

ANALYSIS OF SECTORAL EMPLOYMENT DYNAMICS IN EU COUNTRIES IN THE YEARS 2009-2024

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Purpose: The study aims to understand how similar the trajectories of changes in the average rate of employment are among EU countries and how this similarity changes over time, which is intended to reveal different paths of structural transformation.

Design/methodology/approach: The study covered all member states of the European Union and 17 selected employment sectors. The analysis concerned two comparative periods: 2009-2019 and 2019-2024. The average rate of change in employment in individual sectors was calculated for both periods. Czekanowski's diagram was used to examine the similarities in the average rates of employment change in EU countries.

Findings: The analysis showed that on the scale of the entire EU between 2009 and 2024, there were no major changes in the average rate of employment change in most sectors. Significant changes were recorded in 4 sectors. The vulnerability of countries to employment changes caused by the COVID-19 pandemic varied, which translated into the grouping of countries in both periods.

Research limitations/implications: Limitations: The application of a different grouping method may potentially yield different grouping results. Further research: It is worth extending the analysis to include other factors and examining public policies that contributed to mitigating or accelerating the changes. Comparing the results with other grouping methods is also suggested.

Practical implications: The study enables reliable analysis of trends and prediction of future changes. The conclusions are key for public policies, pointing out sectors with dynamic growth and countries with the greatest sensitivity to global economic shocks.

Social implications: The study provides information for public policy on the impact of strong shocks (pandemic) and long-term trends on the employment structure. This can support decisions regarding social security policies.

Originality/value: The value of the article lies in the application of Czekanowski's diagram to analyze changes in the structure of sectoral employment dynamics in EU countries in the context of major economic shocks. Literature indicates that the average rate of employment change in the EU is not precisely researched. The application of Czekanowski's diagram allows for reliable analysis of trends and visualization of results.

Keywords: Czekanowski's diagram, employment dynamics, COVID-19 pandemic.

Category of the paper: Research paper.

1. Introduction

The structure of sectoral employment in European Union countries has undergone significant changes in the last two decades. The 2008/2009 global financial crisis, which caused severe economic disruptions, credit freezes, demand slowdowns, and significant declines in industrial and construction sectors, presented many EU countries with the necessity of restructuring the production sector. Subsequently, the COVID-19 pandemic (starting from late 2019/2020) acted as another powerful impulse changing the structure of the labor market, through both temporary standstills and permanent changes in demand and service delivery methods (e.g., remote work, mobility restrictions, reduced demand in sectors related to personal interaction). The escalation of the war in Ukraine could also significantly influence changes in the employment structure in some EU countries. Simultaneously, long-term factors—digitization, automation, energy transition and green economy, increasing qualification requirements, demographic pressures (population aging, migration)—are affecting sectoral employment models.

In these conditions, it becomes essential to understand not only *how* employment has changed in individual sectors, but also *how similar* or *different* the trajectories of these changes are among EU countries and how this similarity changes over time. Such comparisons can reveal different paths of structural transformation. Czekanowski's diagram was used to illustrate these trajectories. Thanks to it, groups of countries with similar dynamics of employment changes in the analyzed economic sectors can be easily identified.

The main goal of this article is therefore to examine changes in the structure of sectoral employment dynamics in EU countries in the years 2009-2024, taking into account the impact of the COVID-19 pandemic. Secondary goals include: identifying groups of countries with similar sectoral change dynamics, analyzing how the similarity of the employment structure changes between EU countries over time, and examining which countries "shift" between groups.

2. Literature review

Analyses of employment changes in Poland and EU countries over the last two decades focus on identifying long-term structural trends and short-term economic shocks. The period 2009-2019 was characterized by moderate sectoral restructuring, a decline in industrial employment, and the growing importance of the services sector. In contrast, the years 2019-2024 brought the pandemic shock and economic recovery under new structural conditions,

accompanied by the increasing importance of digitization and the green energy transition (OECD, 2024; ILO, 2022; World Bank, 2019).

In the context of labor market polarization, studies by Goos and Manning (2007) and Autor, Dorn, and Hanson (2013) show that developed countries experience an increase in jobs in low- and high-skilled sectors, and a decrease in middle-skilled sectors. Poland experienced similar trends, although at a slower pace, with a visible increase in the importance of market services and a decrease in the share of industry in employment (GUS, 2020; Kowalik, Magda, 2021).

Between 2009 and 2019, employment in the industrial sector in EU countries increased slightly, while market services saw a marked increase. After 2019, the COVID-19 pandemic caused sharp declines in contact-intensive industries (tourism, gastronomy), followed by recovery with a shift in employment towards logistics and digital services (ILO, 2020; WEF, 2020).

Simultaneously, a new current of research has emerged in the literature concerning the energy transition and its impact on the employment structure (OECD, 2024; World Bank, 2019). It is indicated that sectors with high CO₂ emissions will lose jobs, while employment in green and technological sectors will increase (PIE, 2024). Wójcik (2013) applied Czekanowski's diagram to study the similarities of EU countries regarding the acquisition of energy from renewable sources, which is also significant in the analysis of changes in employment structure in modern and ecological sectors. This method allows for visualizing the degree of similarity and differences between research units, which can be used to assess the rate of employment change in various economic sectors.

Miśkiewicz-Nawrocka (2015) analyzes the threat of unemployment in Polish provinces in the years 2005-2012, indicating significant regional variation. These studies suggest that the rate of employment change is strongly dependent on the specifics of local labor markets, the level of education, and the economic structure of a given region, which can be applied to different countries. Additionally, Polish literature points to specific challenges for the labor market, such as a low share of employment in the modern business services sector, the growing importance of remote work (Król, 2022), and the phenomenon of unstable forms of employment and temporary contracts (PARP, 2022). PIE (2024) studies and MRPiPS (2020) reports indicate that structural changes in employment in Poland are increasingly related to demographics, energy transition, and digitization.

Conclusions from the literature review indicate that the average rate of employment change in Poland and the EU is not precisely researched. Since it is sectorally and regionally diversified, and economic shocks, such as the pandemic, have a significant impact on the employment structure, it is worth looking closely at this. The application of a tool such as Czekanowski's diagram allows for reliable analysis of trends and prediction of future changes.

3. Research methodology

The analysis covers all member states of the European Union (EU-27). The study considers two comparative periods:

- 2009-2019 (the period covered by recovery after the 2008/09 crisis and the decade preceding the pandemic),
- 2019-2024 (the period covering the beginning of the COVID-19 pandemic and the subsequent recovery / transformation period).

The year 2009 appears in both studied periods because it marks both the end of the pre-pandemic period and the beginning of the pandemic. Analyzing the employment structure, 17 sectors with the largest employment were taken into account. They are presented in Table 1.

Table 1.
Selected employment sectors

Symbol	Sector	Symbol	Sector
S1	Legal and accounting activities	S10	Specialised construction activities
S2	Services to buildings and landscape activities	S11	Wholesale and retail trade and repair of motor vehicles and motorcycles
S3	Public administration and defence; compulsory social security	S12	Wholesale trade, except of motor vehicles and motorcycles
S4	Education	S13	Retail trade, except of motor vehicles and motorcycles
S5	Human health activities	S14	Land transport and transport via pipelines
S6	Residential care activities	S15	Food and beverage service activities
S7	Crop and animal production, hunting and related service activities	S16	Computer programming, consultancy and related activities
S8	Manufacture of fabricated metal products, except machinery and equipment	S17	Financial service activities, except insurance and pension funding
S9	Construction of buildings		

The shares of employment in individual sectors were calculated based on employment data in individual sectors and total employment data in individual EU countries originating from the Eurostat website (Eurostat, 2025). For all employment sectors, in all EU countries, the average rate of change was calculated for the years 2009-2019 and 2019-2024, using the formula (Ostasiewicz et al., 2001):

$$\bar{i}_G = \sqrt[n-1]{i_{n/n-1} * i_{n-1/n-2} * \dots * i_{2/1}}, \quad (1)$$

where: $i_{n/n-1} = \frac{y_n}{y_{n-1}}$.

To find out in which countries the average rate of change in individual sectors was similar, Czekanowski's diagram was created. This was done twice, for the average rate of change in the years 2009-2019 and 2019-2024.

The creation of Czekanowski's diagram (Czekanowski, 1913) is one of the oldest taxonomic methods that allows to determine the relationships between objects and to visualize the relationships and similarities between them. The diagram is a visualization of the distance matrix between these objects. The objects most similar to each other are closest to the main diagonal of the distance matrix. The farther from the main diagonal the objects are less similar to each other (Jaskulski, Sołtysiak, 2004; Sołtysiak, Jaskulski, 1999).

The diagram is drawn according to the following stages (Heffner, Gibas, 2007):

- defining the data matrix,
- standardization or unitization of variables,
- selection of the measure of similarity,
- estimation of taxonomic distance matrices,
- determination of the minimum and maximum value in the taxonomic distance matrix,
- estimation of class intervals for taxonomic distances based on the determined empirical variability area,
- developing a disordered Czekanowski diagram,
- organizing Czekanowski's diagram,
- interpretation of obtained results.

Standardization of variables can be performed according to the formula (Dziechciarz, 2012):

$$z_{ij} = \frac{x_{ij} - \bar{x}_{ij}}{s_j}, \quad (2)$$

where:

z_{ij} - standardized variable x_j for the i -th object,

x_{ij} - variable x_j for the i -th object,

\bar{x}_{ij} - arithmetic mean of the variable x_j ,

s_j - standard deviation of the variable x_j .

However, the similarity distance matrix is determined using the Euclidean metric.

4. Empirical analysis

The purpose of the article is to examine the changes occurring in the employment structure in selected sectors in EU countries, so we are interested in the rate of change, not just the employment shares in individual sectors in EU countries.

Figure 1 presents the average rates of employment change in individual sectors during the pre-pandemic period (2009-2019) and the period of the pandemic and immediately thereafter (2019-2024) across the entire EU. In almost all sectors, there were no major changes in the average rate of change. 4 sectors deserve attention:

- services to buildings and landscape activities (S2) and residential care activities (S6), where the trend changed from upward to downward,
- construction of buildings (S9), where the decline in employment shares was halted,
- computer programming, consultancy and related activities, where the already large increase in employment shares was significantly amplified (increase in the average rate of change from 1.04 to 1.08).

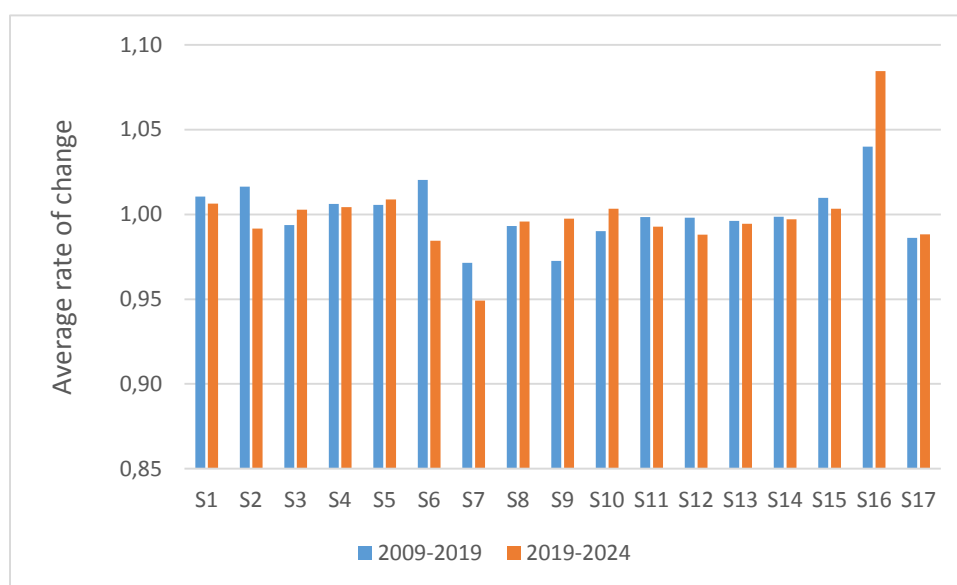


Figure 1. Average rate of change in employment shares in selected sectors across the entire EU.

Source: Own calculations.

How did the changes in the average rate of change in selected sectors look in individual countries? Due to the multitude of both countries and sectors, not all statistics are presented, only selected ones. Table 2 shows only the countries where the largest changes in the average rate of employment change occurred in selected sectors.

Table 2.

Countries with the largest changes in the average rate of employment change in the periods 2009-19 and 2019-2024, in selected sectors

Sector	Largest decreases		Largest increases	
S1	Latvia	-0,158	Netherlands	0,069
S2	Bulgaria	-0,183	Hungary	0,050
S3	Greece, Hungary	-0,019	Netherlands	0,069
S4	Croatia	-0,031	Netherlands	0,037
S5	France	-0,023	Luxembourg	0,048
S6	Lithuania	-0,101	Greece	0,041
S7	Romania	-0,087	Luxembourg	0,108
S8	Slovenia	-0,077	Greece	0,102
S9	Germany	-0,115	Greece	0,179

Cont. table 2.

S10	Latvia	-0,100	Greece	0,122
S11	Malta	-0,075	Luxembourg	0,089
S12	Germany	-0,083	Slovenia	0,125
S13	Slovenia	-0,075	Luxembourg	0,063
S14	Lithuania	-0,074	Malta	0,044
S15	Estonia	-0,076	France	0,022
S16	Estonia	-0,056	Cyprus	0,164
S17	Slovenia	-0,049	Hungary	0,134

We can draw several conclusions from Table 2. Firstly, the range of changes in individual sectors was very diverse, from 0.068 in Sector 4 to 0.294 in Sector 9. Secondly, the COVID-19 pandemic did not have an equally strong impact on changes in the average rate of employment change in individual sectors in all countries. There are several countries that appear quite often in Table 2, meaning the changes in these countries were the most abrupt. These include: Greece, Luxembourg, and Slovenia. 13 countries did not appear in Table 2 at all, which may indicate a smaller impact of the pandemic on the rate of employment change in individual sectors in these countries. To precisely answer the question of which countries experienced sharp changes in the rate of employment change and which experienced minor ones, the average modules of differences in the average rates of change in individual countries were calculated, which are presented in Table 3.

Table3.

Averages of the modules of differences in the average rates of change in EU countries in the years 2009-19 and 2019-2024

Country	Mean	Country	Mean	Country	Mean
Spain	0,017	Poland	0,024	Lithuania	0,034
France	0,018	Slovakia	0,025	Ireland	0,034
Finland	0,018	Hungary	0,026	Bulgaria	0,035
Sweden	0,019	Portugal	0,027	Germany	0,036
Austria	0,019	Netherlands	0,027	Croatia	0,037
Denmark	0,022	Romania	0,030	Malta	0,038
Czechia	0,023	Slovenia	0,030	Greece	0,038
Italy	0,024	Cyprus	0,033	Luxembourg	0,046

From Table 3, we can conclude that indeed the countries that appeared in Table 2 are generally characterized by greater vulnerability to employment changes caused by the COVID-19 pandemic. The largest changes in the average rate of employment change occurred in Luxembourg, Greece, and Malta. Conversely, the smallest changes were observed in Spain, France, and Finland.

Figure 2 presents Czekanowski's diagram for the average rates of employment change in individual sectors in the years 2009-19. Czekanowski's diagram allowed for the distinction of countries where the average rate of employment change during the pre-pandemic period was similar.

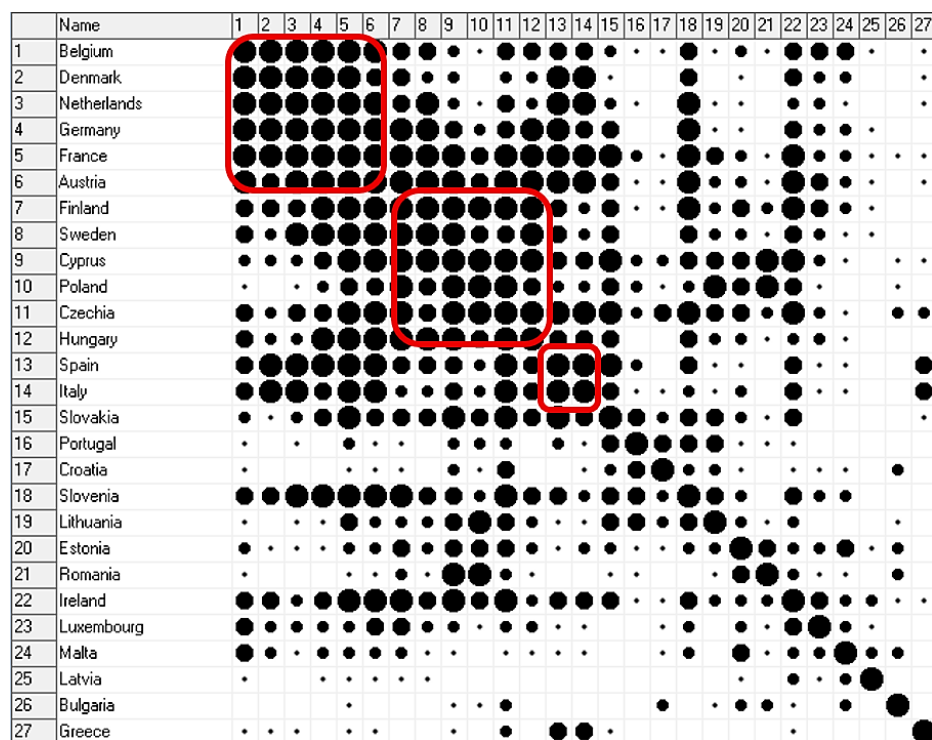


Figure 2. Czekanowski's diagram for the average rate of change in employment in individual sectors in the years 2009-2019.

Source: Own calculations.

In the years 2009-19, three groups of countries with a similar average rate of change in individual sectors were distinguished. It might seem very natural that in certain groups of countries, employment changes proceed similarly—certain economic sectors lose importance while others gain. The first group included: Belgium, Denmark, Netherlands, Germany, France, and Austria. Group 2 included: Finland, Sweden, Cyprus, Poland, Czechia, and Hungary. The last group included Spain and Italy. The first group consists of neighboring countries, while the third group consists of countries where tourism plays an important role. Group 2 is the most diverse, including 2 countries from the northern part of the EU besides Central European countries.

Countries in Group 1 are characterized by a large increase in employment in services related to building maintenance (S2) (an average of 3% annually) and an equally large decrease in employment in agriculture (S7) and construction (S9). In contrast, Group 2 saw a rapid increase in employment in the IT industry (an average of 6% annually) and a large increase in legal and accounting activities (S1) (an average of 3% annually), while employment in agriculture (S7) decreased, similar to Group 1, by an average of 3% annually. Spain and Italy during this period were characterized by a large increase in employment in the IT sector (S16) (an average of 4% annually) and residential care (S6) (an average of 3% annually). The remaining countries did not form groups, meaning the average rate of change in sectors in those countries was not similar to other countries.

In 2019, the COVID-19 pandemic erupted in China. In 2020, the pandemic spread globally, including Europe. Undoubtedly, the pandemic had a significant impact on the economy of EU countries, and how it affected employment in individual sectors, specifically how it affected the similarity of the average rate of employment change in EU countries, is shown in Figure 3.

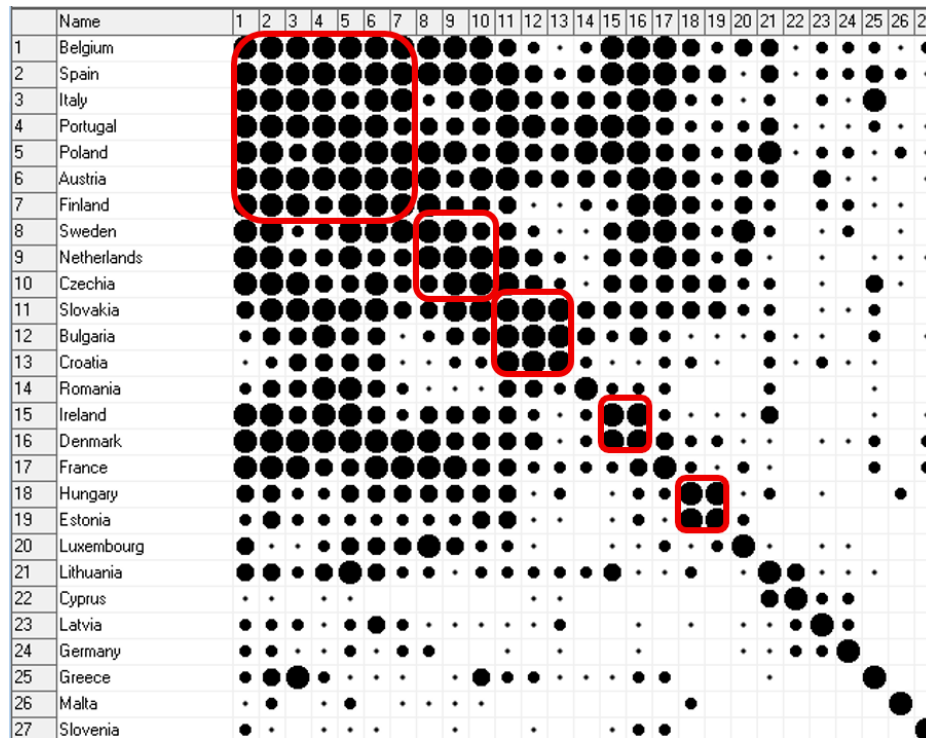


Figure 3. Czekanowski's diagram for the average rate of change in employment in individual sectors in the years 2019-2024.

Source: Own calculations.

Already at first glance, it is visible that a completely different division of countries into groups with similar average rates of employment change in the studied sectors was made. Five groups were distinguished, with the first group containing as many as 7 countries, and the remaining 4 groups containing three or two countries each.

Group 1 included: Belgium, Spain, Italy, Portugal, Poland, Austria, and Finland. This group is characterized by a very large increase in employment in the IT sector (S16) (an average of 8% annually) and a large decrease in employment in agriculture (S7) (an average of 4% annually). A large increase in employment in the IT sector (an average of 6% annually) also occurred in the countries of Group 2: Sweden, Netherlands, and Czechia. These countries were also characterized by a large increase in employment (an average of 4% annually) in Sector 1 related to legal and accounting activities and a large decrease in employment (an average of 3% annually) in the sector related to the manufacture of fabricated metal products (S8). In Slovakia, Bulgaria, and Croatia (Group 3), the largest increase in employment in the IT sector occurred in the years 2019-2024 among all distinguished groups, amounting to an average of 13% annually. Although this is a very large increase, it was significantly higher in Cyprus,

where the average rate of change in this sector in the years 2019-2024 was 1.24. This means that employment in this sector almost doubled in slightly over three years.

Countries in Group 3 are also characterized by a large increase in specialized construction activities (S10) (an average of 5% annually) and in legal and accounting activities (S1) and trade (S11) (an average of 4% annually). In this group, a large increase in employment occurred in as many as 4 sectors, and only in activities related to building maintenance (S2) did a large decrease in employment occur, by an average of 4% annually. Ireland and Denmark (Group 4) felt the effects of the pandemic most strongly among all groups. In as many as 4 sectors, the average rate of employment change adopted a value significantly lower than 1. In agriculture (S7) (0.94), in the manufacture of fabricated metal products (S7) and trade (S11) (0.96), and in activities related to building maintenance (S2) (0.97).

In the last distinguished group, which includes Hungary and Estonia, average annual employment decreases of at least 3% were not recorded. Large increases in employment were noted in financial service activities (S17) (an average of 9% annually), in the IT industry (S16) (an average of 7% annually) and in specialized construction activities (S10) (an average of 4% annually).

10 countries did not form groups with other countries. In these countries, the average rates of employment change in individual sectors are not similar to employment changes in other countries, or those other countries belong to different groups.

5. Summary

The purpose of this article was to examine changes in the structure of sectoral employment dynamics in European Union (EU) countries in the years 2009-2024, with particular emphasis on the impact of the COVID-19 pandemic. The study aimed to identify groups of countries with similar dynamics of sectoral changes and to analyze the evolution of the similarity of the employment structure among these countries over time.

The analysis of the rate of employment change in 17 selected sectors (based on Eurostat data) across two comparative periods (2009-2019 and 2019-2024) led to several key empirical findings:

1. Fundamental shift in sectoral trends in the EU: Significant changes in the average rate of change were recorded across the entire EU in four sectors.

The sectors of services to buildings (S2) and residential care activities (S6) recorded a change in trends from upward to downward.

In construction (S9), the downward trend in employment shares was halted.

In the computer programming sector (S16), the already large increase in employment (rate 1.04) was significantly amplified (rate 1.08).

2. Varied vulnerability of countries to changes: Not all EU member states felt the impact of the COVID-19 pandemic with the same intensity.

Countries such as Luxembourg (0.046), Greece (0.038), and Malta (0.038) were characterized by the greatest vulnerability to changes in the rate of employment (measured by the average modules of differences in the average rates of change).

The smallest changes in the average employment rate were recorded in Spain (0.017), France (0.018), and Finland (0.018).

A particularly abrupt change occurred in Cyprus in Sector S16, where the average rate of change was 1.24, meaning employment in this sector almost doubled in slightly over three years.

3. Change in similarities between countries: The application of Czekanowski's diagram revealed fundamental shifts in the grouping of countries during the studied period. While three groups were distinguished in 2009-2019, as many as five new groups were distinguished in the 2019-2024 period.

For example, Slovakia, Bulgaria, and Croatia (Group 3) recorded the largest increase in employment (as a group) in sector S16 (an average of 13% annually).

Ireland and Denmark (Group 4) felt the effects of the pandemic most strongly, as the average rate of employment change adopted a declining value in as many as 4 sectors.

The results confirm the theses of Goos and Manning (2007) as well as Autor, Dorn, and Hanson (2013) regarding the growing importance of high-skilled sectors. This is demonstrated by a sharp increase in the computer programming sector (S16), where the rate of change rose from 1.04 to 1.08. In Cyprus, employment in this sector nearly doubled within just three years.

In contrast to the period 2009-2019, the years 2019-2024 brought a reversal of trends in building maintenance services (S2) and residential care services (S6), shifting from growth to decline. This finding is consistent with ILO (2020) reports indicating sharp contractions in contact-intensive industries.

The contribution of this article lies in the application of the Czekanowski diagram to the analysis of trajectories of change in sectoral employment dynamics, enabling a robust assessment of trends and offering potential for forecasting future developments. This methodology allows for the straightforward identification of groups of countries exhibiting convergent employment dynamics. Future research could extend the analysis to additional factors (e.g., education levels, rising skill requirements, migration) and examine which public policies have contributed to mitigating or accelerating these changes.

The authors acknowledge that the application of alternative clustering methods may yield different grouping results. Even within the diagram, assigning a country to one group or another may be problematic; therefore, further research may also pursue the use of alternative clustering techniques and compare their outcomes with those obtained in this study. The analysis is planned to be extended to include factors such as education levels, migration, and the impact

of digitalization on sectoral models. It is also advisable to investigate specific public policies that, across different countries, have contributed to mitigating or accelerating the ongoing structural changes.

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