SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2025
ORGANIZATION AND MANAGEMENT SERIES NO. 220

IMPACT OF COVID-19 PANDEMIC ON DEVELOPMENT OF EU REGIONS

Andrzej WÓJCIK

University of Economics in Katowice; andrzej.wojcik@ue.katowice.pl, ORCID: 0000-0003-3803-8840

Purpose: The main purpose of the study is to find out the impact of the COVID-19 pandemic on the development of EU regions in selected aspects of life: employment, tourism, Internet access and human resources in science and technology.
Design/methodology/approach: To study the impact of the pandemic on regional development, the average rates of change before and after the pandemic in most EU regions were counted. By comparing average rates of change in selected areas of life, it was examined what impact the COVID-19 pandemic had on regional development. The regions were also ordered from the most developed (in terms of selected indicators) to the least developed using the Hellwig linear ordering method.
Findings: The analyses show that the pandemic had an impact on the development of the regions of the EU countries, however, it was mostly a short-term impact. The most severe losses were suffered by the tourism industry, here development was halted and only in 2023 the number of nights spent in tourist accommodations is comparable to 2019. In the case of HRST and household access to the Internet, there was indeed an increase in indicators in 2020, however, there was a correction in subsequent years. In the case of the employment indicator, there was a sharp decline in 2020, which was more than made up for in subsequent years in most regions. The regions were also ranked in terms of the development of the characteristics studied (excluding household Internet access) from the most developed to the least developed in 2012, 2019 and 2023.
Research limitations/implications: Further research should focus on further analyzing similarities in the development of EU regions. Taking into account even more indicators, a more complete picture of the development of EU regions and the impact of the pandemic on this development can be obtained. Unfortunately, there are many data gaps in the Eurostat database, which excludes some regions from analysis.
Social implications: Thanks to the conclusions drawn from the analysis, we can get an idea of how regions in the EU are developing and what impact the COVID-19 pandemic has had on this development. We live in a time of globalization, diseases from one end of the world to the other end of the world move very quickly, the possibility of another pandemic in the near future is high. So it is worth seeing which regions have dealt with the effects of the pandemic the best, and you can then adopt some of the solutions that have been applied in those regions to counter the effects of the pandemic.
Originality/value: While countries are often compared with each other, regions are already much less frequently. The article shows the changes that are taking place precisely in the regions of EU countries. Of course, many decisions are made at the national level, however, also at the

level of regions many important decisions can be made, so that some regions develop better and others less well.
Keywords: regions of EU countries, Hellwig linear ordering method, average rate of change.
Category of the paper: empirical research.

1. Introduction

Thanks to globalization, the world is growing faster and faster. Moving even long distances is no longer a major problem. Thanks to the development of information technology, many things can be accomplished online. Transferring money or technology is also not a problem. Unfortunately, globalization also means dangers. One such threat could be that of diseases. Through the rapid movement of people, diseases move just as quickly. Some of them can cause a pandemic. Such was the case with the COVID-19 pandemic caused by the SARS-Cov-2 coronavirus. It began as an epidemic on November 17, 2019 in Wuhan city, Hubei province, central China, and was declared a pandemic by the World Health Organization (WHO) on March 11, 2020 (Businessinsider, 2020; WHO, 2020).

The COVID-19 pandemic in Poland lasted from March 2020 to May 2022, causing 6.5 million cases and 119,000 deaths. There were also more than 200,000 excess deaths in Poland during this time compared to the average of recent years (Plonka-Syroka, 2023, p. 27). Also in the rest of Europe, more than 2 million people died from the pandemic (PAP, 2022).

Such a large number of oversized deaths must have affected the economy. In addition, the restrictions that were introduced also affected all spheres of life, especially transportation and tourism.

In the literature we can find a great number of articles on the impact of the COVID 19 pandemic on the global economy (Jedrzejowska, Wróbel, 2021; Shrestha et al., 2020; Khan, Khan, Shafiq, 2021), or on individual countries (Rangachev, Marinov, Mladenov, 2022; Bogos et al., 2021; Parkitny, Parkitna, 2024). Few studies deal with regions, if there are any they deal with selected regions (Smolarski, Suszczewicz, 2021; Kruczek, Borkowski, Mazanek, 2023, Vasilyeva, Lyeonov, Letunovska, 2020). I am yet to see studies that would cover a larger number of regions, as in this case all EU regions for which data are available in the Eurostat database (2024).

The purpose of the article is to show how EU regions have developed over the 2012 -2023 period in terms of employment, tourism, Internet access and the use of human resources in science and technology, and how the COVID-19 pandemic has affected selected areas of life.

The pandemic caused many excess deaths, which certainly affected employment. The employment rate in the 15-64 age group certainly declined during the peak of the pandemic (2020), but the pandemic also forced a change in the attitude of employers, enabling remote work, which in the long run should result in an increase in the employment rate.

The need to work and study remotely should also strongly affect households' access to the Internet. Many institutions have begun to make much greater use of information technology. The pandemic should foster the development of advanced information technology, and thus should affect the increase in education of the population and the growth of employment in science and technology. To this end, the active population in the 15-74 age group, categorized as HRST (i.e., successfully completed third-level education or working in science and technology), was surveyed.

The restrictions during the pandemic undoubtedly also affected tourism. Bans on leaving homes without a valid reason covered many regions of the EU. Tourism is the area that, along with human transport, has suffered the most. However, here, too, we are interested in the longer term, that is, whether three years after the peak of the pandemic people are as eager to leave as they were before the pandemic, or perhaps they are doing so even more eagerly after the experience of lockdowns. To answer this question, nights spent in tourist accommodations were examined.

2. Methodological notes

All data are from the Eurostat website (2024). Regional development was examined using 4 variables:

- employment rate in the 15-64 age group,
- household Internet access measured as the percentage of households in which each household member has the ability to access the Internet from home,
- human resources of science and technology (HRST) as the share of the active population in the 15-74 age group at the NUTS 2 regional level. The data represents the active population in the 15-74 age group included in HRST (i.e., successfully completing third-level education or working in science and technology) as a percentage of the total active population aged 15-74. HRST is mainly measured using the concepts and definitions set forth in the Canberra Manual, OECD, Paris, 1995,
- nights spent in tourist accommodation establishments. A night is defined as any night that a visitor/tourist (resident or non-resident) actually spends (sleeps or stays) or is registered (his/her physical presence in the facility is not necessary) in a tourist accommodation facility.

For all variables, the average rates of change (1) (Ostasiewicz, Rusnak, Siedlecka, 2001) for the years 2012-2019 and 2019-2023 were counted and then compared with each other. On this basis, the question of whether the COVID-19 pandemic changed the development trends of the variables studied was answered.

$$\bar{i_G} = \sqrt[n-1]{in/_{n-1} \cdot i_{n-1}/_{n-2} \cdot \ldots \cdot i_2/_1} = \sqrt[n-1]{in/_1} \quad (1)$$

In the next step, it was checked in how many regions within the EU countries in terms of the variables studied there was an increase and in how many there was a decrease in the average rate of change of the variables studied.

In the final step, Hellwig's linear ordering method (Hellwig, 1968) was used to arrange the individual regions in order from those in which the variables took on the best values (the highest values because all variables are stimulants) to those that are the worst in terms of the variables under study. Methods of linear ordering, which fall within multivariate comparative analysis and taxonomy more broadly, are largely an output of Polish statistical and econometric thought (Bak, 2016).

3. Employment

The employment rate in the 15-64 age group in the Eurozone (2023) from 2012 to 2023 has been rising steadily except for a slight decline in 2013 and a significant drop in 2020, the pandemic year (Figure 1). Not all EU countries are part of the Eurozone, in addition to the fact that not all regions of each country are developing similarly. The study covered 232 regions for which data was available.

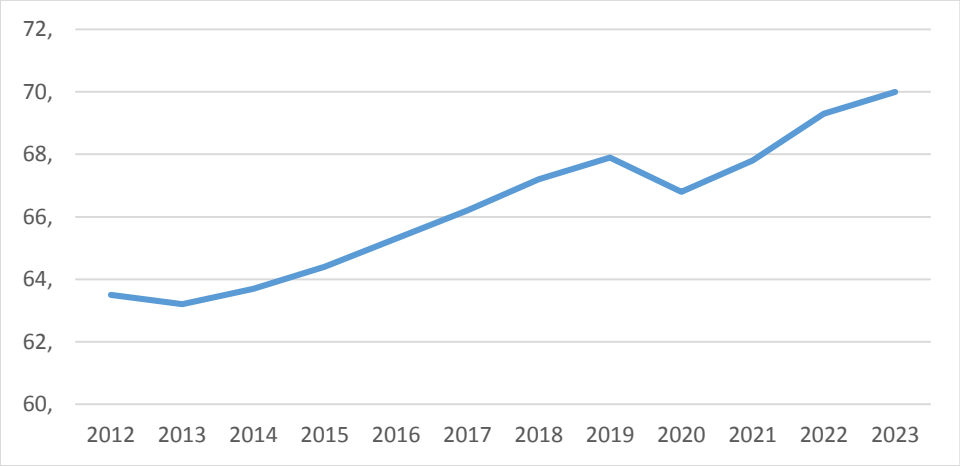

Figure 1. Employment rate in the age group 15-64 in the Euro area (2023) in 2012-2023.
Source: own calculations based on Eurostat data.

Table 1 shows the regions with the highest employment rates in 2012, 2019 and 2023.

Table 1.
Regions with the highest employment rates in 2012, 2019 and 2023

2012			2019			2023		
Emp. rate	**Region**	**Country**	**Emp. rate**	**Region**	**Country**	**Emp. rate**	**Region**	**Country**
80,7	Åland	Finland	81,5	Åland	Finland	84,1	Noord-Brabant	Netherlands
77,8	Freiburg	Germany	81,2	Oberbayern	Germany	84,0	Utrecht	Netherlands
77,8	Utrecht	Netherlands	80,7	Utrecht	Netherlands	83,9	Overijssel	Netherlands
77,6	Oberbayern	Germany	80,1	Niederbayern	Germany	83,3	Zeeland	Netherlands
76,9	Schwaben	Germany	80,1	Noord-Brabant	Netherlands	83,1	Gelderland	Netherlands
76,7	Stockholm	Sweden	79,9	Schwaben	Germany	83,1	Drenthe	Netherlands
76,5	Tübingen	Germany	79,8	Tübingen	Germany	82,7	Friesland	Netherlands
76,4	Mittelfranken	Germany	79,8	Oberfranken	Germany	82,6	Noord-Holland	Netherlands
76,3	Niederbayern	Germany	79,6	Trier	Germany	82,5	Trier	Germany
75,9	Oberfranken	Germany	79,5	Freiburg	Germany	81,6	Niederbayern	Germany

Source: Eurostat.

In both 2012 and 2019, the highest employment rate was in the Åland region in Finland. The top 10 in 2012 included 1 more region from the Netherlands and 1 from Sweden. The remaining positions were held by regions from Germany. In 2019, instead of a region from Sweden, there was another region from the Netherlands. In Table 1, it can be seen that employment rates in 2019 have increased compared to 2012. In 2023, employment rates increased even more, with 8 regions from the Netherlands (there were 12 regions from the Netherlands in all the regions surveyed) and 2 regions from Germany in the top 10. The pandemic appears to have had a significant impact on such a change in ranking. Table 2 shows the 10 regions with the lowest employment rates.

Table 2.
Regions with the lowest employment rates in 2012, 2019 and 2023

2012			2019			2023		
Emp. rate	**Region**	**Country**	**Emp. rate**	**Region**	**Country**	**Emp. rate**	**Region**	**Country**
39,9	Campania	Italy	41,3	Sicilia	Italy	43,8	Guyane	France
41,3	Sicilia	Italy	41,5	Campania	Italy	44,4	Campania	Italy
41,5	Calabria	Italy	42,0	Calabria	Italy	44,6	Calabria	Italy
43,0	Ciudad de Ceuta	Spain	43,3	Guyane	France	44,9	Sicilia	Italy
43,8	La Réunion	France	46,4	Puglia	Italy	47,7	Ciudad de Ceuta	Spain
44,8	Dytiki Makedonia	Greece	46,5	La Réunion	France	48,8	Ciudad de Melilla	Spain
44,9	Puglia	Italy	49,7	Ciudad de Melilla	Spain	50,0	La Réunion	France
45,4	Guyane	France	49,7	Dytiki Elláda	Greece	50,7	Puglia	Italy
45,6	Ciudad de Melilla	Spain	49,8	Guadeloupe	France	51,7	Guadeloupe	France
46,4	Extremadura	Spain	49,9	Ciudad de Ceuta	Spain	54,9	Basilicata	Italy

Source: Eurostat.

Among the regions with the lowest employment rate, regions from Italy, France, Spain and the Dytiki Makedonia region of Greece dominate. Also among the regions with the lowest employment rate, an increase in the rate can be seen, especially in 2023.

Out of 232 regions between 2012 and 2019, as many as 228 regions had an average growth rate of more than 1, meaning that there was an increase in the employment rate. Between 2019 and 2023, growth in the employment rate took place in 195 regions. The region with the largest increase in the employment rate between 2012 and 2023 was the Észak-Magyarország region of Hungary, with a growth rate of 1.032. This means that in the Észak-Magyarország region, employment grew by an average of 3.2% year on year. In contrast, the largest decrease in employment was recorded in Sud-Vest Oltenia in Ruminia (an average decrease of 0.6%).

4. Human resources in science and technology (HRST)

The continuous development of technology forces society to educate itself. The growth of employment in human resources in science and technology (HRST) is a natural thing. In the Eurozone, there has been a continuous increase in the population classified as HRST (Figure 2).

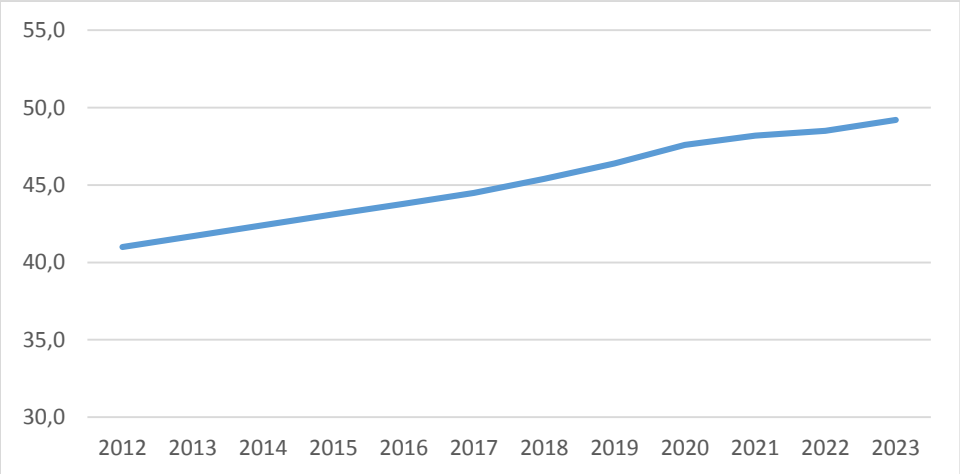

Figure 2. Human resources in science and technology (HRST) in the Euro area (2023) in 2012-2023. Source: own calculations based on Eurostat data.

There are significant regional differences. It can be expected that there is a larger share of the population counted as HRST in large metropolitan areas, which are academic centers. Table 3 shows the 10 regions with the largest share of the population classified as HRST, and Table 4 shows the regions with the smallest human resources in science and technology.

Table 3.
Regions with the highest HRST index values in 2012, 2019 and 2023

2012			2019			2023		
HRST	**Region**	**Country**	**HRST**	**Region**	**Country**	**HRST**	**Region**	**Country**
62,8	Prov. Brabant wallon	Belgium	68,8	Warszawski stołeczny	Poland	72,9	Warszawski stołeczny	Poland
59,8	Helsinki-Uusimaa	Finland	66,7	Stockholm	Sweden	72,5	Prov. Brabant wallon	Belgium
59,1	Stockholm	Sweden	66,4	Prov. Brabant wallon	Belgium	70,1	Sostinės regionas	Lithuania
58,2	Praha	Czech Republik	64,3	Helsinki-Uusimaa	Finland	69,7	Praha	Czech Republik
58,0	Hovedstaden	Denmark	63,5	Ile de France	France	69,4	Stockholm	Sweden
57,7	Ile de France	France	63,3	Utrecht	Netherlands	68,7	Budapest	Hungary
57,1	Bratislavský kraj	Slovakia	63,0	Hovedstaden	Denmark	67,7	Ile de France	France
57,0	Luxembourg	Luxembourg	61,7	Sostinės regionas	Lithuania	65,9	Utrecht	Netherlands
56,1	Prov. Vlaams-Brabant	Belgium	61,6	Berlin	Germany	65,8	Luxembourg	Luxembourg
55,8	Utrecht	Netherlands	61,5	Luxembourg	Luxembourg	65,0	Hovedstaden	Denmark

Source: Eurostat.

Table 4.
Regions with the lowest HRST index values in 2012, 2019 and 2023

2012			2019			2023		
HRST	**Region**	**Country**	**HRST**	**Region**	**Country**	**HRST**	**Region**	**Country**
17,9	Nord-Est	Romania	15,9	Nord-Est	Romania	21,6	Nord-Est	Romania
18,1	Sud-Muntenia	Romania	19,6	Sud-Muntenia	Romania	21,8	Sud-Muntenia	Romania
18,5	Sud-Vest Oltenia	Romania	22,1	Sud-Vest Oltenia	Romania	23,8	Sud-Est	Romania
19,3	Ionia Nisia	Greece	22,9	Sud-Est	Romania	25,5	Ciudad de Ceuta	Spain
20,5	Sud-Est	Romania	24,2	Região Autónoma dos Açores	Portugal	26,1	Sud-Vest Oltenia	Romania
21,0	Nord-Vest	Romania	24,6	Vest	Romania	26,1	Nord-Vest	Romania
22,5	Peloponnisos	Greece	25,3	Dytiki Elláda	Greece	26,3	Sterea Elláda	Greece
22,9	Região Autónoma da Madeira	Portugal	26,8	Notio Aigaio	Greece	27,1	Ionia Nisia	Greece
23,0	Sterea Elláda	Greece	26,9	Nord-Vest	Romania	28,6	Vest	Romania
23,5	Notio Aigaio	Greece	28,1	Észak-Magyarország	Hungary	28,8	Notio Aigaio	Greece

Source: Eurostat.

In Table 3 it can be seen that only in 2012 there are 2 regions from one country (from Belgium), and in the other years the countries are represented by single regions. This shows that there is a high concentration of the population included in HRST in the surveyed countries. It is noteworthy that as many as 4 regions from Central and Eastern Europe are in the top 10 in 2023.

Among the regions with the smallest HRSTs, there are also regions from different countries, however their diversity is much smaller. Dominant here are regions located in Romania, followed by Greece. Also found here are 2 regions from Portugal and 1 each from Hungary and Spain.

Both tables show an increase in the surveyed share, and it seems that the COVID-19 pandemic did not have a significant impact on the average rate of change of the surveyed phenomenon.

5. Tourist accommodation

Restrictions as a consequence of the COVID-19 pandemic had a very severe impact on tourism. The pandemic caused a 49 percent decrease in the use of tourist accommodation in 2020 compared to 2019 (Szczukowska, 2023). Unfortunately, there are data gaps when it comes to data on nights spent in tourist accommodation establishments, which is why 2013 data was used for Greece instead of 2012 data. The Eurostat database also did not provide data for the Eurozone. To illustrate how the number of nights spent in tourist accommodations evolved, Figure 3 shows the phenomenon studied in the Canarias region (Spain). It was the most visited region in the EU.

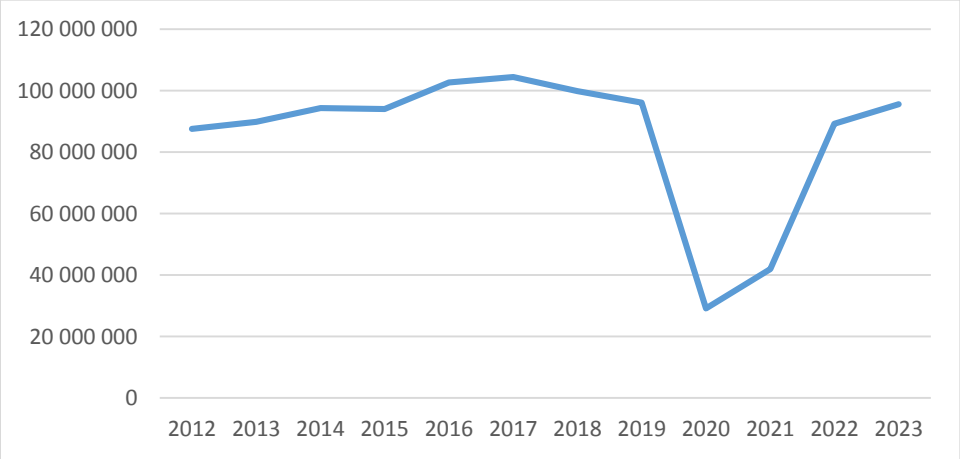

Figure 2. Nights spent in tourist accommodation facilities in the Canarias region in 2012-2023.
Source: own calculations based on Eurostat data.

Figure 2 shows a very large decrease in the number of nights spent in accommodations. This undoubtedly confirms the impact of the COVID-19 pandemic on the tourism industry. After 2020, we see a very rapid increase, but in 2023, it has not yet reached from the level achieved before the pandemic.

Tables 5 and 6 show the regions with the highest and lowest number of nights spent in accommodations.

Table 5.
Regions with the highest number of nights spent in accommodations in 2012, 2019 and 2023.

2012			2019			2023		
Accomo-dations	**Region**	**Country**	**Accomo-dations**	**Region**	**Country**	**Accomo-dations**	**Region**	**Country**
87 549 896	Canarias	Spain	96 113 149	Canarias	Spain	95 574 956	Canarias	Spain
78 104 744	Ile de France	France	86 216 777	Jadranska Hrvatska	Croatia	87 317 514	Jadranska Hrvatska	Croatia
69 692 113	Cataluña	Spain	84 665 344	Ile de France	France	85 635 851	Cataluña	Spain
64 651 179	Illes Balears	Spain	84 140 872	Cataluña	Spain	85 162 673	Ile de France	France
62 352 831	Veneto	Italy	72 044 756	Andalucía	Spain	73 900 351	Andalucía	Spain
59 855 870	Jadranska Hrvatska	Croatia	71 236 630	Veneto	Italy	71 896 863	Veneto	Italy
55 484 758	Provence-Alpes-Côte d'Azur	France	68 376 034	Illes Balears	Spain	68 791 810	Illes Balears	Spain
51 496 216	Andalucía	Spain	54 623 288	Provence-Alpes-Côte d'Azur	France	55 080 043	Provence-Alpes-Côte d'Azur	France
48 709 067	Rhône-Alpes	France	51 484 901	Rhône-Alpes	France	53 752 587	Rhône-Alpes	France
42 651 126	Toscana	Italy	50 063 663	Comunitat Valenciana	Spain	52 449 694	Comunitat Valenciana	Spain

Source: Eurostat.

Table 6.
Regions with the lowest number of nights spent in accommodation facilities in 2012, 2019 and 2023

2012			2019			2023		
Accomo-dations	**Region**	**Country**	**Accomo-dations**	**Region**	**Country**	**Accomo-dations**	**Region**	**Country**
129 259	Ciudad de Melilla	Spain	146 310	Ciudad de Melilla	Spain	132 824	Ciudad de Melilla	Spain
148 704	Ciudad de Ceuta	Spain	167 989	Ciudad de Ceuta	Spain	144 427	Ciudad de Ceuta	Spain
349 483	Guyane	France	354 879	Dytiki Makedonia	Greece	345 477	Dytiki Makedonia	Greece
377 928	Dytiki Makedonia	Greece	396 308	Åland	Finland	420 028	Guyane	France
405 668	Åland	Finland	439 645	Molise	Italy	494 786	Molise	Italy
410 494	Prov. Brabant wallon	Belgium	452 856	Guyane	France	552 952	Prov. Brabant wallon	Belgium
483 858	Severozapaden	Bulgaria	507 424	Prov. Brabant wallon	Belgium	707 654	Opolskie	Poland
540 050	Molise	Italy	566 530	Severozapaden	Bulgaria	741 046	Severozapaden	Bulgaria
613 049	Opolskie	Poland	893 810	Severen tsentralen	Bulgaria	829 531	Severen tsentralen	Bulgaria
671 282	Severen tsentralen	Bulgaria	938 234	Opolskie	Poland	1 232 953	Podlaskie	Poland

Source: Eurostat.

The most visited regions are those of Spain and France. Regions from these countries can also be found among the least visited, but there are also regions from other countries. In 2023, 2 regions each from Spain, Bulgaria and Poland were among the 10 least visited regions.

If we compare, in Tables 5 and 6, the number of nights spent in accommodations in the 2023 and 2019 tats, we find that in many cases the number in 2023 is higher than in 2019. Of all the regions surveyed (231) for which data were available, as many as 136 (58.9%) had more tourists in 2023 than before the pandemic.

6. Household access to the Internet

The effects of the pandemic were far-reaching. People were confined to their homes, students went into remote learning mode. The pandemic also had positive effects. It turns out that some work can be done from home, no need to go to the office. All this has influenced households to equip themselves to contact relatives, teachers, employees, or customers. Internet access has become almost a necessity.

Unfortunately, the availability of complete data on household Internet access, measured as the percentage of households in which each household member has the ability to access the Internet from home, is very limited. The Eurostat database does not have complete data for Germany, France, Greece, Poland Ireland and Lithuania. There is no data at all for Germany and Greece, and partial data for the other countries. The survey therefore covers 134 in 2012, 169 in 2019 and 186 in 2023 EU regions.

Tables 7 and 8 show the regions with the highest and lowest shares of households with Internet access.

Table 7.
Regions with the highest share of households with Internet access in 2012, 2019 and 2023

2012			2019			2023		
Internet	**Region**	**Country**	**Internet**	**Region**	**Country**	**Internet**	**Region**	**Country**
97,6	Flevoland	Netherlands	100,0	Mellersta Norrland	Sweden	99,5	Utrecht	Netherlands
96,2	Drenthe	Netherlands	99,2	Flevoland	Netherlands	99,4	Noord-Holland	Netherlands
95,5	Zeeland	Netherlands	99,2	Limburg	Netherlands	99,4	Drenthe	Netherlands
94,8	Stockholm	Sweden	99,2	Gelderland	Netherlands	99,2	Overijssel	Netherlands
94,5	Overijssel	Netherlands	99,0	Noord-Holland	Netherlands	99,1	Zeeland	Netherlands
94,5	Noord-Holland	Netherlands	98,7	Zeeland	Netherlands	99,1	Luxembourg	Luxemburg
94,4	Midtjylland	Denmark	98,7	Noord-Brabant	Netherlands	98,9	Noord-Brabant	Netherlands
94,3	Hovedstaden	Denmark	98,5	Zuid-Holland	Netherlands	98,9	Flevoland	Netherlands
93,9	Friesland	Netherlands	98,3	Småland med öarna	Sweden	98,8	Limburg	Netherlands
93,7	Gelderland	Netherlands	98,29	Utrecht	Netherlands	98,7	Prov. Vlaams-Brabant	Belgium

Source: Eurostat.

Table 8.
Regions with the lowest share of households with Internet access in 2012, 2019 and 2023

2012			2019			2023		
Internet	**Region**	**Country**	**Internet**	**Region**	**Country**	**Internet**	**Region**	**Country**
38,2	Severozapaden	Bulgaria	70,00	Severozapaden	Bulgaria	77,1	Guyane	France
45,3	Nord-Est	Romania	73,2	Severen tsentralen	Bulgaria	82,40	Calabria	Italy
46,8	Centru	Romania	73,9	Alentejo	Portugal	82,6	Severozapaden	Bulgaria
47,5	Severen tsentralen	Bulgaria	74,	Severoiztochen	Bulgaria	84,2	Basilicata	Italy
47,9	Severoiztochen	Bulgaria	74,7	Yugoiztochen	Bulgaria	85,4	Severen tsentralen	Bulgaria
48,8	Alentejo	Portugal	75,1	La Réunion	France	85,4	Corse	France
48,9	Sud-Vest Oltenia	Romania	75,3	Yuzhen tsentralen	Bulgaria	85,9	Centro	Portugal

Cont. table 8.

49,6	Sud-Muntenia	Romania	76,7	Centro	Portugal	86,2	Norte	Portugal
49,6	Yugoiztochen	Bulgaria	77,	Calabria	Italy	86,5	Severoiztochen	Bulgaria
50,3	Yuzhen tsentralen	Bulgaria	77,3	Guadeloupe	France	86,6	Alentejo	Portugal

Source: Eurostat

Tables 7 and 8 show what a change there has been in household access to the Internet. While the top 10 in all 3 years was dominated by regions from the Netherlands, there have been big changes in the last 10. It is clear that in 2012 the regions of Bulgaria and Romania had the biggest problem with Internet access. The last 10 in 2019 and 2023 no longer include regions from Romania. The regions of Bulgaria are still among the regions where household access to the Internet is difficult, but they have topped regions from Italy, Portugal and France.

7. Average rate of change of studied phenomena in EU regions

Observing Tables 1-8, we can see that the order of the regions is changing. Let's try to answer the question of which regions grew the fastest and which the slowest, and whether the COVID-19 pandemic changed the average rate of change of the phenomena studied before the pandemic.

Between 2012 and 2019, the employment rate grew on average from year to year for 228 out of 332 regions. The largest average increase was in the Észak-Magyarország region (Hungary) at 1,043, which means that the employment rate grew by an average of 4.3% year on year in this region. In contrast, the decrease in the employment rate during the period under review took place only in the Guyane region (France - 0.993), In the other 3 regions, the average rate of change was 1.

In 2019-20023, the largest average increase in the employment rate was in the Dytiki Elláda region (Greece - 1,046), and the largest decrease was in Nord-Est (Romania). During this period, an increase in the employment rate took place in 195 regions. For 75 regions, the average growth rate of the employment rate was higher in 2019-2023 than in 2012-2019, so it can be concluded that the COVID-19 pandemic caused a decrease in the average rate of change in employment in most regions (68%).

In the case of human resources in science and technology (HRST), out of 232 regions, there was an increase in the average rate of change in 223 regions from 2012-2019, and this was the case for 207 regions from 2019-2023. The largest increases in the share of the population included in HRST took place in Ionia Nisia (Greece - 1,069) and Nord Est (Ruminia), respectively. In contrast, the largest decreases in HRST occurred in Corse (France - 0.977) and Ciudad de Ceuta (Spain - 0.967), respectively. For 58% of the regions, there was a lower rate of change of the studied phenomenon in 2019-2023 than in 2012-2019.

Between 2012 and 2019, tourism in the vast majority of regions (96%) developed very well, with a year-on-year increase in the number of nights provided. In the Iperios region (Greece), the number of nights spent in tourist accommodations increased by an average of 12.7% from year to year, and there were also regions where there was a decline, with the largest in the Mazowieckie Voivodeship region (Poland - 0.822). In 2020, tourism services collapsed, but in the following years the situation began to return to normal. Between 2019 and 2023, 131 regions had a higher number of rented nights than before the pandemic in 2019, with the highest average rate of change in the Flevoland region (Netherlands - 1.089) and the lowest in the Opole province (Poland - 0.932). It can be said that the pandemic has left a big mark on the tourism industry, but the situation is quickly normalizing.

Internet access during the pandemic greatly not only facilitated, but also enabled a relatively normal life. Between 2012 and 2019, 99% of the regions surveyed saw a year-on-year increase in the share of households with Internet access. Between 2019 and 2023, the share was already only 91%. Only 12% of the regions had a higher average rate of change between 2019 and 2023 than between 2012 and 2019. This is due to the fact that in 2012 the Internet was not yet so popular and in some regions (especially Eastern Europe) the share of households with Internet access was below 50%. In 2019, there was no longer a region in the EU where the share was below 70%. In the first period under review, the highest average rate of change was in the Severozapaden region (Bulgaria - 1.092), and the lowest in Bratislava (Slovakia - 0.9996). In the next period, also the largest increase was in Bulgaria's Yugozapaden region (1.092), and the smallest this time in Sweden's Mellersta Norrland region (0.988).

Table 9 shows in how many regions of the studied countries there was an increase in the average rate of change of the studied phenomena in 2019-2023 compared to 2012-2019. The chosen periods were adopted to capture the average rates of change in the studied phenomena before and during the pandemic. If the periods 2012-2019 and 2020-2023 were used, the change that occurred between 2019 and 2020 would be lost, and it can be expected that the most significant changes caused by the COVID-19 pandemic took place during that time. It was in 2020 that the EU experienced the greatest disruptions related to the pandemic. Many countries implemented lockdowns.

Table 9.
Number of regions in which the average rate of change of the phenomenon under study was higher in 2019-2023 than in 2012-2019

	Employment rate		**HRST**		**Internet**		**Tourist accommodation**	
	Increased *	**Regions ****	**Increased ***	**Regions ****	**Increased ***	**Regions ****	**Increased ***	**Regions ****
Austria	1	9	0	9	2	9	0	9
Belgium	5	11	6	11	1	11	1	11
Bulgaria	0	6	3	6	1	6	2	6
Cyprus	0	1	1	1	0	1	0	1
Czech Republik	0	8	5	8	1	8	0	8

Danmark	1	5	2	5	1	5	4	5
Estonia	0	1	0	1	0	1	0	1
Finland	0	5	0	5	0	4	-	-
France	21	26	14	26	-	-	0	1
Greece	7	13	4	13	-	-	-	-
Spain	0	19	7	19	0	19	2	19
Netherlands	11	12	9	12	3	12	3	12
Croatia	1	1	0	1	0	1	0	1
Ireland	1	3	3	3	-	-	-	-
Luxembourg	1	1	1	1	1	1	1	1
Latvia	0	1	0	1	0	1	0	1
Malta	0	1	0	1	1	1	0	1
Germany	4	38	14	38	-	-	0	38
Poland	4	15	4	15	-	-	0	10
Portugal	0	7	2	7	0	7	0	2
Romania	0	8	4	8	0	8	0	8
Slovakia	0	4	2	4	4	4	0	4
Slovenia	0	2	0	2	-	-	0	2
Sweden	3	8	2	8	1	8	0	8
Hungary	0	6	6	6	0	6	0	6
Italy	15	21	9	21	0	21	7	21

* number of regions in which the average rate of change increased.
** number of regions examined.

Source: own calculations.

In a few countries (France, the Netherlands, Italy), the average rate of employment growth in the 2019-2023 period was higher than in the 2012-2019 period in most regions, but in the vast majority it was lower. For the population counted in HRST, Belgium, the Czech Republic, France, Hungary, the Netherlands, Ireland and Luxembourg saw growth in most regions. For household Internet access, only 3 small countries saw an increase in the average rate of change (Luxembourg, Malta, Slovakia). On the other hand, the average rate of change for the number of nights provided in 2019-2023 was higher than in 2012-2019 only in Luxembourg and Denmark. As you can see, there are a few countries that repeat themselves. The most common is Luxembourg, but it is a small country with only 1 region. Among the larger countries, France and the Netherlands appear most often.

We know which regions are the best and worst in terms of the phenomena studied. Now, using the Hellwig linear ordering method, the regions were ordered from those in which the variables took the best values to those that took the best values. Household access to the Internet was not taken into account due to large data gaps.

Since the variables are given in the form of indices or as real numbers, the first step involved normalization of the variables. In the next step, the best object was created - a pattern (one that takes the best values for all variables - this is a fictitious object). All variables are stimulants, so the higher the value of the indicator the better, so the pattern takes 1 for each normalized variable. In the last step, the Euclidean distance of the regions from the pattern was counted. Tables 10-12 show the top 30 regions in 2012, 2019 and 2023.

Table 10.
Top 30 regions in terms of studied characteristics in 2012

Position	Region	Country	Position	Region	Country	Position	Region	Country
1	Ile de France	France	11	Darmstadt	Germany	21	Västsverige	Sweden
2	Oberbayern	Germany	12	Schleswig-Holstein	Germany	22	Helsinki-Uusimaa	Finland
3	Cataluña	Spain	13	Comunidad de Madrid	Spain	23	Stuttgart	Germany
4	Berlin	Germany	14	Illes Balears	Spain	24	Freiburg	Germany
5	Noord-Holland	Netherlande	15	Lombardia	Italy	25	Karlsruhe	Germany
6	Tirol	Austria	16	Toscana	Italy	26	Köln	Germany
7	Veneto	Italy	17	Hovedstaden	Denmark	27	Zuid-Holland	Netherlande
8	Praha	Czech Republik	18	Hamburg	Germany	28	Gelderland	Netherlande
9	Emilia-Romagna	Italy	19	Salzburg	Austria	29	Kýpros	Cyprus
10	Stockholm	Sweden	20	Mecklenburg-Vorpommern	Germany	30	Utrecht	Netherlande

Source: own calculations.

Table 11.
Top 30 regions in terms of studied characteristics in 2019

Position	Region	Country	Position	Region	Country	Position	Region	Country
1	Ile de France	France	11	Veneto	Italy	21	Lombardia	Italy
2	Cataluña	Spain	12	Schleswig-Holstein	Germany	22	Darmstadt	Germany
3	Rhône-Alpes	France	13	Comunidad de Madrid	Spain	23	Salzburg	Austria
4	Oberbayern	Germany	14	Canarias	Spain	24	Toscana	Italy
5	Noord-Holland	Netherlande	15	Comunitat Valenciana	Spain	25	Hamburg	Germany
6	Berlin	Germany	16	Aquitaine	France	26	Hovedstaden	Denmark
7	Provence-Alpes-Côte d'Azur	France	17	Praha	Czech Republik	27	Eastern and Midland	Ireland
8	Illes Balears	Spain	18	Emilia-Romagna	Italy	28	Pays de la Loire	France
9	Tirol	Austria	19	Stockholm	Sweden	29	Languedoc-Roussillon	France
10	Jadranska Hrvatska	Croatia	20	Mecklenburg-Vorpommern	Germany	30	Bretagne	France

Source: own calculations.

Table 12.
Top 30 regions in terms of studied characteristics in 2023

Position	Region	Country	Position	Region	Country	Position	Region	Country
1	Ile de France	France	11	Illes Balears	Spain	21	Languedoc-Roussillon	France
2	Cataluña	Spain	12	Veneto	Italy	22	Darmstadt	Germany
3	Rhône-Alpes	France	13	Schleswig-Holstein	Germany	23	Zuid-Holland	Netherlande
4	Noord-Holland	Netherlande	14	Comunidad de Madrid	Spain	24	Hamburg	Germany
5	Oberbayern	Germany	15	Praha	Czech Republik	25	Bretagne	France

Cont. table 12.

6	Provence-Alpes-Côte d'Azur	France	16	Comunitat Valenciana	Spain	26	Andalucía	Spain
7	Berlin	Germany	17	Stockholm	Sweden	27	Budapest	Hungary
8	Aquitaine	France	18	Canarias	Spain	28	Lombardia	Italy
9	Tirol	Austria	19	Salzburg	Austria	29	Pays de la Loire	France
10	Jadranska Hrvatska	Croatia	20	Hovedstaden	Denmark	30	Warszawski stołeczny	Poland

Source: own calculations.

In terms of the characteristics studied, the top 30 regions are dominated by regions from the "old" EU countries. Each time, among the countries of Central and Eastern Europe, the highest is Praha (Czech Republic). In 2023, the Warsaw Capital Region was ranked 30th. In each year, the Ile de France (France) region is the best, and Cataluña (Spain) is very high. Regions whose capitals are large cities with academic centers dominate.

8. Summary

Regions of EU countries are constantly developing. The article examines their development as influenced by employment in the 15-64 age group, household access to the Internet, the size of the population classified as HRST, and the number of nights spent in tourist accommodations. Unfortunately, there are data gaps, especially in the case of household access to the Internet.

Examining the average rate of change of individual phenomena, one can conclude that the COVID-19 pandemic had a significant impact on regional development. On more than one occasion, this development was almost halted, as was the case with tourism. Employment also declined in 2020, as did the size of the population counted ho HRST. Unsurprisingly, the pandemic had little effect on the availability of households to the Internet; indeed, in 2020, in most regions the rate grew faster than the average rate of change counted for 2012-2019 would indicate, but then quickly declined. The situation was similar for HRST, with a noticeable increase in 2020, but a correction in subsequent years. In 42% of the regions, the average rate of change in 2019-2023 was higher than in 2012-2019.

For employment, the negative effects of the pandemic have been very short-lived, with a rapid upward rebound after a decline in 2020. In both the top 10 and last 10 regions, the employment rate was higher in 2023 than in 2019.

Much more severe losses were suffered by the tourism industry, here growth was halted and only in 2023 the number of nights spent in tourist accommodations is comparable to 2019.

Among the best-developed regions of the EU countries (in terms of the characteristics studied), the Ile de France (France) region uninterruptedly dominates. The Cataluña region (Spain) also always ranks very high. Most of the best-developed regions are those with large

cities that are academic centers. This is dominated by the regions of the "old" EU, and among the countries of Central and Eastern Europe, only Praha (Czech Republic) (3 times) and the capital Warsaw (Poland) (2023) are in the top 30.

The obtained results suggest that the regions of Central and Eastern Europe are approaching the development level of Western European countries.

Of course, this classification could have looked different if a different linear ordering method had been used, and it certainly would have looked different if other variables had been used. This is where the analysis can be enriched by adding more variables, such an analysis would give an answer to the question of which EU region is the most comprehensively developed. Here, the analysis can be enriched by adding additional variables, making it more reliable. In classification methods, much depends on the choice of indicators used in the study (which is always subjective), so a significant increase in their number would be advisable. A limitation of the analysis is, of course, data availability. The Hellwig linear ordering method can be applied if data is available for all objects, in our case, the EU regions.

References

1. Bąk, A. (2016). Porządkowanie liniowe obiektów metodą Hellwiga i TOPSIS – analiza porównawcza. *Prace naukowe Uniwersytetu Ekonomicznego we Wrocławiu, No. 426. Taksonomia, 26. Klasyfikacja i analiza danych – teoria i zastosowania,* pp. 22-31, DOI: 10.15611/pn.2016.426.02
2. Bogos, K., Kiss, Z., Fronius, A.K., Temesi, G., Elek, J., Madurka, I., Cselko, Z., Csanyi, P., Abonyi-Toth, Z., Rokszin, G., Barcza, Z., Moldvay, J. (2021). Different Trends in Excess Mortality in a Central European Country Compared to Main European Regions in the Year of the COVID-19 Pandemic (2020): a Hungarian Analysis. *Pathology and Oncology Research, Vol. 27*, pp. 1-9, doi: 10.3389/pore.2021.1609774
3. *Businessinsider*. Retrieved from: https://web.archive.org/web/20201009083217/ https://www.businessinsider.com/coronavirus-patients-zero-contracted-case-november-2020-3, 21.03.2020.
4. *Eurostat*. Retrieved from: https://ec.europa.eu/eurostat, 10.10.2024.
5. Hacoğliu-Hoke, S., Känzig, D.R., Surico, P. (2021). The distributional impact of the pandemic. *European Economic Review, Vol. 134*, 103680
6. Hellwig, Z. (1968). Zastosowanie metody taksonomicznej do typologicznego podziału krajów ze względu na poziom ich rozwoju oraz zasoby i strukturę wykwalifikowanych kadr. *Przegląd Statystyczny, vol. 4*, pp. 307-327.
7. Jędrzejowska, K., Wróbel, A. (2021). Wielki lockdown i deglobalizacja: wpływ pandemii COVID-19 na gospodarkę światową. *Rocznik Strategiczny 2020/21*, pp. 173-198.

8. Khan, A., Khan, N., Shafiq, M. (2021). The Economic Impact of COVID-19 from a Global Perspective. *Global Economy, Health and medicine and law, Economic development, No. 1,* pp. 64-75. Akademia Ekonomiczno-Humanistyczna w Warszawie
9. Kruczek, Z., Borkowski, K., Mazanek, L. (2023). Turystyka w regionie małopolskim w czasie pandemii COVID-19. *Studia Periegetica, Vol. 37(1),* pp. 107-129. https://doi.org/10.5604/01.3001.0015.9044
10. Ostasiewicz, S., Rusnak, Z., Siedlecka, U. (2001). *Statystyka. Elementy teorii i zadania*. Wydawnictwo AE Wrocław.
11. *PAP*. Retrieved from: https://www.pap.pl/aktualnosci/news%2C1208699%2Cwho-ponad-2-miliony-ludzi-zmarlo-w-europie-na-covid-19.html, 15.10.2024.
12. Parkitny, M., Parkitna, A. (2023). Wpływ pandemii na zasoby finansowe przedsiębiorstw MŚP – przykład Polski. *European Journal of Management and Social Science, vol. 4, No. 1-2,* pp. 28-32.
13. Płonka-Syroka, B. (2023). Pandemia COVID-19 (2020-2022) zagrożeniem dla zdrowia publicznego w Polsce i systemu jego ochrony. *Zeszyty Naukowe Collegium Witelona, no. 47(2),* pp. 27-50.
14. Rangachev, A., Marinov, G.K., Mladenov, M. (2022). The demographic and geographic impact of the COVID pandemic in Bulgaria and Eastern Europe in 2020. *Scientific Reports, 12,* p. 6333.
15. Shrestha, N., Shad, M.Y., Ulvi, O., Khan, M.H., Karamehic-Muratovic, A., Nguyen, U.D.T., Baghbanzadeh, M., Wardrup, R., Aghamohammadi, N., Cervantes, D., Nahiduzzaman, K.M., Zaki, R.A., Haque, U. (2020). The impact of COVID-19 on globalization. *One Health, Vol. 11,* doi: 10.1016
16. Smolarski, M., Suszczewicz, M. (2021). Wpływ pandemii COVID-19 na funkcjonowanie regionalnego transportu kolejowego obszarów przygranicznych – na przykładzie województwa dolnośląskiego (PL) i kraju libreckiego (CZ). *Czasopismo Geograficzne, 92(1),* 121-140. https://doi.org/10.12657/czageo-92-06
17. Szczukowska, A. (2023). Wpływ pandemii COVID-19 na branżę turystyczną w Polsce. *Nierówności Społeczne a Wzrost Gospodarczy, No. 74(2),* pp. 124-140, DOI: 10.15584/nsawg.2023.2.8
18. Vasilyeva, T.A., Lyeonov, S.V., Letunovska, N.Y. (2020). *The economic impact of COVID-19: forecasting for ukrainian regions.* Socio-Economic Challenges: Proceedings of the International Scientific and Practical Conference, Sumy, November 3–4, 2020. Sumy: Sumy State University, pp. 18-22.
19. *WHO*. Retrieved from: https://web.archive.org/web/20200312090756/https://twitter.com/WHO/status/1237777021742338049?s=20, 11.03.2020.