region was just under 2.5m, and this systematically rose until it reached 3.2m in 2019. In 2020 it dropped by nearly 100,000 to 3.1 – see Table 10. The largest decreases in employees in this industry were in Poland (65,000, 7% y/y) and Romania (27,000, 5% y/y). In those countries, the share of employment in the high-tech industry as part of total employment also fell – see Table 11. At the same time, however, there were countries in Central Europe which, even during the economic crisis of the pandemic period, maintained the growth in employment in the high-tech industry. The highest of these was achieved in Latvia (4,000, 29% y/y), which simultaneously noted the highest increase in employee numbers during the entire period analysed, i.e. 2009-2020 (by 56%).

Table 10. Employment in the high-tech and medium-high-tech industries in Central Europe (number of employees in thousands)

Country	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2020/2009, %
Bulgaria	117	101	100	107	114	111	119	119	119	127	135	134	**15.1**
Croatia	57	53	61	60	54	52	51	54	60	57	58	59	**3.0**
Czech Republic	468	461	484	519	518	557	565	591	595	597	609	599	**27.9**
Estonia	24	20	26	26	25	22	23	26	25	27	28	28	**17.0**
Lithuania	27	23	21	23	23	25	27	29	29	30	33	36	**30.4**
Latvia	13	12	11	13	16	14	14	16	15	14	15	20	**56.0**

[23] All the data presented concerning employment in high-tech also includes the medium high-tech category.

Poland	765	707	749	759	776	819	851	929	964	967	959	895	**16.9**
Romania	425	380	403	391	411	458	475	490	515	552	562	535	**25.8**
Slovakia	203	199	225	237	228	223	256	268	283	291	282	284	**39.7**
Slovenia	83	83	77	72	75	78	86	88	94	100	101	101	**22.0**
Hungary	294	305	325	321	332	367	384	415	433	443	436	429	**46.2**
Central Europe	2475	2343	2482	2526	2572	2726	2850	3024	3133	3204	3217	3118	**25.97**

Source: Own elaboration based on Eurostat data.

Table 11. Employment in the high-tech and medium-high-tech industry in Central Europe (% of total employment)

Country	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2020/2009, %
Bulgaria	3.6	3.3	3.4	3.6	3.9	3.7	3.9	4	3.8	4	4.2	4.3	**19.4**
Croatia	3.3	3.1	3.8	3.8	3.6	3.3	3.2	3.4	3.7	3.5	3.5	3.6	**9.1**
Czech Republic	9.5	9.5	9.9	10.6	10.5	11.2	11.2	11.5	11.4	11.3	11.5	11.5	**21.1**
Estonia	4.1	3.5	4.4	4.2	4.1	3.5	3.6	4	3.8	4.1	4.1	4.3	**4.9**
Lithuania	2.1	1.8	1.7	1.8	1.8	1.9	2.1	2.1	2.2	2.2	2.4	2.6	**23.8**
Latvia	1.4	1.3	1.3	1.5	1.8	1.6	1.6	1.8	1.7	1.6	1.7	2.2	**57.1**
Poland	4.8	4.6	4.8	4.9	5	5.2	5.3	5.7	5.9	5.9	5.8	5.4	**12.5**
Romania	4.6	4.4	4.7	4.5	4.8	5.3	5.6	5.8	5.9	6.4	6.5	6.3	**37.0**
Slovakia	8.6	8.6	9.7	10.2	9.8	9.4	10.6	10.8	11.2	11.3	10.9	11.2	**30.2**
Slovenia	8.5	8.6	8.2	7.8	8.3	8.6	9.4	9.6	9.8	10.2	10.3	10.4	**22.4**
Hungary	7.8	8.2	8.7	8.4	8.5	8.9	9.1	9.5	9.8	9.9	9.7	9.6	**23.1**
Central Europe	5.5	5.4	5.7	5.8	5.9	6.2	6.4	6.7	6.8	6.9	6.9	6.8	**23.5**

Source: Own elaboration based on Eurostat data.

Furthermore, in this case it should also be pointed out that the Central European countries succeeded in increasing employment in the high-tech industry in the context of all EU states. In 2009, the eleven Central European economies analysed accounted for 20% of the employment in the high-technology industry in the EU-28

membership states, whereas by 2019 it was almost 24%[24]. At the same time, however, compared to the dominant EU countries in this field the nominal amount of employees is again small. In Germany alone there are more employees in this sector of industry than in the entire Central European region – nearly 4.2m.

However, taking into account the share of employment in the high-tech industry when looking at the entire employment figures, the Central European countries are leaders in the EU as a whole. In 2020, the Czech Republic, Slovakia and Slovenia noted the highest figures in this regard among all the member states. At the same time, they were the only countries in the EU apart from Germany whose share of employees in this sector exceeded 10% of total employment in the national economy.

Turning to employment in high-tech services: in the eleven Central European countries this stood at 0.8m in 2009, and 1.4m in 2020. In the case of services, no collapse in employment numbers can be noticed in the year when the COVID-19 pandemic broke out, with only slight drops in Estonia, Croatia and Bulgaria. What is more, in some countries the number of employees in high-tech services clearly increased at that time; compared to the previous year, the largest rise was in Latvia (5,000, 20% y/y), and in numerical terms, in Hungary (16,500, 12% y/y) – see Table 12. This is, above all, the result of increased employment in activity associated with programming and IT consultancy. Forced isolation and the resulting transfer of many activities to the virtual world contributed to a greater demand for IT specialists. There was also an increase in the share of employment in high-tech services in total employment numbers – see Table 13.

[24] In 2020 there is no data from the UK. The share of Central European countries in the UE-27 then stood at 26%.

Table 12. Employment in high-tech services in Central Europe (number of employees in thousands)

Country	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2020/2009, %
Bulgaria	68	73	69	70	74	73	87	91	93	100	100	99	**44.9**
Croatia	37	39	37	31	35	39	42	48	45	55	57	56	**51.1**
Czech Republic	129	137	142	125	140	149	147	156	159	174	176	184	**42.6**
Estonia	14	13	15	15	18	22	26	28	29	28	31	31	**125.9**
Lithuania	22	20	24	27	25	23	27	29	28	34	38	40	**82.4**
Latvia	19	24	24	20	24	26	25	23	27	29	25	30	**60.3**
Poland	307	293	293	316	333	349	359	341	366	398	421	436	**42.0**
Romania	117	109	115	132	134	140	168	165	188	189	179	191	**63.7**
Slovakia	48	55	56	60	54	58	69	70	71	72	82	94	**96.2**
Slovenia	31	32	31	28	29	31	35	32	36	34	35	41	**34.2**
Hungary	82	82	83	96	110	99	101	117	106	120	139	156	**91.3**
Central Europe	872	876	889	919	976	1008	1086	1101	1149	1231	1283	1358	**55.6**

Source: Own elaboration based on Eurostat data.

Table 13. Employment in high-tech services in Central Europe (% of total employment)

Country	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2020/2009, %
Bulgaria	2.1	2.4	2.3	2.4	2.5	2.4	2.9	3	3	3.2	3.1	3.2	**52.4**
Croatia	2.1	2.3	2.3	2	2.3	2.5	2.7	3	2.8	3.3	3.4	3.4	**61.9**
Czech Republic	2.6	2.8	2.9	2.6	2.8	3	2.9	3	3	3.3	3.3	3.5	**34.6**
Estonia	2.3	2.2	2.5	2.5	2.9	3.5	4	4.3	4.5	4.3	4.7	4.7	**104.3**
Lithuania	1.7	1.6	1.9	2.1	2	1.8	2	2.2	2.1	2.5	2.8	3	**76.5**
Latvia	2.1	2.8	2.7	2.2	2.7	2.9	2.8	2.5	3	3.1	2.8	3.4	**61.9**
Poland	1.9	1.9	1.9	2	2.1	2.2	2.2	2.1	2.2	2.4	2.6	2.7	**42.1**
Romania	1.3	1.2	1.4	1.5	1.6	1.6	2	2	2.2	2.2	2.1	2.2	**69.2**
Slovakia	2	2.4	2.4	2.6	2.3	2.5	2.8	2.8	2.8	2.8	3.2	3.7	**85.0**

Slovenia	3.2	3.3	3.3	3	3.2	3.4	3.8	3.5	3.7	3.5	3.6	4.2	**31.3**
Hungary	2.2	2.2	2.2	2.5	2.8	2.4	2.4	2.7	2.4	2.7	3.1	3.5	**59.1**
Central Europe	1.9	2.0	2.1	2.1	2.2	2.3	2.4	2.4	2.5	2.7	2.8	3.0	**52.6**

Source: Own elaboration based on Eurostat data.

In terms of employment in high-tech services, the Central European countries also managed to increase their share in the context of the EU as a whole. In 2009, the eleven Central European economies analysed accounted for 15% of the employment in high technology services in the EU-28 membership states, whereas by 2019 it was almost 17.5%[25]. Again, however, the nominal number of employees in this sector in the Central Europe region is small compared to the dominant states of the EU in this regard. While the figure for all the Central European states combined was almost 1.4m, in Germany it was over 1m.

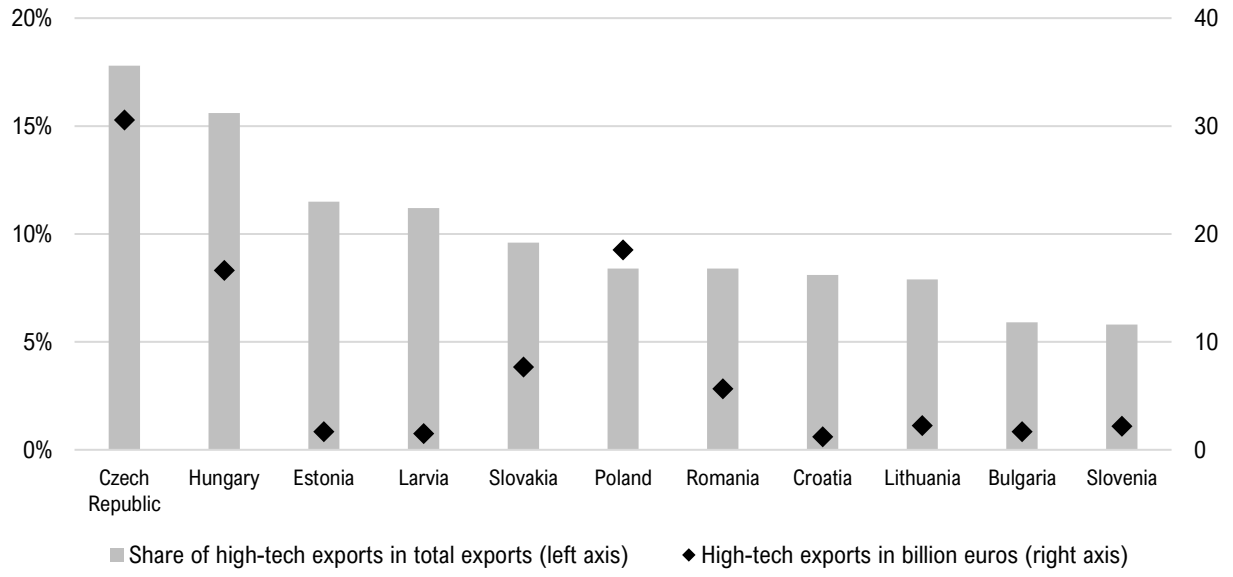
Also, when taking into account the share of employment in high-tech services when looking at the total employment figure, the Central European countries are behind such countries as Ireland, Finland and Sweden, which were in the top positions in this regard, with results exceeding 5%. Immediately after them came Estonia and Slovenia. It was also a Central European country that closed the list, however, as Romania was lowest with a result of 2.2%.

[25] In 2020 there is no data from the UK. The share of Central European countries in the UE-27 then stood at 20%.

4. Central European high-tech leaders

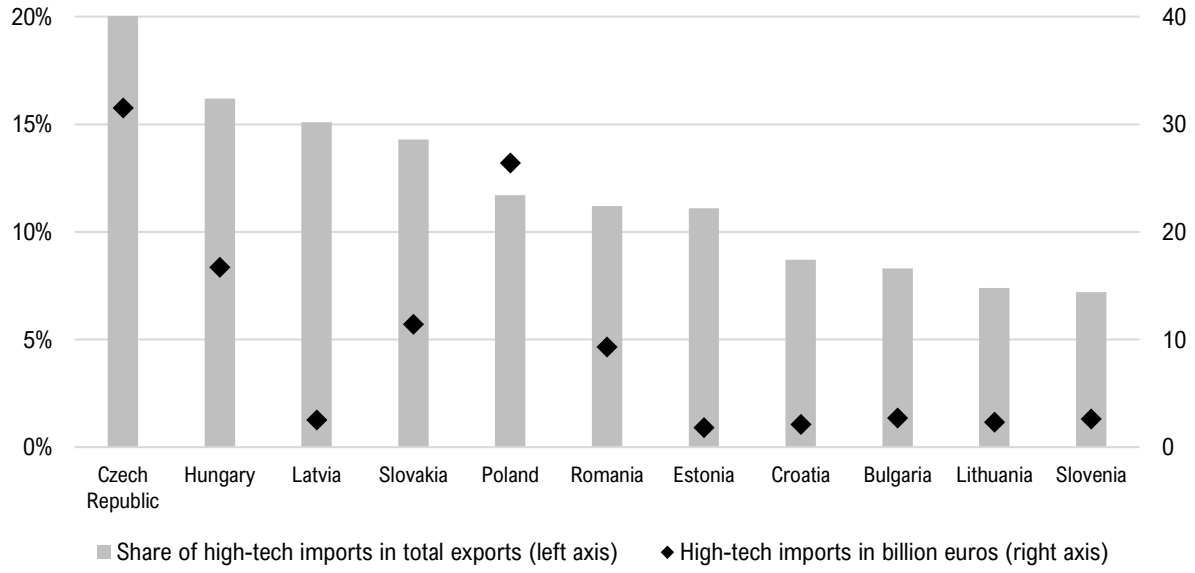
The leaders in high technology in Central Europe were determined based on the previously analysed indices, including foreign trade in high-tech goods – see Figures 3 and 4, as well as employment in high-tech industry and services – see Figures 5 and 6.

Figure 3. High-tech in export goods in the Central European countries in 2018



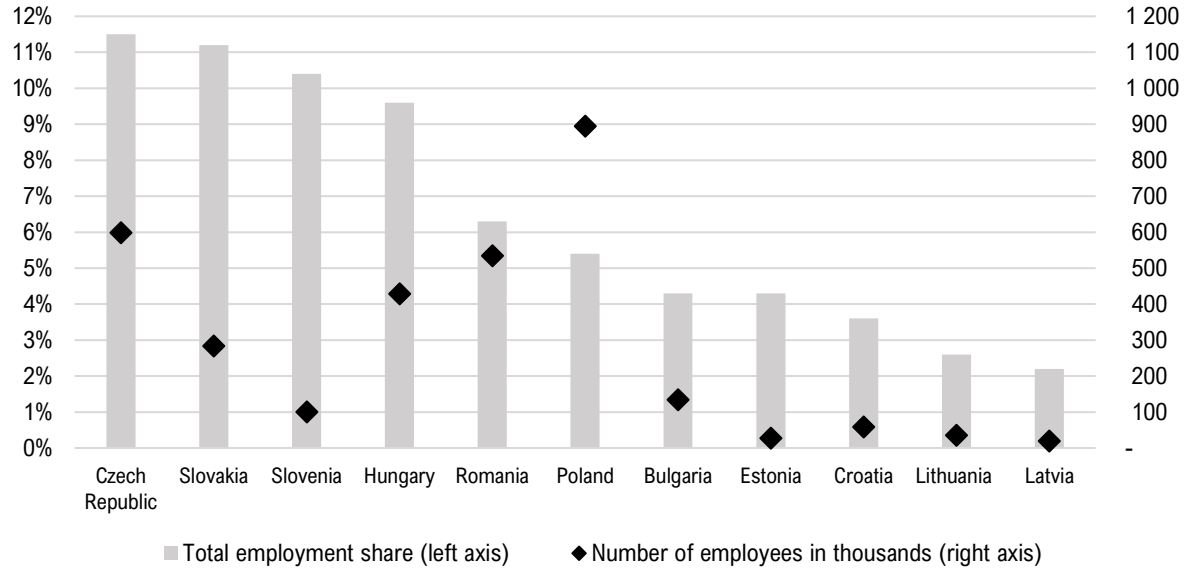
Source: Own elaboration based on Eurostat data.

Figure 4. High-tech in import goods in the Central European countries in 2018



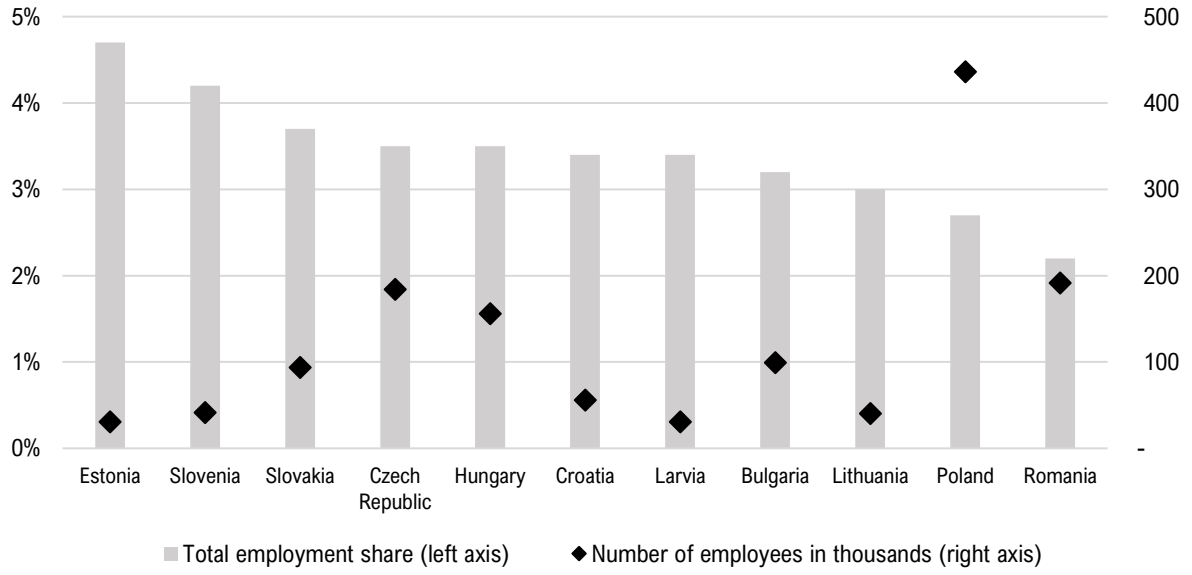
Source: Own elaboration based on Eurostat data.

Figure 5. Employment in the high-tech and medium-high-tech industries in Central Europe in 2020



Source: Own elaboration based on Eurostat data.

Figure 6. Employment in high-tech services in Central Europe in 2020



Source: Own elaboration based on Eurostat data.

Among the Central European countries, the leader in terms of the importance of the high-tech sector, especially in international trade, is the Czech Republic: both when we analyse absolute measures – the share in total exports and imports, and relative – the value of exports and imports of high-tech goods. At the same time, the Czech Republic was the country with the highest share of employment in the high-tech industry when looking at the total employment figure. The country's position was only slightly lower when we look at employment in high-tech services.

The main driving forces behind the Czech high-tech industry are electronics and telecommunications devices (13 bn EUR of exports in 2018) and computers and office machines (12 bn EUR) – see Table 14 in the statistical annex. The structure of Czech imports is also similar – see Table 15 in the statistical annex. Czech companies manufacturing electronics, computers and office equipment belong to renowned brands such as Foxconn, Siemens and Panasonic. These are the same entities that lead in the foreign expansion of this economy. In the ranking of Czech

exporters prepared by the Chamber of Commerce in 2020, the three companies mentioned take second (after Skoda), eighth and ninth places[26].

Czech manufacturing of electronics and computer equipment is connected with the rich industrial tradition of that economy. In the first years after the formation of the Czechoslovakian state in 1918, it was already one of the most industrialised economies in the world, with dynamically developing machine and electro-technical industries. And this is also the case today. The share of industrial production in employment in the Czech Republic was nearly 26% in 2020, which was also the highest figure for any EU state, and added value was 29%, the second highest result in the EU. At the same time the Czech Republic is the most innovative country of the Visegrad Group[27] as well as a pioneer of the fourth industrial revolution. In 2020, the Czech Republic was in first place in the EU in terms of large companies using 3D printing and the IoT, and it came third in terms of use of robots in industry[28]. In addition, according to the Deloitte Technology Fast 50 Central Europe 2020 ranking of the fastest expanding technology firms in Central Europe, 21 of the 50 included are from the Czech Republic[29].

The long-term strategy of stimulating innovation is also important in the development of the high-tech sector in the Czech Republic. As early as 2002, a government agency was formed there – the Council for Scientific Research and Innovation (*Rada pro Vědu, Výzkum a Inovace České Republiky*); three years later,

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[26] Exporter Roku (Exporter of the Year), http://www.exporterroku.com/ [20.09.2021].

[27] M. Gołębiowska, J*ak rozpędzić gospodarkę, czyli polityki innowacyjne państw Grupy Wyszehradzkiej (How to stimulate the economy: the innovative policies of the Visegrad Group countries)*, "Prace Instytutu Europy Środkowej" 2020, no. 20, https://ies.lublin.pl/prace/jak-rozpedzic-gospodarke-czyli-polityki-innowacyjne-panstw-grupy-wyszehradzkiej/ [20.09.2021].

[28] M. Gołębiowska, *Roboty, drukarki 3D, big data, internet rzeczy: lekcje wdrażania nowych technologii z Czech* (*Robots, 3D printers, big data, internet of things: lessons in implementing new technology from the Czech Republic*), "Komentarze IEŚ" 2021, no. 362, https://ies.lublin.pl/komentarze/roboty-drukarki-3d-big-data-internet-rzeczy-lekcje-wdrazania-nowych-technologii-z-czech/ [20.09.2021].

[29] *Deloitte Technology Fast 50 Central Europe 2020*, https://www2.deloitte.com/ce/en/pages/about-deloitte/topics/technology-fast-50.html [20.09.2021].

a system of tax incentives for R&D entities was implemented and in the following years numerous programs financing such activities. Strong economic ties with Germany – the largest economy in the EU – expressed in industrial interconnections and significant trade exchange, also have a significant impact on the importance of the high-tech sector in the Czech Republic.

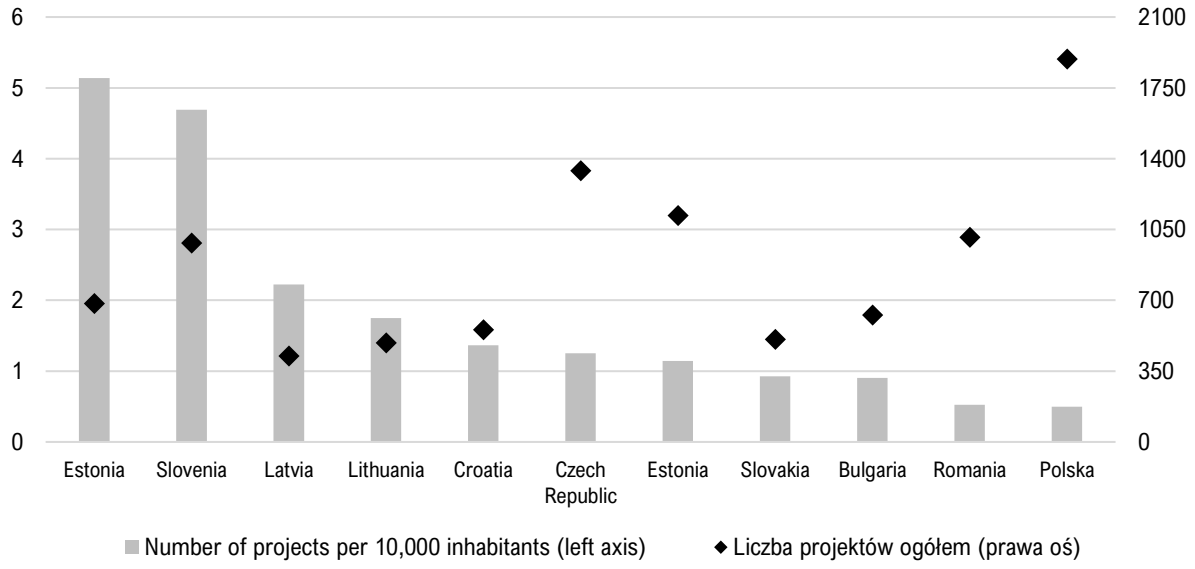
Hungary is also a leading country in Central Europe in terms of the importance of the high-tech sector, both when we consider the percentage of these products in trade and the number of employees, especially in industry. The key high-tech exports in Hungary are, similar to the Czech Republic, electronic and telecommunications devices – the value of exports in 2018 was almost 8 bn EUR. However, exports of these devices recorded a significant decline in 2011-2014: from over 10 bn EUR to 5bn EUR, mainly due to reduced production and, consequently, a decline in TV exports. At that time, the Hungarian market turned out to be less resistant to competition from East Asia, to which, due to costs, part of this production had then shifted. However, since 2015, the value of electronics exports has increased. The largest Hungarian companies producing electronics include such brands as Flextronics International, Samsung, Jabil and Foxconn. Among the Hungarian advanced technology sectors, the pharmaceutical sector also deserves attention, led by companies such as Richter Gedeon and Chinoin. The export of pharmaceuticals from Hungary increased from 0.3 bn EUR in 2009 to 1.8 bn in 2018, which is also the highest value among the Central European countries.

Another important country on the map of Central Europe in terms of technological advancement is Estonia, which is a leader in terms of the share of employment in high-tech services among total employment levels. This is mainly due to IT employees. Estonia is a country with an outstanding level and maturity of digitisation, not only by Central European standards. It is sometimes called Silicon Valley by the Baltic, mainly due to its digital public services. The idea to expand IT

in Estonia was born from the need to limit the costs of running the country. The first steps in this direction were taken in the nineties. It was then that, among others, a decision was taken to allocate 1% of GDP for this purpose. This initiative was called the *Tiigrihüpe* (Tiger Leap), and its aim was to increase access to IT infrastructure, primarily in schools. In 2000, every educational establishment had access to the internet. In that year, Estonians were first able to submit tax returns online, and five years later the world's first elections by internet were organised. Start-ups founded in Estonia include Skype, TransferWise, Pipedrive, Fortumo, Erply, Taxify and Lingvist. The last decade, the period analysed here, also saw a distinct increase in employment in high-tech services – from 14,000 to 31,000, percentage-wise the largest in Central Europe. The importance of the electronics industry is also systematically increasing in Estonia. This Baltic state has also become a cradle of regional tech giants such as ABB, Ericsson, Eolane, Stoneridge Electronics and Enics.

In relation to the EU framework programme mentioned in the introduction, in the field of scientific research it is also worth emphasising that Estonian participation in the Horizon 2020 programme is the highest in Central Europe per head of population – see Figure 7.

Figure 7. Participation in projects of the Horizon 2020 programme – number of projects per 10,000 inhabitants, and total number



Source: Own elaboration based on data from CORDIS, https://cordis.europa.eu/projects/en and Eurostat, https://ec.europa.eu/eurostat/web/population-demography/demography-population-stock-balance/database [20.10.2021].

The leading importers and exporters of high-tech in terms of share of total export and import goods during the analysed period were joined by Latvia, which between 2009 and 2018 doubled its percentage of technological exports and imports, having previously been near the bottom of the table. This was due, to a great extent, to aviation equipment, exports of which increased from a mere 9 m EUR in 2009 to 313 m EUR in 2018. Latvia had already been a centre for the production of high technology for the aviation industry in Soviet times. Latvia's research and development capabilities and highly educated workforce in this sector are thus the result of many years of experience. In addition, the Latvian national airline airBaltic has become a leader in the Baltic states in recent years, transforming the international airport in Riga into a major regional hub. It is worth giving a few examples demonstrating the development potential of this sector in

Latvia over the past few years: SIA Pelegrin is commencing production of ultra-light aircraft under the Tarragon brand; SIA Flight Consulting Group is developing the unique ATOM flight control software; and SIA Airline Support Baltics, which is relocating to Latvia from Sweden, is starting to provide MRO services (maintenance and repairs) for business and commercial aircraft at the airport in Riga. One of the priorities of the long-term development strategy for aviation in Latvia is to further increase the competitiveness of technical services, construction and repair of aeroplanes, and expanding export markets[30]. Aviation equipment currently accounts for 21% of Latvian high-tech exports, and 35% of imports, the highest figures among the Central European countries – see Figures 9 and 10.

In Latvia, the electronics industry has also been developing quickly over the past decade, exploring international markets and entering large supply chains. The result has been a growth in Latvian exports of electronic devices – from 109 m EUR in 2009 to 773 m EUR in 2018. Examples are SIA Mikrotīkls (also known as MikroTik), which produces equipment for computer networks and routers, and Lexel Fabrika, which forms part of the global French Schneider Electric group and is involved in manufacturing and distributing materials for electrical installations. The value of exports by those two electronics manufacturers in 2020 exceeded 50 m EUR[31].

In the case of Lithuania, which is not actually a leader in high-tech in the Central Europe region, it is worth pointing out their chemical industry, as the importance of such high-tech goods in its trade structure is great by Central European standards. In 2018, exports of these amounted to 619 m EUR – the largest among all the Central European countries, see Table 14 in the statistical annex. A year later, Lithuania was the world's 15th largest exporter of diagnostic and

[30] Latvijas Aviācijas Asociācija, *Aviācijas apgāde un saistītās nozares*, https://www.laa.aero/post/29-11-2019-avi%C4%81cijas-apg%C4%81de-un-saist%C4%ABt%C4%81s-nozares [23.09.2021].
[31] Latvian Export and Import Directory, http://www.exim.lv/ [27.09.2021].

laboratory reagents, with a 1.4% share in world exports of those products, and it was the 15th largest exporter of fertiliser, with a share of 1.6%[32].

[32] *Overview of Lithuanian Chemicals Industry*, https://www.enterpriselithuania.com/wp-content/uploads/2021/05/Overview-of-Lithuanian-Chemicals-Industry.pdf [27.09.2021].

Conclusions

1. The high technology sector in the Central European countries increased in significance during the decade between the crises – from the world financial crisis to the one caused by the COVID-19 pandemic.
    a. Firstly, there was a significant increase in the value of trade in high-tech goods. The total combined exports of technologically advanced goods from the Central European countries rose from 40 to 90bn euro, and imports – from 51 to 109bn euro. At the same time, the share of exports and imports of these goods increased in relation to total Central European exports and imports – to 11.4% and 13.6%.
    b. Employment in the high-tech industry rose from 2.5 to 3.1 m, and in high-tech services – from 0.8 to 14 m. At the same time, the share of high-tech workers when we look at the total Central European employment figure increased from 5.5% to 6.8% in industry, and from 1.9% to 3% in services. In addition, the importance of the Central European high-tech sector among EU countries has increased. At the beginning of the period studied, the Central European countries were responsible for 8.7% of EU high-tech exports, rising to 10.9% by the end. In the case of high-tech imports, the analogous growth was from 11.4% to 14%; in the case of employment in the high-tech industry, growth went from 20% to 24%, and in high-tech services – from 15% to 17.5%.
2. However, the Central European high technology sector is highly diversified. Among the high-tech leaders is the Czech Republic – a highly-industrialised economy where extensive manufacturing of electronics and computer equipment produced technologically high export goods worth nearly 31 bn EUR during the period in question, the highest of any country in Central Europe. High-tech goods constituted nearly 18% of industrial production for

export there, the fifth highest in the whole EU. In Central Europe, large shares of high technology in exports are also seen in Hungary – 16%, and in Estonia – 12%. Due to its highly developed IT sector, Estonia is also the leader in Central Europe in terms of its percentage of employees in high-tech services. The leading importers and exporters of high-tech in terms of the share of total export and import goods during the period studied were joined by Latvia, which doubled its percentage of high-tech exports and imports during the analysed period and advanced from almost the bottom of the EU ranking.

At the same time, however, there are countries in Central Europe where the high technology sector is far less significant. The share of high-tech goods was lowest in Slovenia and Bulgaria, both located in the south of the region, where it did not exceed 6%. Other countries where the high technology sector was of less importance were Romania and Croatia. In the context of the Central European eleven, Poland and Lithuania are also lower, even second to bottom when it comes to the share of high-tech employees in Lithuania, and of services in Poland. It is also worth mentioning that Polish participation in the aforementioned Horizon 2020 programme was the lowest in Central Europe per head of population.

3. The structure of trade in high-tech goods also shows clear variations between individual countries. While in terms of exports many of them (nine of the eleven analysed) were dominated by electronics and telecommunications at the end of the period studied, in Estonia that dominance was the result of those products making up 78% of high-tech exports, while in Lithuania it was only 28%.
4. The ranking of Central European exports and imports of high-tech goods shows a negative balance of trade in those goods, which rose from 11.5 bn EUR at the start of the period to almost 19.7bn. Taking into consideration

absolute measures, imports of hi-tech goods were 29% higher than exports in 2009, but only 22% higher in 2018. In most of the countries, there was a high negative balance in the trade of high-tech goods throughout the period investigated. The exceptions were Hungary, Lithuania and the Czech Republic, which saw a surplus of high technology export goods over imports.

5. In the year that the COVID-19 pandemic struck, the number of employees in the high-tech industry in Central Europe fell by nearly 100,000 to 3.1 m. The greatest reductions in employment were seen in Poland, Romania and the Czech Republic. In the case of high-tech services, there was no analogous trend, with only minor drops seen in Estonia, Croatia and Bulgaria. What is more, in some countries the number of employees in high-tech services clearly increased – compared to the previous year the largest rise was in Latvia (by 20%), and in numerical terms in Hungary (by 16,500).

Statistical annex

Table 14. Exports in individual high-tech industries (in millions of EUR)

		Bulgaria	Croatia	Czech Republic	Estonia	Lithuania	Latvia	Poland	Romania	Slovakia	Slovenia	Hungary
Electronics - telecommunications	**2009**	200	180	4,621	330	97	109	1,566	1,668	1,676	208	8,650
	2010	283	178	5,555	750	147	116	2,007	2,821	2,315	359	10,460
	2011	310	145	7,169	1,496	178	363	2,044	3,135	2,593	419	11,004
	2012	335	200	6,917	1,506	236	372	2,914	1,903	3,710	365	7,744
	2013	472	241	6,678	1,574	315	532	4,228	1,699	4,392	371	6,777
	2014	463	164	7,334	1,701	460	721	6,093	2,117	4,600	398	5,072
	2015	497	215	9,147	1,508	546	826	6,367	2,629	5,020	462	6,139
	2016	610	283	9,430	1,537	498	701	6,025	3,120	4,894	436	6,906
	2017	720	256	11,134	1,196	656	788	5,827	3,079	6,036	485	7,325
	2018	883	254	13,043	1,291	630	773	5,489	3,567	5,785	497	7,769
Scientific research instruments	**2009**	127	64	669	65	95	28	398	167	115	148	1,296
	2010	158	77	762	95	114	52	566	186	130	165	1,636
	2011	197	78	990	162	135	58	707	215	168	211	1,874
	2012	170	75	1,071	141	177	72	763	264	270	209	1,962
	2013	108	84	1,100	148	182	82	924	313	214	216	2,087
	2014	120	82	1,128	158	206	83	1,080	438	196	231	2,377
	2015	134	86	1,298	165	256	106	1,315	563	224	247	1,846
	2016	177	95	1,386	181	270	78	1,370	770	259	265	2,024

	2017	203	101	1,622	179	343	98	1,842	1,064	299	299	2,245
	2018	223	118	1,858	200	376	122	2,155	1,165	284	313	2,010
Computers – office machines	**2009**	31	37	5,306	11	59	81	2,345	200	324	145	2,071
	2010	39	28	7,881	14	94	96	3,013	254	482	139	2,179
	2011	56	27	8,925	20	143	94	2,505	231	721	62	2,342
	2012	65	21	9,434	17	190	119		230	863	58	2,478
	2013	84	21	8,284	16	199	120	2,726	202	1,257	61	2,532
	2014	84	37	9,121	13	233	123	2,469 3,102	188	1,206	87	2,599
	2015	104	45	8,985	25	238	160	3,856	190	1,029	101	2,745
	2016	126	39	8,446	36	254	199	3,859	208	1,114	115	2,777
	2017	158	40	10,056	33	277	133	4,231	194	1,042	136	3,190
	2018	170	47	12,388	39	266	141	5,162	223	1,040	127	3,319
Pharmaceuticals	**2009**	92	91	242	8	31	45	148	48	35	329	285
	2010	112	115	315	10	36	55	193	73	45	319	440
	2011	130	124	302	10	43	64	190	84	55	393	624
	2012	131	176	288	10	57	27	292	107	43	426	666
	2013	133	146	352	11	72	36	332	132	55	420	650
	2014	119	140	478	12	101	46	326	138	65	397	744
	2015	155	228	460	13	163	52	368	129	115	431	1,284
	2016	188	430	483	15	198	61	514	127	134	483	1,208
	2017	195	619	457	18	181	61	1,100	132	74	495	1,421
	2018	207	447	551	21	217	57	1,033	159	85	723	1,875
Aviation equipment	**2009**	47	20	515	7	23	9	587	64	40	65	57
	2010	8	57	367	-	11	4	938	108	53	15	43
	2011	-95	-14	48	-61	-14	-21	67	-126	-11	-21	-4
	2012	40	34	392	2	51	12	1,142	55	29	39	54
	2013	19	32	484	5	28	8	1,409	102	15	60	59

	2014	8	11	436	6	14	8	1,430	112	11	21	74
	2015	-10	-26	201	-1	-19	-128	490	21	-52	46	-20
	2016	-42	-55	155	-7	-23	-21	369	-93	-78	18	-25
	2017	40	28	731	27	51	157		72	13	88	99
	2018	13	24	604	23	37	313	2,542 2,640	69	28	87	91
Electrical machines	**2009**	16	32	384	10	17	5	77	133	49	22	309
	2010	18	24	546	16	22	6	101	119	56	34	398
	2011	20	10	664	11	20	14	113	135	78	29	316
	2012	20	8	598	21	26	54	109	152	80	39	302
	2013	20	9	651	22	31	57	130	152	110	122	391
	2014	31	10	671	29	27	19	176	181	104	152	413
	2015	55	12	670	26	35	15	401	203	73	128	485
	2016	68	16	684	28	37	17	455	233	91	56	491
	2017	89	25	771	38	39	17	528	168	107	101	478
	2018	89	30	836	30	52	22	552	182	116	128	467
Non-electrical machines	**2009**	6	80	424	5	8	12	162	90	53	63	398
	2010	8	82	503	8	11	7	155	85	74	71	338
	2011	11	84	605	9	24	11	184	105	109	106	414
	2012	10	87	713	12	27	18	323	91	114	105	518
	2013	15	81	603	12	34	9	393	99	124	102	465
	2014	12	103	715	12	38	25	516	114	140	93	522
	2015	17	89	785	11	31	6	648	112	145	118	698
	2016	25	92	846	5	37	9	786	128	159	133	799
	2017	32	97	786	16	42	8	776	130	170	134	709
	2018	24	98	869	15	36	18	833	140	185	134	473
Chemicals	**2009**	16	17	103	14	354	6	175	14	36	49	154
	2010	17	17	121	18	504	8	224	18	35	61	160

	2011	20	23	150	65	566	19	288	37	44	70	203
	2012	23	19	155	57	563	29	297	27	32	53	212
	2013	32	27	154	45	564	30	344	55	36	46	221
	2014	32	33	156	35	511	31	346	75	58	62	264
	2015	43	38	179	38	437	29	402	83	64	113	364
	2016	39	37	169	31	438	33	451	95	47	130	369
	2017	54	33	148	37	501	43	496	117	52	135	596
	2018	55	48	198	41	619	41	547	145	43	131	572
Armaments	**2009**	:	47	67	1	4	1	127	5	29	6	14
	2010	:	40	74	1	7	1	93	5	27	5	15
	2011	:	46	78	1	6	2	26	5	25	9	11
	2012	-	71	95	2	8	3	27	8	24	9	23
	2013	:	108	124	2	9	3	46	12	27	7	23
	2014	-	106	128	1	4	2	54	13	56	8	23
	2015	-	92	153	2	7	1	109	6	99	12	25
	2016	-	199	179	2	11	1	183	8	75	19	28
	2017	-	107	194	3	44	1	112	7	90	21	43
	2018	-	121	209	4	11	1	110	8	107	28	33

Source: Author's own work based on Eurostat data.

Table 15. Imports in individual high-tech industries (in millions of EUR)

		Bulgaria	**Croatia**	**Czech Republic**	**Estonia**	**Lithuania**	**Latvia**	**Poland**	**Romania**	**Slovakia**	**Slovenia**	**Hungary**
Electronics - telecommunications	**2009**	544	503	5,100	306	218	178	4,387	1,986	415	7,075	544
	2010	664	465	7,276	760	313	240	5,448	2,692	616	8,865	664
	2011	920	388	6,874	1,349	362	430	5,206	3,940	687	8,767	920
	2012	1,178	426	6,761	1,404	384	416	5,595	4,900	572	7,662	1,178
	2013	732	566	7,186	1,399	462	570	6,304	5,615	553	7,209	732
	2014	796	473	8,190	1,543	579	765	7,703	5,711	593	5,933	796

	2015	864	573	10,208	1,353	703	833	9,353	6,648	710	6,590	864
	2016	954	622	9,944	1,362	748	730	9,189	6,868	693	7,323	954
	2017	1,005	660	12,858	1,144	903	853	9,621	7,341	773	8,007	1,005
	2018	1,148	703	15,515	1,130	891	842	10,075	7,672	863	8,331	1,148
Scientific research instruments	**2009**	131	139	1,241	71	103	50	2,426	897	197	524	131
	2010	114	137	1,387	99	111	59	3,019	1,060	209	705	114
	2011	123	144	1,450	113	154	79	3,131	1,407	244	747	123
	2012	161	139	1,438	118	176	109	2,223	2,202	214	821	161
	2013	185	133	1,376	141	185	114	1,889	2,007	228	742	185
	2014	180	139	1,472	127	204	108	2,111	1,908	215	846	180
	2015	224	173	1,706	131	263	142	2,365	2,045	258	978	224
	2016	183	180	1,640	112	244	105	2,349	1,977	272	989	183
	2017	222	186	1,794	124	288	125	2,660	1,387	290	1,044	222
	2018	236	213	2,155	144	319	143	2,930	986	306	1,150	236
Computers – office machines	**2009**	215	224	4,780	67	128	95	2,975	562	301	1,559	215
	2010	227	227	6,993	88	191	119	3,652	676	306	1,592	227
	2011	213	217	7,879	107	247	144	3,286	951	215	1,705	213
	2012	250	201	7,498	123	304	193	3,839	1,084	195	1,853	250
	2013	276	225	6,421	123	309	188	3,781	1,419	191	2,049	276
	2014	306	225	6,913	124	356	199	3,985	1,429	231	2,062	306
	2015	301	244	8,346	135	360	225	4,653	1,355	259	2,323	301
	2016	302	229	7,258	132	372	278	4,397	1,339	258	2,360	302
	2017	342	263	8,384	155	429	261	5,000	1,289	281	2,526	342
	2018	330	274	9,200	183	397	273	5,197	1,280	283	2,905	330
Pharmaceuticals	**2009**	140	180	721	59	89	99	953	310	193	531	140
	2010	187	180	776	63	90	119	1,098	327	203	715	187
	2011	219	194	846	75	115	134	1,130	333	224	997	219

	2012	251	202	841	77	147	96	1,176	308	241	971	251
	2013	261	198	835	73	152	107	1,346	340	214	943	261
	2014	284	236	951	77	173	117	1,475	364	252	1,058	284
	2015	344	324	1,073	86	254	130	1,534	478	268	1,552	344
	2016	349	661	1,090	88	211	132	1,776	481	316	1,439	349
	2017	358	458	1,146	72	252	141	2,144	432	370	1,721	358
	2018	409	514	1,277	75	257	126	2,497	458	591	2,207	409
Aviation equipment	**2009**	18	115	298	22	42	9	497	41	92	59	18
	2010	49	86	500	17	34	57	783	50	80	56	49
	2011	110	37	306	66	36	30	843	29	43	78	110
	2012	151	34	369	29	35	15	1,428	32	132	51	151
	2013	40	30	240	9	59	15	1,440	40	93	69	40
	2014	44	39	390	11	55	15	1,168	84	74	92	44
	2015	17	47	254	9	39	135	1,228	74	33	87	17
	2016	44	73	340	28	52	36	1,646	91	44	104	44
	2017	72	35	475	34	65	484	2,117	131	97	106	72
	2018	67	34	837	48	43	858	2,118	81	117	115	67
Electrical machines	**2009**	31	45	252	25	18	10	286	120	37	611	31
	2010	29	41	389	45	22	13	362	184	48	696	29
	2011	33	32	514	63	27	14	364	206	47	462	33
	2012	45	28	527	65	28	17	446	183	46	413	45
	2013	38	27	562	62	35	19	481	279	128	415	38
	2014	54	30	579	73	33	22	572	226	160	454	54
	2015	85	37	612	58	40	25	785	179	145	546	85
	2016	103	43	646	61	43	24	768	226	75	591	103
	2017	105	52	678	72	51	32	1 092	242	96	586	105
	2018	128	57	741	76	76	46	917	251	107	575	128
Non-electrical machines	**2009**	32	59	307	14	30	11	283	148	106	376	32
	2010	31	60	396	8	18	11	279	243	102	523	31
	2011	34	81	530	21	25	83	326	283	121	707	34
	2012	46	81	573	19	23	44	413	309	97	848	46

	2013	63	79	548	16	36	16	547	272	121	882	63
	2014	72	87	604	15	47	36	632	357	126	874	72
	2015	72	77	823	18	47	21	963	319	95	1,108	72
	2016	89	80	668	22	54	15	915	401	142	1,102	89
	2017	78	80	742	29	60	26	942	303	126	1,135	78
	2018	84	115	795	34	58	25	1,167	371	163	815	84
Chemicals	**2009**	108	71	350	23	89	33	702	138	77	315	108
	2010	133	74	452	24	100	39	851	113	92	322	133
	2011	170	86	601	86	135	49	946	139	110	398	170
	2012	182	86	572	63	152	64	937	154	97	394	182
	2013	200	112	604	47	170	70	1,018	166	88	415	200
	2014	226	98	628	49	171	81	1,139	185	105	462	226
	2015	244	120	605	51	177	86	1,250	194	158	499	244
	2016	228	118	534	49	186	97	1,195	196	153	474	228
	2017	262	114	610	44	191	104	1,183	204	143	533	262
	2018	268	143	889	51	193	98	1,303	201	129	595	268
Armaments	**2009**	-	16	20	35	4	15	109	16	21	9	-
	2010	-	18	21	40	4	12	119	13	32	10	-
	2011	-	50	21	13	6	12	175	12	13	8	-
	2012	-	52	30	29	9	11	221	26	7	14	-
	2013	-	29	31	24	5	12	108	35	6	12	-
	2014	-	20	33	15	6	7	262	30	7	14	-
	2015	-	8	34	27	21	9	223	61	7	20	-
	2016	-	65	46	108	18	26	240	93	8	29	-
	2017	-	40	53	33	62	26	203	57	12	38	-
	2018	-	14	57	54	42	47	241	67	16	34	-

Source: Author's own work based on Eurostat data.

Table 16. Balance of trade in individual high-tech industries (in millions of EUR)

		Bulgaria	Croatia	Czech Republic	Estonia	Lithuania	Latvia	Poland	Romania	Slovakia	Slovenia	Hungary
Electronics - telecommunications	**2009**	-344	-323	-479	24	-121	-69	-2,821	-602	-310	-207	1,575
	2010	-381	-287	-1,721	-10	-166	-124	-3,441	-453	-377	-257	1,595
	2011	-610	-243	295	147	-184	-67	-3 162	-78	-1 347	-268	2,237
	2012	-843	-226	156	102	-148	-44	-2,681	-599	-1,190	-207	82
	2013	-260	-325	-508	175	-147	-38	-2,076	-1,112	-1,223	-182	-432
	2014	-333	-309	-856	158	-119	-44	-1,610	-769	-1,111	-195	-861
	2015	-367	-358	-1,061	155	-157	-7	-2,986	-596	-1,628	-248	-451
	2016	-344	-339	-514	175	-250	-29	-3,164	-585	-1,974	-257	-417
	2017	-285	-404	-1,724	52	-247	-65	-3,794	-1,086	-1,305	-288	-682
	2018	-265	-449	-2,472	161	-261	-69	-4,586	-1,059	-1,887	-366	-562
Scientific research instruments	**2009**	-4	-75	-572	-6	-8	-22	-2,028	-162	-782	-49	772
	2010	44	-60	-625	-4	3	-7	-2,453	-261	-930	-44	931
	2011	74	-66	-460	49	-19	-21	-2,424	-276	-1,239	-33	1,127
	2012	9	-64	-367	23	1	-37	-1,460	-245	-1,932	-5	1,141
	2013	-77	-49	-276	7	-3	-32	-965	-277	-1,793	-12	1,345
	2014	-60	-57	-344	31	2	-25	-1,031	-212	-1,712	16	1,531
	2015	-90	-87	-408	34	-7	-36	-1,050	-233	-1,821	-11	868
	2016	-6	-85	-254	69	26	-27	-979	-12	-1,718	-7	1,035
	2017	-19	-85	-172	55	55	-27	-818	212	-1,088	9	1,201
	2018	-13	-95	-297	56	57	-21	-775	121	-702	7	860
Computers – office machines	**2009**	-184	-187	526	-56	-69	-14	-630	-290	-238	-156	512
	2010	-188	-199	888	-74	-97	-23	-639	-317	-194	-167	587
	2011	-157	-190	1,046	-87	-104	-50	-781	-394	-230	-153	637
	2012	-185	-180	1,936	-106	-114	-74	-1,113	-394	-221	-137	625

	2013	-192	-204	1,863	-107	-110	-68	-1,312	-403	-162	-130	483
	2014	-222	-188	2,208	-111	-123	-76	-883	-509	-223	-144	537
	2015	-197	-199	639	-110	-122	-65	-797	-564	-326	-158	422
	2016	-176	-190	1,188	-96	-118	-79	-538	-565	-225	-143	417
	2017	-184	-223	1,672	-122	-152	-128	-769	-607	-247	-145	664
	2018	-160	-227	3,188	-144	-131	-132	-35	-638	-240	-156	414
Pharmaceuticals	**2009**	-48	-89	-479	-51	-58	-54	-805	-426	-275	136	-246
	2010	-75	-65	-461	-53	-54	-64	-905	-472	-282	116	-275
	2011	-89	-70	-544	-65	-72	-70	-940	-518	-278	169	-373
	2012	-120	-26	-553	-67	-90	-69	-884	-524	-265	185	-305
	2013	-128	-52	-483	-62	-80	-71	-1 014	-506	-285	206	-293
	2014	-165	-96	-473	-65	-72	-71	-1 149	-510	-299	145	-314
	2015	-189	-96	-613	-73	-91	-78	-1 166	-550	-363	163	-268
	2016	-161	-231	-607	-73	-13	-71	-1 262	-518	-347	167	-231
	2017	-163	161	-689	-54	-71	-80	-1 044	-635	-358	125	-300
	2018	-202	-67	-726	-54	-40	-69	-1 464	-629	-373	132	-332
Aviation equipment	**2009**	29	-95	217	-15	-19	-	90	-45	-1	-27	-2
	2010	-41	-29	-133	-17	-23	-53	155	-20	3	-65	-13
	2011	-95	-14	48	-61	-14	-21	67	-126	-11	-21	-4
	2012	-111	-	23	-27	16	-3	-286	-47	-3	-93	3
	2013	-21	2	244	-4	-31	-7	-31	-12	-25	-33	-10
	2014	-36	-28	46	-5	-41	-7	262	67	-73	-53	-18
	2015	-10	-26	201	-1	-19	-128	490	21	-52	46	-20
	2016	-42	-55	155	-7	-23	-21	369	-93	-78	18	-25
	2017	-32	-7	256	-7	-14	-327	425	-267	-118	-9	-7
	2018	-54	-10	-233	-25	-6	-545	522	-102	-53	-30	-24
Electrical machines	**2009**	-15	-13	132	-15	-1	-5	-209	-11	-71	-15	-302
	2010	-11	-17	157	-29	-	-7	-261	-89	-128	-14	-298
	2011	-13	-22	150	-52	-7	-	-251	-91	-128	-18	-146
	2012	-25	-20	71	-44	-2	37	-337	-74	-103	-7	-111
	2013	-18	-18	89	-40	-4	38	-351	-87	-169	-6	-24

	2014	-23	-20	92	-44	-6	-3	-396	-97	-122	-8	-41
	2015	-30	-25	58	-32	-5	-10	-384	-103	-106	-17	-61
	2016	-35	-27	38	-33	-6	-7	-313	-112	-135	-19	-100
	2017	-16	-27	93	-34	-12	-15	-564	-221	-135	5	-108
	2018	-39	-27	95	-46	-24	-24	-365	-304	-135	21	-108
Non-electrical machines	**2009**	-26	21	117	-9	-22	1	-121	-33	-95	-43	22
	2010	-23	22	107	-	-7	-4	-124	-119	-169	-31	-185
	2011	-23	3	75	-12	-1	-72	-142	-98	-174	-15	-293
	2012	-36	6	140	-7	4	-26	-90	-120	-195	8	-330
	2013	-48	2	55	-4	-2	-7	-154	-68	-148	-19	-417
	2014	-60	16	111	-3	-9	-11	-116	-118	-217	-33	-352
	2015	-55	12	-38	-7	-16	-15	-315	-370	-174	23	-410
	2016	-64	12	178	-17	-17	-6	-129	-394	-242	-9	-303
	2017	-46	17	44	-13	-18	-18	-166	-400	-133	8	-426
	2018	-60	-17	74	-19	-22	-7	-334	-453	-186	-29	-342
Chemicals	**2009**	-92	-54	-247	-9	265	-27	-527	-242	-102	-28	-161
	2010	-116	-57	-331	-6	404	-31	-627	-294	-78	-31	-162
	2011	-150	-63	-451	-21	431	-30	-658	-361	-95	-40	-195
	2012	-159	-67	-417	-6	411	-35	-640	-376	-122	-44	-182
	2013	-168	-85	-450	-2	394	-40	-674	-369	-130	-42	-194
	2014	-194	-65	-472	-14	340	-50	-793	-366	-127	-43	-198
	2015	-201	-82	-426	-13	260	-57	-848	-403	-130	-45	-135
	2016	-189	-81	-365	-18	252	-64	-744	-448	-149	-23	-105
	2017	-208	-81	-462	-7	310	-61	-687	-512	-152	-8	63
	2018	-213	-95	-691	-10	426	-57	-756	-521	-158	2	-23
Armaments	**2009**	-	31	47	-34	-	-14	18	2	13	-15	5
	2010	-	22	53	-39	3	-11	-26	-7	14	-27	5
	2011	-	-4	57	-12	-	-10	-149	-1	13	-4	3
	2012	-	19	65	-27	-1	-8	-194	-5	-2	2	9
	2013	-	79	93	-22	4	-9	-62	11	-8	1	11
	2014	-	86	95	-14	-2	-5	-208	11	26	1	9

2015	-	84	119	-25	-14	-8	-114	-7	38	5	5
2016	-	134	133	-106	-7	-25	-57	8	-18	11	-1
2017	-	67	141	-30	-18	-25	-91	-6	33	9	5
2018	-	107	152	-50	-31	-46	-131	-34	40	12	-1

Source: Author's own work based on Eurostat data.

Bibliography

1. *Atomic Power for Europe*, "The New York Times", February 4, 1958, p. 17.
2. Baruch Y., *High technology organization what it is, what it isn´t*, "International Journal of Technology Management" 1997, no. 13(2), pp. 179-195.
3. Białowąs T., P. Pasierbiak, M. Wojas, *Structural changes and technological progress as factors of labour market developments in the V4 countries in 2004–2018*, "Problemy Zarządzania" 2019, no. 17(6), pp. 11-30.
4. CB Insights, *Global Unicorn Club: Private Companies Valued at $1B+ (as of September 30th, 2021)*, https://www.cbinsights.com/research-unicorn-companies.
5. *Deloitte Technology Fast 50 Central Europe 2020*, https://www2.deloitte.com/ce/en/pages/about-deloitte/topics/technology-fast-50.html.
6. European Commission, *The 2020 EU Industrial R&D Investment Scoreboard*, 2021, https://iri.jrc.ec.europa.eu/scoreboard/2020-eu-industrial-rd-investment-scoreboard.
7. Eurostat, *Aggregation of products by SITC Rev. 4*, https://ec.europa.eu/eurostat/cache/metadata/Annexes/htec_esms_an5.pdf.
8. Eurostat, *Aggregations of manufacturing based on NACE Rev. 2*, https://ec.europa.eu/eurostat/cache/metadata/Annexes/htec_esms_an3.pdf.
9. Exportér Roku, http://www.exporterroku.com/.
10. Gołębiowska M., *Jak rozpędzić gospodarkę, czyli polityki innowacyjne państw Grupy Wyszehradzkiej*, "Prace Instytutu Europy Środkowej" 2020, no.

20, https://ies.lublin.pl/prace/jak-rozpedzic-gospodarke-czyli-polityki-innowacyjne-panstw-grupy-wyszehradzkiej/.

11. Gołębiowska M., *Roboty, drukarki 3D, big data, internet rzeczy: lekcje wdrażania nowych technologii z Czech*, "Komentarze IEŚ" 2021, no. 362, https://ies.lublin.pl/komentarze/roboty-drukarki-3d-big-data-internet-rzeczy-lekcje-wdrazania-nowych-technologii-z-czech/.
12. Jóźwik B., *Transformacja i rozwój gospodarczy w państwach Europy Środkowej i Wschodniej*, "Rocznik Instytutu Europy Środkowo-Wschodniej" 2016, no. 4(5), pp. 49-66.
13. Kazimierczak M.F., J. James, W.T. Archey, *We are still losing the competitive advantage: Now is the time to act*, American Electronics Association, Washington 2007.
14. *European Commission*, "Horizon Europe", https://ec.europa.eu/info/funding-tenders/find-funding/eu-funding-programmes/horizon-europe_pl.
15. Korpus J., Ł. Banach, *Przedsiębiorstwa z sektora wysokich technologii w erze gospodarki cyfrowej*, "Ekonomika i Organizacja Przedsiębiorstwa" 2017, no. 3, pp. 132-140.
16. Latvian Export and Import Directory, http://www.exim.lv/.
17. Latvijas Aviācijas Asociācija, *Aviācijas apgāde un saistītās nears*, https://www.laa.aero/post/29-11-2019-avi%C4%81cijas-apg%C4%81de-un-saist%C4%ABt%C4%81s-nozares.
18. Lawrence M., High-tech industries drive global economic activity, "National Science Foundation" 1998, no. 7(20), pp. 319-322.
19. Meral Y., *High technology export and high technology export impact on growth*, "Bussecon Review of Finance & Banking" 2019, no. 1(1), pp. 26-31.

20. O´Regan N., M.A. Sims, *Identifying high technology small firms: A sector analysis*, "Technovation" 2008, no. 28, pp. 408-423.
21. *Overview of Lithuanian Chemicals Industry*, https://www.enterpriselithuania.com/wp-content/uploads/2021/05/Overview-of-Lithuanian-Chemicals-Industry.pdf.
22. Ratajczak-Mrozek M., *Specyfika przedsiębiorstw zaawansowanych technologii (high-tech)*, "Przegląd Organizacji" 2011, no. 2, pp. 26-29.
23. Sandu S., B. Ciocanel, *Impact of R&D and Innovation on High-tech Export*, "Procedia Economics and Finance" 2014, no. 15, pp. 80-90.
24. Skala A., *Nowa metoda identyfikacji przedsiębiorstw wysokiej technologii na przykładzie Warszawy*, "Modern Management Review", vol. 19, 2014, no. 21(2), pp. 109-127.
25. Van Roy V., D. Vértesy, M. Vivarelli, *Technology and employment: Mass unemployment or job creation? Empirical evidence from European patenting firms*, "Research Policy" 2019, no. 47(9), pp. 1762-1776.
26. Zarzewska-Bielawska A., *The strategic dilemmas of innovative enterprises: proposals for high technology sectors*, "R+D Management" 2012, no. 42(5), pp. 303-314.

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"The decade of economic growth following the crisis of 2007-8 was a notable one for the region. A few years earlier, the Central European countries had joined the European Union, and the consequences of this included a dynamic expansion of transport along with economic and social infrastructure, financed from EU funds. It seems that after many years of that effort, it is fitting to ask questions about the competitiveness of the region, its trade, and about the development of the most modern companies and the highly qualified workforces they employ. The monograph presented answers those questions".

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"The study concerns the interesting and topical problem of sectoral transformations in the national economy, and particularly the high technology sector. This is an important area of economic research, especially for countries

which are still at a relatively low level of economic development but which have ambitions to accelerate that development. These include the Central European countries."

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