BIBLIOTEKA REGIONALISTY

**Biblioteka Regionalisty**
**Regional Journal**
Year 2025, No. 25
ISSN 2449-9781
journals.ue.wroc.pl/br

# Regional disparities in knowledge-intensive sectors. A comparative study of Poland and Czechia in the context of sustainable development

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**Quote as:** Miszczak, K., Mempel-Śnieżyk, A., & Dědková, J. (2025). Regional disparities in knowledge-intensive sectors. A comparative study of Poland and Czechia in the context of sustainable development. *Biblioteka Regionalisty. Regional Journal*, (25), 133-147.

DOI 10.15611/br.2025.1.11

JEL: O33, R11, O14, Q56

## Abstract

The study aimed to explore regional disparities in the employment of high-technology and knowledge-intensive sectors across Polish and Czech regions from 2019 to 2023 to identify which areas are thriving in innovation and economic growth and which are lagging, highlighting regional imbalances. The research applied a quantitative approach, utilising publicly available data from Eurostat to explore trends in employment in knowledge-intensive sectors and R&D personnel. The study also incorporated visual representations to illustrate regional trends and disparities. High-technology and knowledge-

-intensive sectors are critical for future economic resilience. Exploring disparities can reveal how prepared different regions are for economic shifts such as the transition to Industry 4.0 and the green economy. This research contributes to the existing literature by offering a comparative, longitudinal analysis of regional disparities in knowledge-intensive sectors in Poland and Czechia. It highlights the implications of these disparities for sustainable development and regional innovation policies, offering a unique perspective on the socio-economic dynamics within Central and Eastern Europe.

**Keywords:** knowledge-intensive services, high-technology manufacturing sectors, sustainable development, Poland, Czechia

## 1. Introduction

The current intensification of competition between the world's leading economies forces, especially in the turbulent global economic and environmental crises, is reflected in a constant search for the most effective and stable growth factors. One of them is knowledge (in a static approach) and the process of its distribution and commercialisation (in a dynamic approach). The ability to create and absorb knowledge largely determines the competitive position of a given spatial unit in the international arena. Traditional factors previously perceived as key, such as labour costs, exchange rates, interest rates, and economies of scale, have given way to features characteristic of the knowledge-based economy. It is, therefore, necessary to search for new sources of competitive advantages. The transition process from a traditional economy based on industry and agriculture to a knowledge-based economy or learning economy should be driven by sectors that constitute its carriers: education, science, knowledge-intensive services, high-technology industries[1], and research and development activities (Miszczak, 2012a).

The experience of the last 50 years indicates that after reaching a 40% share of added value generated by the industry to its total value, further growth slows down or shrinks significantly. The share of agriculture is decreasing, and the service sector is developing rapidly. Structural changes are taking place in the industry – the share of raw materials industries is decreasing while the share of industrial processing is growing. In the latter period, changes also occurred, including the growing role of manufacturing companies, which required significant capital outlays and a large amount of human capital. Currently, the industrial processing sector requires strong cooperation with the service sector, hence the dynamic growth of the latter.

It should be underlined that the share of the modern technology industry and services with high knowledge saturation, such as electronic, satellite, cable services, or management and analysis of large data sets – Big Data, is growing in the economy. This process is generally accompanied by increased spending on research and development and investment in advanced technologies and intangible capital. As a result of the increased demand for highly qualified employees, wages are increasing, which stimulates demand. The economy is developing, and society is becoming more prosperous.

High-technology and knowledge-intensive sectors are the answer not only to business needs (GUS, 2023), and their impact is visible in all aspects of territorial development. Introducing such issues to operations of enterprises and regional authorities, such as artificial intelligence, data analytics, blockchain technology, and advanced cloud solutions, helps optimise production, increase competitive advantage of enterprises and regions, affect environmental protection and determine their

[1] High technology includes areas where R&D expenditure accounts for more than 4% of sales (according to OECD). It consists of the production of aircraft and spacecraft, pharmaceuticals, office machines and computers, radio, television and communication equipment and devices, and the production of precision and optical medical instruments, clocks and watches.

development. It is worth stressing that technology and knowledge-intensive sectors are crucial for regional sustainability.

The research focused on Poland and Czechia as two representative countries of Central and Eastern Europe that underwent similar economic transformations after the fall of centrally planned economies. Both countries face the challenge of strengthening their economic competitiveness through knowledge-intensive and high-technology sectors, whilst dealing with growing spatial inequalities which significantly impact regional development dynamics. A comparative analysis of these countries identified key similarities and differences in developing knowledge-intensive sectors, providing a broader understanding of processes occurring in post-transformation regions.

Sustainable development provides an important contextual framework for this research. Knowledge--intensive and high-technology sectors not only contribute to economic growth but also play a crucial role in achieving environmental and social goals. In countries like Poland and Czechia, the development of high-technology sectors can significantly reduce spatial economic inequalities, enhance resource efficiency, and drive innovations aimed at environmental protection. Moreover, these sectors enable regions to better respond to global challenges, such as transitioning to a low-carbon and digital economy, in line with EU and national sustainable development policies. The fundamental problem of sustainable development in most countries, including Poland and Czechia, are the ever-increasing spatial disparities which occur and are discussed in a regional approach. Economic activity attains closure and assumes character within regions' spatial-institutional framework (Chojnicki & Czyż, 2006). Research on development using a regional approach is of key importance for understanding the contemporary nature of socio-economic development in terms of growing sustainability challenges and integral links with the processes of spatial concentration of knowledge-intensive sectors.

## 2. Sustainable approach for knowledge-intensive sectors development

In the contemporary globalisation process, there are strong tendencies to appropriate knowledge at the level of regions and cities (Dziemianowicz & Jałowiecki, 2004), which leads to the emergence of technological and economic clusters that create knowledge much faster and, at the same time, automatically trigger mechanisms that bring in knowledge, capital, technology, and knowledge workers. Regions with creative knowledge metropolises in their centres become powerful information stores (Florida, 2005a, 2008). After a regional knowledge centre emerges, an avalanche of knowledge creation and, above all, knowledge processing are spontaneously started. The universality of information and its integrating nature emphasises the systemic nature of metropolises and their immediate surroundings, i.e. the region, as never before. These large urban complexes, regardless of location, become ‘islands’ of a higher standard of living and economic efficiency and centres of the fastest adaptation, processing, and transmission of innovation in all types of activity.

It is also worth stressing that knowledge, which determines research and development processes and innovation, contributes to the transformation of the socio-economic space by expanding suburban and pre-urban zones and, consequently, in the emergence of metropolitan areas or city regions. The entire social, urban and regional fabric is changing. In most modern regions, a new type of society is formed: a knowledge society or a learning society (Lundvall, 2004). The essence of this phenomenon is not the increase in the number of people living in these regions but the dominance of qualitative factors such as the concentration of managerial functions, the R&D sector, and cultural functions. In the group of innovative, fastest developing regions, functions related to the management of the information society (Drucker, 1992) and the development of knowledge-intensive sectors (Consoli & Elche-Hortelano, 2010; Ronnie et al., 2017) appear on a scale exceeding even the scope of the state. Knowledge-oriented sectors are defined as high-technology manufacturing sectors (HTMS) and knowledge-intensive services. High-technology manufacturing sectors correspond to the following ISIC divisions/ groups/classes (OECD, 2009): manufacture of office machinery and computers; manufacture of

pharmaceuticals, medicinal chemicals and botanical products; manufacture of medical, precision and optical instruments, watches and clocks; manufacture of radio, television and communication equipment and apparatus; manufacture of aircraft and spacecraft. Knowledge-intensive services include the following ISIC divisions (OECD, 2009): post and telecommunications, water transport, real estate activities, air transport, financial intermediation, except insurance and pension funding, Activities auxiliary to financial intermediation, insurance and pension funding, except compulsory social security, computer and related activities, rental of machinery and equipment without operator and of personal and household goods, education, health and social work, research and development, recreational, cultural and sporting activities, and other business activities. All these activities tend to be concentrated in certain regions since investments, infrastructure, and physical and human capital tend to be geographically clustered. It is recognised that the knowledge-intensive sectors are crucial in terms of economic benefits and are a key part of the growth in value-added employment and labour productivity (Freel, 2006). They also play a multidimensional role as a facilitator of information, knowledge, and innovation (Muller & Doloreux, 2007).

Additionally, as the knowledge base grows, cooperation develops. Combining certain know-how elements is one reason for the emergence of industrial networks or networks created by scientific and research entities operating in regions. Moreover, researchers of regional economics, starting with Marshall's papers on industrial regions, pointed to regional networks as sources of specialist knowledge (Maskell & Malmberg, 1999). Hence, the authors concluded that the relations between the processes of knowledge creation and transfer and the processes of socio-economic development of regions operating in networks are positive feedback loops, as a result of which the implementation of new knowledge management methods increases the level of knowledge of the inhabitants/ employees of the region and thus contributes to the growth of innovation in this area. This is the first stage in building a creative class or, more broadly, learning regions (Florida, 1995, 2005b). The dynamism of the regional environment shows that the possessed knowledge is fleeting, used up faster than other resources, and requires constant deepening, renewal and expansion (Kwiatkowski, 2001). The environment in which knowledge is generated is also significant. The features of a network organisation must undoubtedly dominate it. If there is the accumulation and, more importantly, ‘intelligent’ diffusion of knowledge in a particular territory, the degree of flexibility of this regional complex increases, favouring the creation of technological innovations. Thus, entering new markets and sectors, the region is diametrically changing the previous development path and its position internationally (Lundvall, 2006).

The factors leading to the growing importance of regional development in the modern world, manifested in the change in the position of economic regions, include (Miszczak, 2012b):

1. Dynamic socio-economic development resulting from the scientific and technological revolution, which causes transformations of many areas in the national economy and leads to changes in the territorial division of labour, population distribution, and infrastructure; as a result of these changes, regions that were until recently considered leading may transform into problem areas.
2. The development of mass communication and information flow, causing an increase in the dissemination of knowledge about the differences in the level of wealth of individual countries or regions, leads to actions aimed at reducing the differences – the distance between less and highly developed areas.
3. Integration processes taking place in many places around the world mean that problems of regional development must be solved at international level, which leads to the internationalisation of regional policy.

A crucial determinant of the region's development is the increased threat to the natural environment, both within individual countries and in international cross-sections, creating the need to take coordinated actions aimed at its limitation (Kunhui et al., 2016). Sustainability practices are a driver for regional innovation, and these practices should be implemented internally (as a strategy to improve the internal operations and make them more respectful of the environment and society) and beyond

the boundaries of the regions (collaborating with other regions, in particular with those representing a similar level of development). The modern strategy for sustainable development is based on scientific and technical improvements driven by innovative resources, interdisciplinary research initiatives, localities' engagement and a culture of creativity (Zieschank, 2004). Information and communication technologies, digital services, and products enable process optimisation and cost reduction and more environmentally responsible functioning for particular stakeholders of the market and decision-makers. However, a sustainable digital footprint is multidimensional, and taking positive action in one dimension can harm the environment in another. Companies that invest in modern machines and innovative environmentally friendly solutions must also consider the negative social impact since they will need a smaller staff to operate them, ultimately leading to the elimination of existing jobs and consequently impacting the quality of the regional labour market. This will require employees to acquire new knowledge and new skills so that they can skilfully use the achievements of technological progress and, as a result, become desirable personnel for knowledge-intensive sectors. A good example of the need to analyse technological solutions in light of regional studies concepts in the long term and multi-dimensionally, i.e. from the perspective of environmental, social and economic impact, is the sharing economy (Zhang et al., 2013). This idea, responding to the need for access to resources and their effective use and social inclusion, aims to build new relationships between stakeholders of local and regional economies.

High-technology and knowledge-intensive sectors are important for achieving sustainable development, particularly in regions striving to balance economic growth, social equity, and environmental sustainability. The interdependence between knowledge-intensive activities and sustainable development goals is discussed in the literature referring to creative capital – scholars discussed the relationship between knowledge-intensive activities and sustainable development goals within the context of the creative economy (Levickaitė, 2015; Štreimikienė & Kačerauskas, 2020). Knowledge capital is studied as a component of human resources and a contributor to economic growth in a sustainable path. Furthermore, the researchers indicate that the creative industries can leverage knowledge for innovations, which supports the creation of added value and contributes to sustainability (Sokół & Mempel-Śnieżyk, 2022). According to Domenech et al. (2016), knowledge--intensive activities are crucial to innovation. In turn, innovation drives economic growth and regional development, and understanding the factors that are conducive to knowledge-intensive activities is important for regions in planning and building toward a sustainable future (Domenech et al., 2016).

It is worth mentioning that sustainable development issues are multifaceted and require expertise from various fields. Higher education encourages interdisciplinary approaches that can integrate knowledge across different domains to devise innovative solutions (Wang et al., 2022). Studies also emphasise that higher education institutions are key to raising awareness about sustainable development goals among, e.g. students, and disseminating knowledge and fostering critical thinking is essential for addressing complex sustainability challenges (Tchamyou, 2020). Thus, higher education serves as a vital vehicle for promoting sustainable development by educating and actively engaging students, fostering interdisciplinary collaboration, and developing the human capital necessary for addressing sustainability challenges (Wang et al., 2022).

## 3. Research methodology

This study used a comparative, longitudinal analysis of regional disparities in the employment of high--technology and knowledge-intensive sectors across Polish and Czech regions from 2019 to 2023 to identify which areas were thriving in innovation and economic growth, and which were lagging, highlighting regional imbalances. The author employed a quantitative approach, utilising publicly available data from Eurostat to explore trends in employment in knowledge-intensive sectors and R&D personnel, and incorporated visual representations to illustrate regional trends and disparities. The

definitions proposed by Eurostat interpret high-technology and knowledge-intensive sectors as follows, and the knowledge-intensive services are defined as:

1. High-tech knowledge-intensive 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.
2. Knowledge-intensive market services (excluding financial intermediation and high-tech services): water transport; air transport; legal and accounting activities; activities of head offices; management consultancy activities; architectural and engineering activities; technical testing and analysis; advertising and market research; other professional, scientific and technical activities; employment activities; security and investigation activities.
3. Knowledge-intensive financial services: financial service activities, except insurance and pension funding; insurance, reinsurance and pension funding, except compulsory social security; activities auxiliary to financial services and insurance activities.
4. Other knowledge-intensive services: publishing activities; veterinary activities; public administration and defence; compulsory social security; education; human health activities; residential care activities; social work activities without accommodation; creative, arts and entertainment activities; libraries, archives, museums and other cultural activities; gambling and betting activities; sports activities and amusement and recreation activities.

Eurostat aggregated the manufacturing industry according to technological intensity to compile high--tech economic activity statistics. In this study, high-technology manufacturing sectors were considered according to Eurostat and included the following manufacturing methods: manufacturing basic pharmaceutical products and pharmaceutical preparations; manufacturing computer, electronic, and optical products; manufacturing air and spacecraft, and related machinery.

## 4. Results and discussion

Knowledge-oriented sectors are gaining importance due to their association with innovative products and services, new production processes and their impact on productivity, sustainability, international competitiveness, and overall economic growth. Individuals employed in knowledge-intensive sectors are often in R&D, increasing scientific knowledge and using it to develop products and production processes whilst others apply technology in other activities, including: the design of equipment, processes, and structures; computer applications; sales, purchasing, and marketing; quality management; and the management of these activities.

When comparing employment in technology and knowledge-intensive sectors in recent years in Poland and in Czechia, it should be noted that Poland experienced a four times greater increase in employment in these sectors than Czechia. The regions with the highest employment rate in high--technology manufacturing sectors (HTMS) and knowledge-intensive services (KIS), shown in Table 1, were almost all capital regions where most public administrations tend to be concentrated.

In Czechia, the Praha region recorded the highest employment rate in HTMS and KIS, followed by the Jihovýchod region. The Severozápad region had the lowest average employment rate in these sectors, whereas the largest increase in employment in the HTMS and KIS sectors in 2019-2023 occurred in the Střední Čechy region (an increase of 19,8%), followed by the second largest increase in the Praha region (an increase of 16.6%). The growth dynamics in the Střední Čechy region was more than three times higher than the national average rate, yet the most significant decrease in employment in HTMS and KIS occurred in the Střední Morava region (a decrease of 16.5%), and the second 'inglorious' place was taken by the Severovýchod region (a decrease of 4.5%).

The ratio in the north-eastern and south-eastern regions was particularly low in Poland. Based on the available data, voivodeships such as the Świętokrzyskie and the Opolskie had the lowest employment rate in the HTMS and KIS sectors (respectively 5.2% and 74%). The Warsaw capital region recorded the highest subject statistical indicator, followed by the Dolnośląski region and the Małopolski region. Although the Podlaskie voivodeship was characterised by an average level of employment in HTMS and KIS compared to other regions, in the period under review, it recorded the highest 70% increase in employment in the sectors, i.e. an increase of 2.5 times greater than the average for Poland. The following voivodeships demonstrated equally high employment growth dynamics in HTMS and KIS in the period 2019-2023: Małopolskie (an increase of 58.8%), Śląskie (an increase of 53.5%), Kujawsko--Pomorskie (an increase of 53.1%), and Zachodniopomorskie (an increase of 52.3%). Compared to the Czech regions, no Polish region recorded reduced employment in high-technology manufacturing sectors and knowledge-intensive services.

**Table 1.** Employment in technology and knowledge-intensive sectors. High-technology sectors (high-technology manufacturing and knowledge-intensive high-technology services) in Polish and Czech regions in 2019-2023

| Regions | 2019 | 2020 | 2021 | 2022 | 2023 | Increase/ Decrease |
|---|---|---|---|---|---|---|
| Czechia | 257.7 | 264.1 | 297.5 | 277.3 | 273.4 | 6.1 |
| Praha | 73.0 | 72.8 | 92.9 | 76.0 | 85.1 | 16.6 |
| Střední Čechy | 30.8 | 33.3 | 39.6 | 41.9 | 36.9 | 19.8 |
| Jihozápad | 23.2 | 23.7 | 23.9 | 24.3 | 22.4 | −3.4 |
| Severozápad | 10.8 | 10.9 | 15.0 | 12.8 | 11.0 | 1.9 |
| Severovýchod | 30.8 | 30.4 | 30.9 | 30.9 | 29.4 | −4.5 |
| Jihovýchod | 43.1 | 48.0 | 47.9 | 43.7 | 46.9 | 8.8 |
| Střední Morava | 23.1 | 21.6 | 22.4 | 21.9 | 19.3 | −16.5 |
| Moravskoslezsko | 23.0 | 23.3 | 24.8 | 25.9 | 22.4 | −2.6 |
| Poland | 582.9 | 591.9 | 628.1 | 633.5 | 743.7 | 27.6 |
| Małopolskie | 60.4 | 67.1 | 79.4 | 72.7 | 95.9 | 58.8 |
| Śląskie | 48.4 | 58.6 | 69.1 | 65.2 | 74.3 | 53.5 |
| Wielkopolskie | 35.3 | 33.7 | 37.9 | 35.6 | 42.0 | 19.0 |
| Zachodniopomorskie | 15.1 | 12.6 | 16.3 | 19.5 | 23.0 | 52.3 |
| Lubuskie | 10.2 | 11.1 | 10.1 | : | : | : |
| Dolnośląskie | 68.9 | 69.3 | 71.2 | 73.6 | 75.7 | 9.9 |
| Opolskie | 7.4 | : | : | : | : | : |
| Kujawsko-pomorskie | 21.3 | 23.0 | 23.2 | 23.1 | 32.6 | 53.1 |
| Warmińsko-mazurskie | 8.2 | 10.1 | : | : | 10.7 | 30.5 |
| Pomorskie | 49.7 | 43.8 | 43.8 | 48.8 | 70.6 | 42.1 |
| Łódzkie | 35.8 | 44.5 | 44.1 | 47.1 | 46.0 | 28.5 |
| Świętokrzyskie | 5.2 | : | : | : | : | : |
| Lubelskie | 14.3 | 18.0 | 15.5 | 13.7 | 20.1 | 40.6 |
| Podkarpackie | 20.9 | 18.1 | 17.3 | 20.2 | 21.7 | 3.8 |
| Podlaskie | 7.0 | : | 10.2 | 12.1 | 11.9 | 70.0 |
| Warszawski stołeczny | 158.4 | 146.3 | 148.8 | 150.8 | 175.4 | 10.7 |
| Mazowiecki regionalny | 16.3 | 16.6 | 21.5 | 19.6 | 18.3 | 12.3 |

Source: own elaboration on the base of Eurostat data (access 4.12.2024).

Czechia showed greater regional disparities in technology and knowledge-intensive sectors' development than Poland (Figure 1). These disproportions were more significant regarding average absolute values and percentage increases and decreases in employment in these sectors.

In Czechia, the highest concentration of knowledge-intensive services was observed in the Prague region, reflecting its role as a central hub for administrative, financial, and educational functions. Other regions, such as Central Bohemia and Moravia, showed moderate levels of employment in these sectors, driven by a mix of scientific and educational activities.

In Poland, the Mazowieckie region (Warsaw) dominated in terms of employment in knowledge--intensive services. This was closely linked to the presence of key institutions in finance, technology, and education. Other regions, such as Dolnośląskie (Wrocław) and Wielkopolskie (Poznań), also demonstrated relatively high employment levels, supported by the concentration of urban centres and industrial-service clusters. However, regions in the eastern and rural parts of Poland exhibited much lower employment shares in these sectors, indicating a pronounced regional imbalance.

Figure 1 reveals the uneven distribution of knowledge-intensive services, with urban and capital regions leading in both countries, reflecting the established role of these regions as economic and innovation hubs, emphasising the challenges faced by peripheral areas in catching up with their more developed counterparts. The distribution of knowledge-intensive services across regions demonstates differing economic and social development capacities. Regions with higher concentrations of these services often benefit from enhanced innovation potential, more substantial employment growth, and improved quality of life. Expanding the reach of these sectors to less developed areas could help bridge development gaps, fostering more inclusive growth and aligning regional strategies with the principles of sustainable development. By doing so, regions can contribute to a balanced and equitable socio--economic transformation.

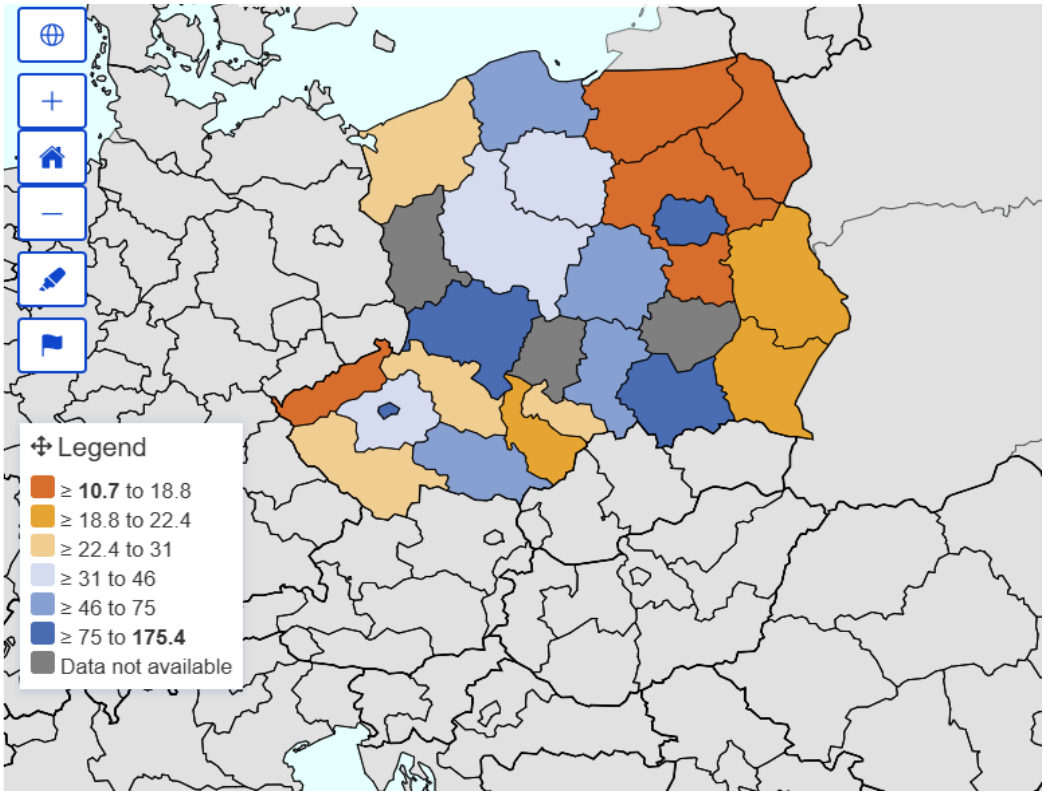


**Fig. 1.** Employment in technology and knowledge-intensive sectors. High-technology sectors (high-technology manufacturing and knowledge-intensive high-technology services) in Polish and Czech regions in 2023

Source: own elaboration on the base of Eurostat data (access 4.12.2024).

As emphasised in this paper, R&D personnel and researchers are fundamental to successfully developing high-technology manufacturing and knowledge-intensive services. The authors analysed this variable on NUTS 2 level in Poland and the Czechia (Table 2) and found no significant regional differences between the countries in the category of growth dynamics (Figure 2). In both Poland and Czechia, the highest increase in R&D staff was 32.6% (respectively, the Wielkopolskie region and the Severozápad region), and the highest decrease was 3.4% (respectively, the Lubuskie region and the Jihovýchod region).

**Table 2.** R&D personnel and researchers in Polish and Czech regions in 2019-2022

| Regions | 2022 | 2021 | 2020 | 2019 | Increase/decrease |
|---|---|---|---|---|---|
| Małopolskie | 26 501.9 | 25 860.6 | 25 110.7 | 21 569.7 | 5.1 |
| Śląskie | 16 327.1 | 16 161.1 | 15 315.3 | 14 164.9 | −1.6 |
| Wielkopolskie | 11 329.6 | 10 577.3 | 9 825.9 | 9 862.9 | 32.6 |
| Zachodniopomorskie | 3 800.9 | 3 434.3 | 3 292.8 | 3 376.2 | 17.1 |
| Lubuskie | 1 254.3 | 1 120.3 | 1 077.6 | 1 193.3 | −3.4 |
| Dolnośląskie | 19 071 | 17 806.1 | 16 046.4 | 14 620.9 | 0.8 |
| Opolskie | 1 898.1 | 1 677.7 | 1 512.5 | 1 683.7 | 18.3 |
| Kujawsko-pomorskie | 6 562.8 | 6 243.1 | : | : | 4.7 |
| Warmińsko-mazurskie | 3 096.4 | 3 147.3 | : | : | 16.9 |
| Pomorskie | 14 407.1 | 12 955.5 | 12 112.1 | 10 868.9 | −1.8 |
| Łódzkie | 9 487.6 | 8 824.7 | 9 110.3 | 8 100.7 | 11.0 |
| Świętokrzyskie | 1 480.3 | 1 601.1 | 1 478.3 | 1 532.8 | 4.9 |
| Lubelskie | 7 349.8 | 7 029.4 | 6 948.4 | 7 289.4 | 8.3 |
| Podkarpackie | 6 250.8 | 6 144.5 | 5 769.6 | 5 284.2 | 0.6 |
| Podlaskie | 2 886.8 | 2 948.4 | 2 848.6 | 2 756.2 | −3.0 |
| Warszawski stołeczny | 61 466.4 | 57 774 | 52 593.2 | : | 15.5 |
| Mazowiecki regionalny | 1 924.7 | 2 008 | 1 959.8 | : | 8.5 |
| Praha | 31 549.5 | 30 244.9 | 29 086.5 | 28 415.9 | −0.3 |
| Střední Čechy | 8 583.8 | 8 385.1 | 8 397.5 | 8 183.2 | 5.1 |
| Jihozápad | 6 943 | 6 667.4 | 6 380.1 | 6 409.6 | −1.6 |
| Severozápad | 1 433 | 1 429.9 | 1 334.4 | 1 425.1 | 32.6 |
| Severovýchod | 7 233 | 7 483.7 | 7 176.9 | 7 456.9 | 17.1 |
| Jihovýchod | 18 627.2 | 18 679.5 | 17 396 | 16 130.3 | −3.4 |
| Střední Morava | 6 984.1 | 6 908.8 | 6 296.6 | 6 437.9 | 0.8 |
| Moravskoslezsko | 4 771.1 | 4 871.1 | 4 890 | 4 786.1 | 18.3 |

Source: own elaboration on the base of Eurostat data (access 4.12.2024).

Figure 2 illustrates the distribution of research and development (R&D) personnel and researchers across Polish and Czech regions in 2022. The map highlights significant regional disparities, reflecting the concentration of R&D activities and innovation capacity in specific areas.

In Czechia, the highest concentration of R&D personnel was observed in the Prague region, which serves as a national hub for research institutions, universities, and innovation-driven companies. The South Moravian region, with Brno as its centre, also demonstrated a notable presence of R&D personnel, attributed to its strong academic and technological ecosystem. In Poland, the Mazowieckie region (Warsaw) stood out as the leading centre for R&D activities, driven by the concentration of research institutions, government agencies, and private-sector innovation initiatives. Other regions, such as Małopolskie (Kraków) and Dolnośląskie (Wrocław), also recorded significant numbers of R&D personnel, reflecting their robust academic environments and regional investment in innovation.

However, much of eastern and rural Poland showed significantly lower levels of R&D employment, highlighting persistent regional disparities in research capacity.

The map underlines the dominance of capital and major urban regions in both countries in terms of R&D activities, reflecting the uneven distribution of resources and opportunities for research and innovation, which are concentrated in metropolitan areas with well-established infrastructure, higher education institutions, and industry-academia collaborations. These disparities suggest the need for targeted regional policies to enhance research capacity and reduce inequalities, particularly in less developed regions.

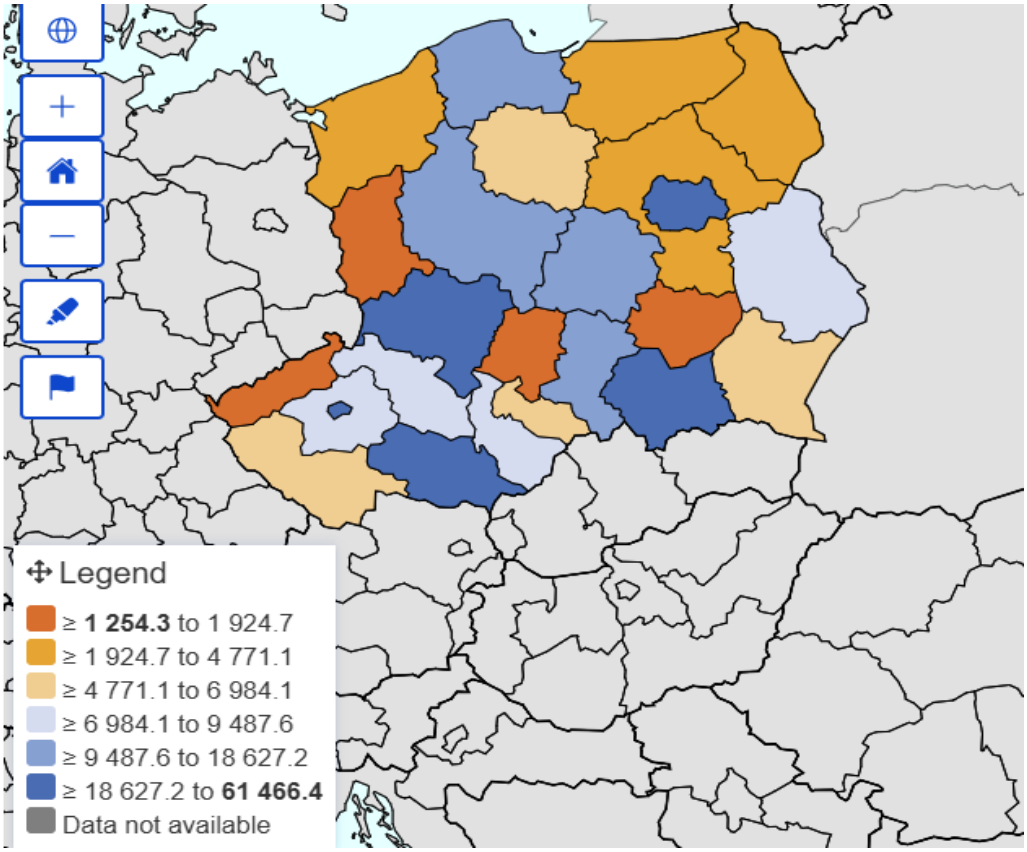


**Fig. 2.** R&D personnel and researchers in Polish and Czech regions in 2022

Source: own elaboration on the base of Eurostat data (access 4.12.2024).

The basis of developing R&D personnel and researchers are persons with tertiary education, hence this indicator was compared for Polish and Czech regions in 2019-2023 (Table 3). In Czechia, the largest increase in persons with tertiary education was in the Jihozápad region (an increase of 7.4%), followed by the second largest increase in the Prague region (an increase of 6.1%). The growth dynamics in the Jihozápad region amounted to more than three times higher than the national average rate (2.2%). The Severovýchod region was the only Czech region with a decrease in the number of persons with tertiary education (5.9%). No Polish voivodeship recorded a decrease in the number of persons with tertiary education in the analysed period. The region with the highest increase of this indicator was the Pomorskie voivodeship (18.8%), and the lowest growth dynamics in this category – in Podlaskie voivodship (3,8%).

From 2019 to 2023, Poland experienced a significant increase in the number of persons with tertiary education, rising from 9,034.3 to 10,029.6, representing an 11.0% growth. In comparison, Czechia showed a smaller overall increase in the same period, from 2,426.9 to 2,480.8, i.e. 2.2%.

**Table 3.** Persons with tertiary education in Polish and Czech regions in 2019-2023 (in thousands)

| Regions | 2019 | 2020 | 2021 | 2022 | 2023 | Increase/ decrease in % |
|---|---|---|---|---|---|---|
| Czechia | 2 426.9 | 2 477.2 | 2 558.1 | 2 492.9 | 2 480.8 | 2.2 |
| Praha | 511.4 | 520.8 | 564.1 | 539.2 | 542.5 | 6.1 |
| Střední Čechy | 310.8 | 316.5 | 324.1 | 309.8 | 314.1 | 1.1 |
| Jihozápad | 241.0 | 242.1 | 250.4 | 243.7 | 258.8 | 7.4 |
| Severozápad | 190.3 | 184.3 | 186.3 | 185.6 | 190.9 | 0.3 |
| Severovýchod | 306.3 | 304.5 | 309.0 | 311.1 | 288.3 | −5.9 |
| Jihovýchod | 399.1 | 416.2 | 416.0 | 405.6 | 402.7 | 0.9 |
| Střední Morava | 231.8 | 246.7 | 257.2 | 253.2 | 242.5 | 4.6 |
| Moravskoslezsko | 236.4 | 246.1 | 251.0 | 244.7 | 240.9 | 1.9 |
| Poland | 9034.3 | 9194.7 | 9293.3 | 9370.1 | 10029.6 | 11.0 |
| Mazowiecki regionalny | 437.5 | 443.1 | 458.3 | 469.4 | 490.5 | 12.1 |
| Warszawski stołeczny | 1 330.3 | 1 344.1 | 1 347.1 | 1 350.2 | 1 441.5 | 8.4 |
| Podlaskie | 261.7 | 250.4 | 253.2 | 266.4 | 271.6 | 3.8 |
| Podkarpackie | 423.6 | 425.9 | 432.7 | 430.1 | 454.6 | 7.3 |
| Lubelskie | 434.1 | 462.5 | 439.3 | 419.9 | 458.1 | 5.5 |
| Świętokrzyskie | 239.1 | 251.6 | 242.8 | 241.4 | 253.8 | 6.1 |
| Łódzkie | 519.1 | 534.1 | 552.2 | 548.8 | 568.2 | 9.5 |
| Pomorskie | 582.4 | 591.5 | 594.0 | 639.8 | 692.0 | 18.8 |
| Warmińsko-mazurskie | 253.9 | 261.6 | 271.2 | 280.2 | 291.0 | 14.6 |
| Kujawsko-pomorskie | 381.2 | 407.0 | 422.4 | 417.9 | 442.7 | 16.1 |
| Opolskie | 189.3 | 197.0 | 198.9 | 194.8 | 209.3 | 10.6 |
| Dolnośląskie | 768.4 | 802.9 | 799.5 | 780.5 | 836.3 | 8.8 |
| Lubuskie | 200.7 | 213.9 | 220.1 | 217.6 | 224.7 | 12.0 |
| Zachodniopomorskie | 365.1 | 370.5 | 375.8 | 404.9 | 426.6 | 16.8 |
| Wielkopolskie | 740.7 | 741.6 | 730.8 | 752.8 | 839.9 | 13.4 |
| Śląskie | 1 052.3 | 1 040.1 | 1 084.9 | 1 086.1 | 1 164.9 | 10.7 |
| Małopolskie | 855.0 | 857.0 | 870.1 | 869.5 | 964.0 | 12.7 |

Source: own elaboration on the base of Eurostat data (access 4.12.2024).

To provide a clearer understanding of the distribution of tertiary education attainment, it is useful to analyse the data as a percentage of the labour force, as shown in Table 4. This perspective highlighted the differences between Poland and Czechia from 2019 to 2023. In 2023, 49.4% of Poland's labour force with tertiary education qualifications, compared to 44.9% in 2019, reflecting a significant improvement, whereas Czechia saw an increase from 39.0% in 2019 to 41.9% in 2023, indicating slower growth.

**Table 4.** Persons with tertiary education in Polish and Czech regions in 2019 and 2023 (in % of the population in the labour force)

| Country/region | 2019 | 2023 |
|---|---|---|
| 1 | 2 | 3 |
| Czechia | 39.0 | 41.9 |
| Poland | 44.9 | 49.4 |
| Małopolskie | 48.3 | 54.1 |
| Śląskie | 46.7 | 50.7 |
| Wielkopolskie | 39.2 | 43.3 |
| Zachodniopomorskie | 42.3 | 48.8 |
| Lubuskie | 39.5 | 43.2 |

| 1 | 2 | 3 |
|---|---|---|
| Opolskie | 38.3 | 41.0 |
| Kujawsko-pomorskie | 36.7 | 41.1 |
| Warmińsko-mazurskie | 37.8 | 42.1 |
| Pomorskie | 46.0 | 53.9 |
| Świętokrzyskie | 38.3 | 41.9 |
| Łódzkie | 38.6 | 43.5 |
| Lubelskie | 40.7 | 42.9 |
| Podkarpackie | 41.1 | 44.3 |
| Podlaskie | 43.4 | 44.3 |
| Mazowiecki regionalny | 37.0 | 40.5 |
| Praha | 61.4 | 69.7 |
| Střední Čechy | 39.1 | 40.9 |
| Jihozápad | 33.9 | 37.0 |
| Severozápad | 30.5 | 32.3 |
| Severovýchod | 35.4 | 35.5 |
| Jihovýchod | 40.3 | 42.6 |
| Střední Morava | 32.9 | 36.2 |
| Moravskoslezsko | 34.1 | 37.1 |

Source: own elaboration on the base of Eurostat data (access 4.12.2024).

More significant regional disparities in the enrolment rate for persons with tertiary education occurred in Czechia than in Poland (Figure 3).

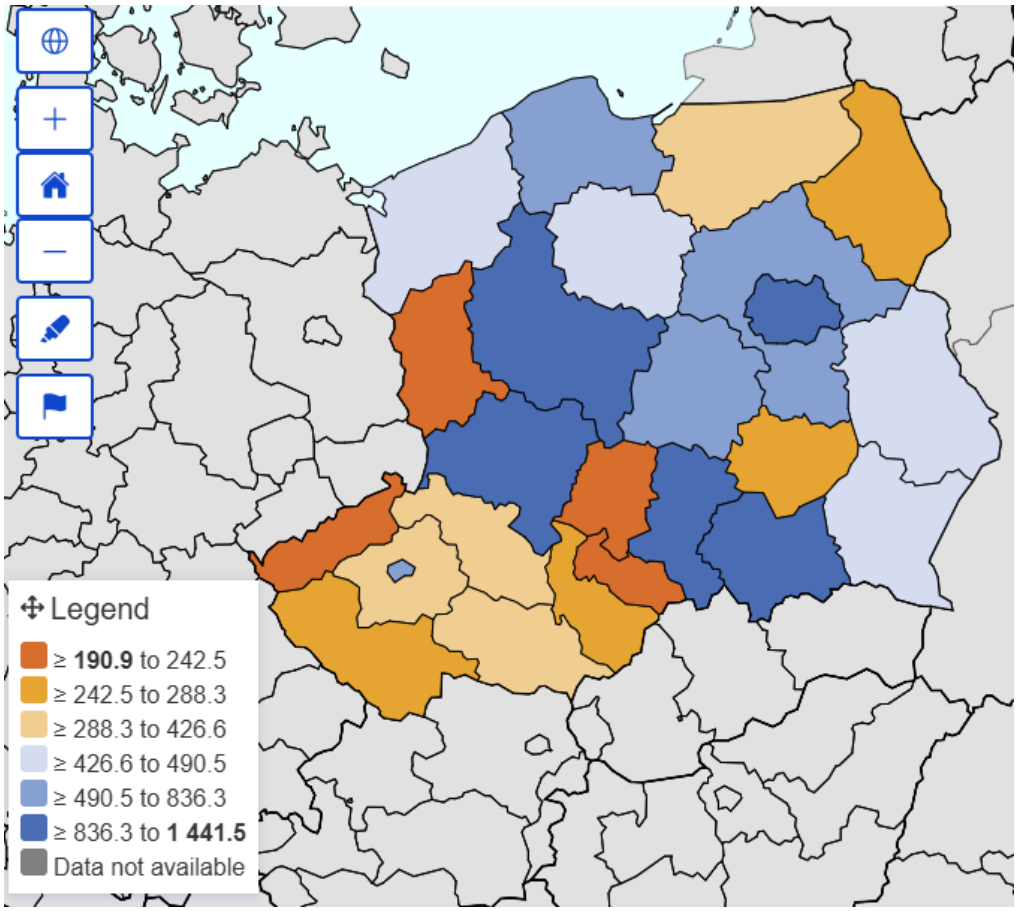


**Fig. 3.** Persons with tertiary education in Polish and Czech regions in 2023 (in thousands)

Source: own elaboration on the base of Eurostat data (access 4.12.2024).

In Czechia, the concentration was heavily skewed towards Prague, with 69.7% of the labour force with tertiary education, while other regions, e.g. Severozápad, fell significantly behind at 32.3%. In Poland, while such disparities existed, the distribution was more balanced, with regions such as Małopolskie (54.1%) and Pomorskie (53.9%) leading, and others e.g. Opolskie (41.0%) and Świętokrzyskie (41.9%) showing moderate attainment levels.

## 5. Conclusions

In contemporary regional development it is necessary to acknowledge the growing role of the interaction of two relatively independent trends: the development of new information technologies and the efforts undertaken by the 'old' society to reorganise itself by using the power of technology to serve the technology of power. The results of this interaction between technology and society are essentially undetermined because they depend on the stochastic relationships of many quasi--independent variables. Hence, a holistic approach to explaining the development of regions and their changing role in the global economy seems increasingly attractive. The transformations taking place in the structure of modern regions are determined by the ongoing development of high-technology and knowledge-intensive sectors, significantly modified by European integration and, equally importantly, the intensive networking of forms of learning organisations (Miszczak, 2011). The stimulus for creating a friendly climate for the functioning of such territorial units in the socio-economic space comes from knowledge, technology and sustainability. With the growing importance of innovative creative capital based on social trust, so drastically weakened in the recent global economic crisis, the knowledge--based economy and the related technologies are also gaining new dimensions (Miszczak, 2013). Thus is all the more worthwhile to re-evaluate the existing knowledge and look for an adequate paradigm for developing the regional economy, in which new organisational forms can be distinguished with more effective structures of flat organisations based on decentralisation, multidirectional communication, green innovations and networking.

In countries like Poland and Czechia, where spatial inequalities remain a pressing issue, the development of high-technology sectors plays a dual role. On the one hand, it accelerates economic convergence between regions by creating new opportunities for employment and innovation, and on the other, it enhances the regions' capacity to meet sustainable development challenges by fostering green technologies, improving resource efficiency, and supporting cultural and educational advancements (Rodrigues & Franco, 2019). The interaction between creativity, innovation, and sustainability has been particularly emphasised in urban contexts, where cultural activities and creative industries act as catalysts for economic vitality and improved quality of life.

The study revealed substantial growth in employment within knowledge-intensive and high--technology sectors across both Poland and Czechia, with Poland demonstrating a more balanced regional development compared to the concentrated growth in Czechia. The analysis underlined the role of tertiary education in fostering regional innovation, as regions with higher shares of tertiary--educated individuals exhibited stronger performance in these sectors. However, persistent disparities in R&D activities and sectoral development stress the need for targeted regional policies to enhance inclusivity and innovation capacity, especially in rural and peripheral regions. These findings emphasise the importance of aligning regional development strategies with sustainable development goals to promote balanced socio-economic growth and innovation-led resilience in Central and Eastern Europe.

To conclude, the observed disparities in the distribution of R&D personnel and researchers have significant implications for sustainable development. Regions with a high concentration of R&D activities are better positioned to drive innovation, enhance resource efficiency, and support the transition to a knowledge-based economy. However, the underrepresentation of R&D personnel in peripheral and rural areas pointed to the challenges in achieving balanced regional development. Addressing these disparities through targeted investments and policies can contribute to more inclusive and sustainable growth, ensuring that all regions benefit from advancements in research and innovation.

The authors acknowledge the study's limitations, primarily its reliance on selected basic indicators to capture initial insights, which may not fully reflect the complexity of regional disparities. Moreover, the focus on Poland and Czechia, while representative of Central and Eastern Europe, may limit the generalisability of findings to other regions with differing socio-economic and political contexts.

To build upon the insights from this study, future research should deepen the sectoral analysis to investigate specific sub-sectors within high-technology and knowledge-intensive industries to identify niche areas of growth and innovation. It would also be valuable to assess the role of emerging technologies, namely artificial intelligence, blockchain, and advanced analytics, in fostering regional development. Future research could also refer to the social dimensions of disparities and examine the social implications of regional disparities, for example access to education, quality of life, and social mobility, and their interaction with high-technology employment.

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## Regionalne dysproporcje w sektorach wiedzochłonnych. Studium porównawcze Polski i Czech w kontekście zrównoważonego rozwoju

### Streszczenie

Badanie ma na celu przeanalizowanie regionalnych dysproporcji w zatrudnieniu w sektorach wysokich technologii i wiedzochłonnych w regionach Polski i Czech w latach 2019-2023, aby zidentyfikować obszary rozwijające się pod względem innowacji i wzrostu gospodarczego oraz te, które pozostają w tyle. Analiza ta pozwala uwypuklić nierówności regionalne. Badanie wykorzystuje podejście ilościowe, opierając się na publicznie dostępnych danych Eurostatu w celu analizy trendów w zatrudnieniu w sektorach wiedzochłonnych oraz wśród pracowników B+R. Zastosowano również wizualizacje, które ilustrują regionalne trendy i dysproporcje. Sektory wysokich technologii i wiedzochłonne są kluczowe dla przyszłej odporności gospodarczej. Badanie dysproporcji może ujawnić, jak dobrze różne regiony są przygotowane na zmiany gospodarcze, takie jak przejście na Przemysł 4.0 czy zieloną gospodarkę. Artykuł wnosi wkład do istniejącej literatury, oferując porównawczą, podłużną analizę regionalnych dysproporcji w sektorach wiedzochłonnych w Polsce i Czechach. Podkreślono implikacje tych dysproporcji dla zrównoważonego rozwoju i polityki innowacji regionalnych, oferując unikalną perspektywę na dynamikę społeczno-gospodarczą Europy Środkowo-Wschodniej.

**Słowa kluczowe:** usługi wiedzochłonne, sektory produkcji wysokich technologii, zrównoważony rozwój, Polska, Czechy