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CONVERGENCE OF CHANGES IN THE EMPLOYMENT STRUCTURE IN THE EUROPEAN UNION COUNTRIES

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Purpose: Multidimensional scaling is a method that allows the representation of complex observations in a space with fewer dimensions (usually on the plane) in such a way that the distance matrix counted on the plane is as similar as possible to the matrix counted in the original space. The paper presents a proposal to use this approach in the analysis of spatial-temporal structures describing changes in the structure of employment in EU countries. The structures are described by shares, so no procedure is necessary to bring the shares to comparability due to the unit of measure. Separate multidimensional scaling is carried out for each unit of time. The purpose of the study is to try to separate groups of European Union countries similar due to their employment structures.
Methodology: The paper uses one of the frequently used non-hierarchical methods - the k-means method. The study of multidimensional clustering of EU regions, which uses the k-means algorithm to identify similar areas are used in many fields among others to group regions or countries.
Findings: In the EU countries, enterprises employing up to 9 people account for the largest percentage. On average, they accounted for 95.14% in 2015 and in 2020 the percentage of these enterprises increased slightly to 95.27%. The highest percentage of enterprises employing up to 9 people was in Slovakia, with 97.41% in 2020, while the lowest was in Germany, where the value of this indicator was 82.44%. Among the countries analysed, Germany and Luxembourg stood out in particular, where there was a relatively high number of companies employing between 50 and 249 people.
Originality/value: The importance of the indicated research is extremely important from the point of view of EU countries. Therefore, the methods indicated in the article can also be used in other aspects of the economy.
Keywords: employment; European Union countries; multidimensional scaling.
Category of the paper: Research paper.

1. Introduction

Data shows that small and medium-sized enterprises (SMEs) represent 99% of all companies in the EU and employ around 64.5% of workers in the EU non-financial sector. Small businesses (employing fewer than 50 people) account for approximately 48.4% of employment in the non-financial economy. Medium-sized enterprises (50-249 employees) employ an additional approximately 16% of employees and generate a similar percentage of added value in the economy. However, large companies, although they constitute only 0.2% of all companies, employ approximately 33.5% of employees, which shows their key role in employment at the European level.

The structure of companies by number of employees formed the basis of analyses carried out using the k-means method, which is based on the use of similarity measures.

The use of similarity (dissimilarity) measures in conjunction with the clustering method makes it possible to study the structural transformation of economic objects in time and space, i.e.: at different times for one object, at one moment for a group of objects, at many moments for many objects. Similarity (dissimilarity) of objects understood as similarity (dissimilarity) in the sense of the values of variables observed in these objects is the greater (smaller) the value of the measure (Walesiak, 1993).

Structural analyses, assessments of similarity and changes in structures are widely present in the literature and apply to all aspects of socio-economic processes. One of the most common research topics is the structure of employment (considered at different levels of territorial division), which determines the distribution of the population by employment in sectors, sections, industries and branches of the economy.

The structure of employment is determined by the level of economic development, resources (natural, capital and human), results from the specialization of the territorial unit shaped over the years, the needs of the internal market and the macro environment. Works on the nature of changes in European employment structures, along with attempts to look for patterns of structural changes in employment in Europe, are becoming an important part of research (Erber, 2002; Goos, Manning, Salomons, 2009; Fernández-Macías, 2012; Markowska, Sokolowski, 2019; Strahl, 2014; Canale, Liotti, Musella, 2022). The purpose of this study is to try to separate groups of European Union countries similar by employment structures in dynamic terms (period 2015-2020).

2. Employment structure in the European Union countries

The labour market in the European Union (EU) is one of the most important components of its economy. It is a complex system that encompasses a variety of aspects, such as the level of unemployment, types of employment, industry structure, labour force demographics and government policies affecting its operation. This article discusses changes in the employment structure in terms of the number of people in employment so that it is possible to show how the structure of the labour market is evolving in the EU.

Since the creation of the European Community, one of the main objectives has been, among others, the creation of a common labour market. The 1957 Treaties of Rome laid the foundation for the free movement of people, with the goal of allowing citizens of member countries to move and work freely in other member states. This was the first step toward labour market integration in Europe.

Another important stage in the shaping of the EU labour market was the enlargement of the Union to include new Member States. In 2004 and 2007, many central and eastern European countries joined the European Union, significantly increasing the number of available workers on the EU labour market. This enlargement also introduced new challenges, such as the need to integrate new workers and manage migration flows.

3. Structure of businesses in EU countries

In order to systematise structure of the labour market at the beginning of the 1990s, the statistical classification of economic activities in the European Community (called NACE Rev. 1 or NACE Rev. 1.1) was established by Council Regulation (EEC) No 3037/90 (Council, 1990), which, with various modifications, continued to operate and apply in the changing European Union until 2008. Due to technological developments and structural changes in the economy, an updated classification called NACE Revision 2 was introduced (Regulation…, 2006). This classification is the basis for assigning employed persons to specific sections, due to the primary activity of the company - the employer. The data collected in Eurostat relates, inter alia, to the EU countries - and it is this level of division that will constitute the spatial scope of the analyses conducted in this paper. The current statistical classification of activities (usually referred to as NACE Rev. 2), established - as indicated - in 2006, has been in force since 2008, and the latest available statistics on employment in EU countries are for the year 2020.

The structures in this regard covered in the analysis relate to the total business economy category. Business statistics cover industry, construction, distributive trades and most other services. They exclude a range of economic activities, such as: agriculture, forestry and fishing;

public administration; education; health and social work; arts, entertainment and recreation. Alongside these, financial and insurance activities have traditionally been excluded, given their specific nature and the limited availability of statistics in this area.

Table 1.
Changes in key indicators characterising labour market dynamics in EU countries in 2015/2010, 2020/2015

	Enterprises - 2015/2010 %	Value added at factor cost - 2015/2010 %	Persons employed 2015/2010 %	Enterprises 2020/2015 %	Value added at factor cost - 2020/2015 %	Persons employed - 2020/2015 %
Total business economy	9,31	12,51	4,85	4,81	10,48	4,22
Mining and quarrying	-5,06	-41,81	-18,23	-5,47	-20,02	-16,11
Manufacturing	-1,23	15,54	-0,06	3,90	9,99	5,44
Electricity, gas and air conditioning supply	68,91	1,59	-1,80	58,16	22,18	20,18
Water supply; waste management	11,91	16,22	11,29	7,00	18,91	15,94
Construction	5,70	2,49	-4,08	10,61	27,30	14,07
Wholesale and retail trade	0,87	10,02	0,22	-4,33	12,27	2,14
Transportation and storage	4,61	11,38	5,43	12,10	-5,67	3,61
Accommodation and food service activities	9,00	20,98	14,56	-0,39	-29,47	-3,57
Information and communication	28,32	10,45	14,58	18,15	26,63	16,72
Real estate activities	20,12	21,45	13,33	0,39	1,54	3,40
Professional, scientific and technical activities	19,24	18,54	16,72	9,29	10,26	3,38
Administrative and support service activities	25,85	24,82	15,64	11,86	10,21	-1,51
Repair of computers and household goods	10,88	1,25	5,25	-4,98	-3,40	-8,52

Source: own study based on Eurostat, https://ec.europa.eu/eurostat/, October 2024.

In the EU countries, there were 23.38 million enterprises operating in 2020, employing 127.62 million workers and generating €6,496,218.8 million in value added at factor cost. During the analysed period, the biggest changes occurred for value added at factor cost in the mining and quarrying sector of 2015 compared to 2010 (Tab. 1). The change was significant and indicated a decrease of as much as 42%. In the next period analysed, the decrease in this indicator was 20% in 2020 compared to 2015. Such a large change is due to the tightening of the European Union's policy on fossil fuel extraction companies. In the EU, it is forbidden to subsidise any loss-making industry with taxpayers' money unless the whole Union, represented by the European Commission, agrees (this is a consequence of the common open market), and this applies to a large extent to the mining sector.

The lack of subsidies has resulted in a decrease or total reduction in the extraction of fossil fuels and especially hard coal in Sweden, Ireland, the Netherlands, Belgium, France, Germany, the Czech Republic, Austria, Hungary, Bulgaria, Romania, Spain, Italy, Croatia and Poland. Another reason for the reduction in the extraction of fossil fuels within the EU has been the increase in output per worker outside Europe, which is several times higher, the reason for the closure of many European mines. Employment in the sector was also systematically reduced by 18% in 2015 compared to 2010 and by 16% in 2020 compared to 2015, respectively.

There was also a significant decrease in value added at factor cost in the accommodation and food service activities sector in 2020 compared to 2015 of 29.47%. This industry was mainly affected by the COVID-19 pandemic.

The most favourable changes can be observed in the electricity, gas and air conditioning supply sector. The number of start-ups increased by 68.91% in the first years analysed and by 58.16% in the following period. This resulted in a 20.18% increase in employment in 2020 compared to 2015 and the value added at factor cost increased by 22.18% in this sector. There is also dynamic growth in the information and communication sector, where the number of businesses increased by 28.32% in 2015 compared to 2010, resulting in a 26.63% increase in revenue over the following five years. Income also increased in the administrative and support service activities sector by 24.82%, similarly, the number of businesses operating in this sector increased by 25.85%. A favourable trend in this sector can also be observed in the next analysed period, with income increasing by 10.21% and the number of enterprises by 11.86% in 2020 compared to 2015. Further analysis was carried out on the structure of enterprises in the total business activity category in terms of the structure of employment in terms of the number of persons employed.

4. Material and method

In this paper, selected methods from the group of non-hierarchical methods were used to group European Union countries in terms of employment structure.

The k-means method is a method belonging to the group of cluster analysis algorithms, i.e. an analysis involving the search for and separation of groups of similar objects (clusters). It represents a group of non-hierarchical algorithms. The main difference between non-hierarchical and hierarchical algorithms is the need to specify the number of clusters in advance and that objects can change the cluster they belong to during running of the algorithm.

With the k-means method, k different possibly distinct clusters will be created. This algorithm consists of moving objects from cluster to cluster until intra-cluster and inter-cluster variability is optimised. It is obvious that the similarity within a cluster should be as high as possible, while the separate clusters should differ from each other as much as possible.

Among the non-hierarchical methods, the k-means method is often used. A study on multidimensional clustering of EU regions based on this method was presented by Pavone and Pagliacci (2021) and Rybak (2022). Another example of the application of the k-means method is a paper describing the grouping of EU countries according to the development of a circular economy using k-means by Gomorov and Ratner (2021).

The analyses were carried out for the European Union countries for the years 2015, 2020. Using a landslide diagram, it was decided to create 4 groups of countries similar in terms of the structure of the number of people employed (Figure 1).

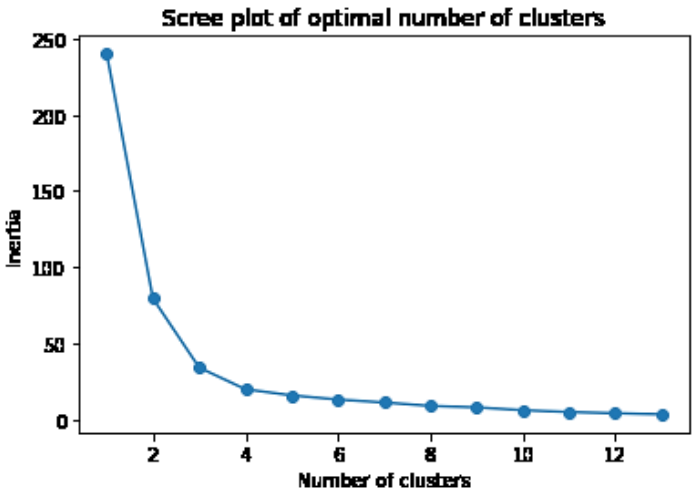

Figure 1. Landslide plot for the optimal number of clusters.
Source: own study.

5. Results of the research

The use of non-hierarchical methods made it possible to create groups of countries similar in terms of their employment structure, taking into account the number of people employed. A landslide diagram indicated that 4 groups of countries made the most sense. Of these, group one is the most numerous and includes 12 countries, group two includes four countries. Taking into account the specifics of the employment structure, one site was classified in group 3 and this was Germany, while group 4 included seven countries.

Table 2.
Key characteristics for EU countries classified in Group 1(%)

GROUP I	Belgium, Czechia, France, Hungary, Italy, Netherlands, Portugal, Poland, Slovakia, Slovenia, Spain, Sweden,									
	2015					2020				
	0-9	10-19	20-49	50-249	>250	0-9	10-19	20-49	50-249	>250
mean	95,14	2,60	1,42	0,70	0,14	95,27	2,54	1,39	0,66	0,14
minimum	94,09	1,92	0,81	0,51	0,09	94,31	1,23	0,79	0,46	0,10
maximum	96,53	3,27	1,68	0,93	0,20	97,41	3,27	1,72	0,85	0,20
SD*	0,67	0,48	0,24	0,12	0,03	0,89	0,60	0,24	0,11	0,03
CV**	0,70	18,33	17,05	17,84	21,56	0,93	23,69	17,23	16,08	20,21

SD* - standard deviation, **CV – coefficient of variation.

Source: own study based on Eurostat, https://ec.europa.eu/eurostat/, October 2024.

In the first group, the highest percentage of countries with the number of enterprises employing up to nine people was observed. On average, it represented 95.14% in 2015 and in 2020 the percentage of these enterprises increased slightly to 95.27%. In this group of countries, the percentage of enterprises with the smallest employment was a very homogeneous group and the coefficient of variation for this characteristic was 0.7%. The greatest coefficient of variation between countries in this group was in 2020 in the group of enterprises with 10 to 19 employees, as indicated by the highest value of the coefficient of variation at 23.69%.

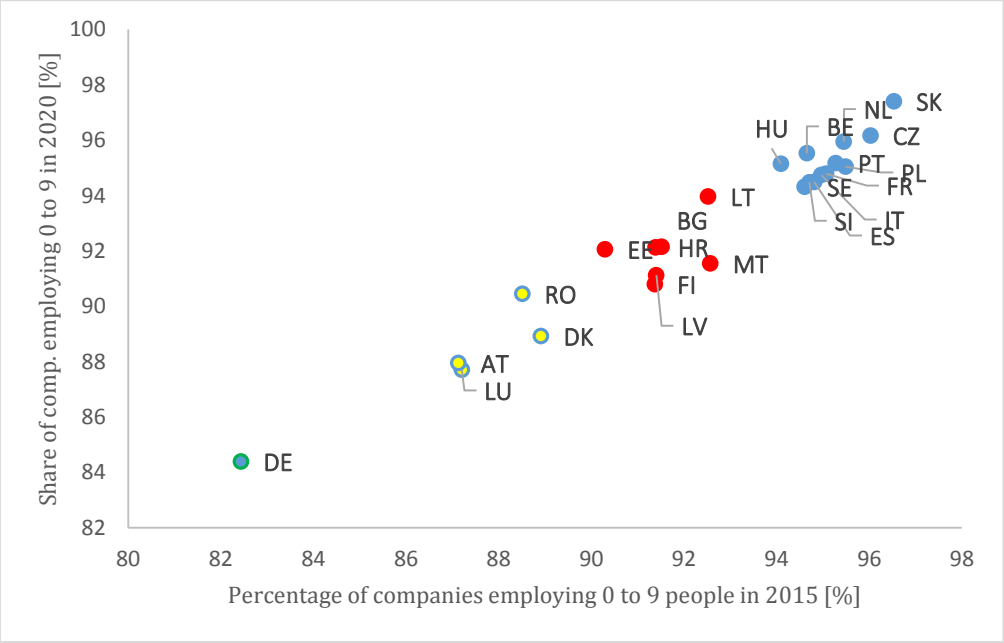

Figure 2. Share in the employment structure of EU countries of enterprises employing up to 9 persons.
Source: own study based on Eurostat, https://ec.europa.eu/eurostat/ October 2024.

In order to present the specifics of the phenomenon in individual countries, it can be observed that the highest proportion of enterprises employing up to 9 persons was in Slovakia (Fig. 2). In 2020, it was 97.41%, while it was lowest in Germany, where the proportion of the smallest enterprises was 82.44%. The biggest changes, however, occurred in Hungary and Belgium, but the increase in the number of these smallest enterprises did not exceed 1pc there.

Table 3.
Key characteristics for EU countries classified in Group 1I(%)

Group II	Luxembourg, Denmark, Romania, Austria									
	2015					2020				
	0-9	10-19	20-49	50-249	>250	0-9	10-19	20-49	50-249	>250
mean	87,94	6,25	3,67	1,77	0,37	88,76	5,81	3,43	1,65	0,35
minimum	87,13	5,56	3,49	1,62	0,32	87,71	4,94	2,96	1,35	0,29
maximum	88,91	7,15	3,84	1,98	0,46	90,45	6,63	3,70	2,00	0,46
SD*	0,91	0,72	0,16	0,15	0,06	1,24	0,73	0,32	0,27	0,08
CV**	1,03	11,58	4,41	8,55	16,63	1,40	12,54	9,33	16,45	21,49

SD* - standard deviation, *CV – coefficient of variation.

Source: own study based on Eurostat, https://ec.europa.eu/eurostat/, October 2024.

The second group of countries in the employment structure has the highest number of enterprises employing between 10 and 19 people. On average, the percentage of these companies was 6.25% in 2015 and 5.81% in 2020. The percentage of companies employing between 20 and 49 people is also highest in this group. In 2015 and 2020, the percentage of medium-sized enterprises was 3.67% and 3.43% respectively. During the analysed period, there was a slight increase in the average value (by 0.82 p.p.) of the number of companies employing fewer than 9 people. In other categories, a decrease in the average share of employment in the total number of enterprises was observed.

Figure 3. Share in the employment structure of EU countries of enterprises employing between 10 and 19 persons.

Source: own study based on Eurostat, https://ec.europa.eu/eurostat/, October 2024.

The highest percentage of companies with 10 to 19 employees was in Germany, with 9.84% in 2015 and 8.64% in 2020. This was followed by Austria and Luxembourg where the percentage of those employing 10 to 19 people was at 7.15% and 6.52% respectively in 2015. The lowest percentage of small enterprises was in Slovakia and Poland and the Czech Republic where the number of small enterprises did not exceed 2% of the total (Fig. 3).

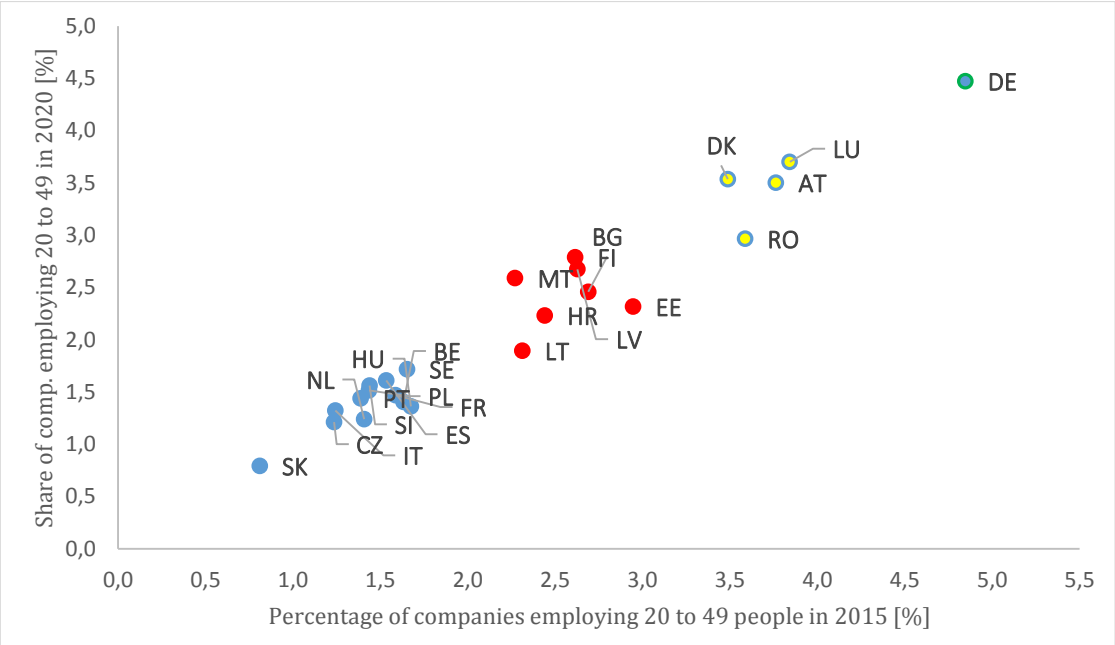

Figure 4. Share in the employment structure of EU countries of enterprises employing between 20 and 49 persons.

Source: own study based on Eurostat, https://ec.europa.eu/eurostat/, October 2024.

The third group is the one where Germany is classified and the percentage of companies employing between 20 and 49 people in the group of all operating companies did not exceed 4.85% in 2015 and 4.37% in 2020. %. Due to this feature, the EU countries create visible separate groups in 2020 (Fig. 4).

Table 4.
Key characteristics for EU countries classified in Group 1V(%)

IV	Bulgaria, Estonia, Malta, Finland, Latvia, Croatia, Lithuania									
	2015					2020				
	0-9	10-19	20-49	50-249	>250	0-9	10-19	20-49	50-249	>250
mean	91,58	4,36	2,56	1,28	0,22	91,97	4,23	2,42	1,18	0,20
minimum	90,30	3,77	2,27	1,18	0,18	90,80	3,03	1,89	0,95	0,16
maximum	92,57	4,95	2,95	1,56	0,26	93,96	4,82	2,79	1,32	0,27
SD*	0,78	0,44	0,24	0,13	0,04	1,03	0,60	0,30	0,14	0,04
CV*	0,85	10,11	9,20	10,46	16,20	1,12	14,23	12,56	12,07	18,72

SD* - standard deviation, **CV – coefficient of variation.

Source: own study based on Eurostat, https://ec.europa.eu/eurostat/, October 2024.

Seven countries were classified into group four. In 2020, compared to 2015, the diversity in all analysed employment groups increased, as indicated by increasing coefficients of variation. Countries were the most diverse in terms of the group of enterprises employing more than 250 persons. The coefficient of variation in this group increased by 2.52 p.p. in 2020 compared to 2015. The average share of enterprises employing up to 9 persons also increased slightly (by 0.39 p.p.).

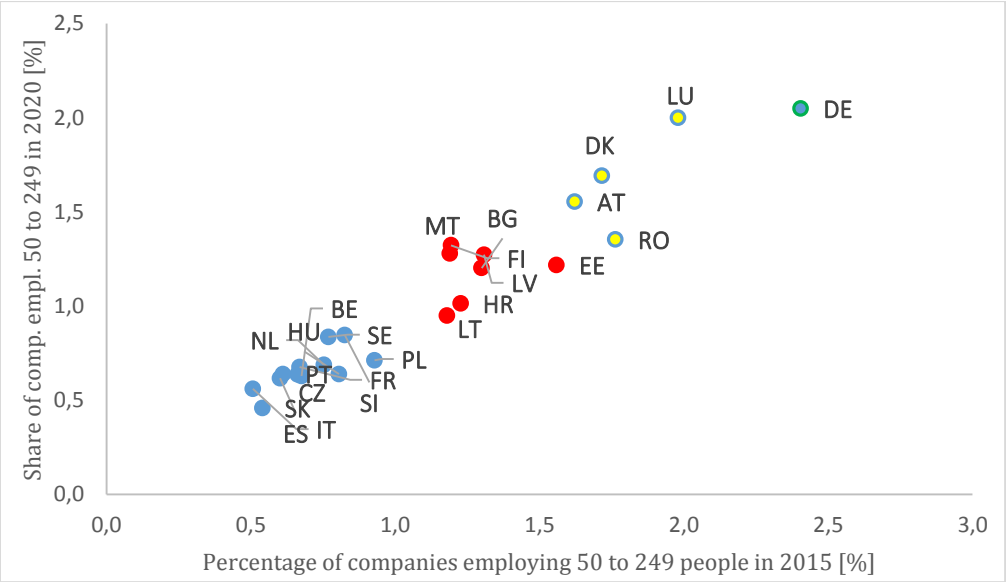

Figure 5. Share in the employment structure of EU countries of enterprises employing between 50 and 249 persons.

Source: own study based on Eurostat, https://ec.europa.eu/eurostat/, October 2024.

The proportion of the largest enterprises employing up to 249 people was highest in Germany and Luxembourg (Fig. 5). Although small and medium-sized enterprises are the most common employers in Germany, with as many as 59% of employees in the labour market working for SME companies, among EU countries in Germany the largest enterprises account for a relatively large proportion of employers.

Germany's economy is very versatile, but as far as manufacturing companies are concerned, it is based most heavily on the highly developed engineering industry. The automotive industry and the mechanical and plant engineering industry are the most important here. Germany is one of the largest car manufacturers in the world. The world's top two companies are the Volkswagen Group and Daimler. The number of employees testifies to the importance of the German automotive industry. It employs nearly 800,000 people (Destatis, 2024). In addition to the automotive industry, Germany also has a highly developed engineering industry. It is made up of almost 6500 companies in Germany. One of the largest representatives of this industry on the market is Siemens. The German economy also includes a very strong chemical, medical, pharmaceutical and food industry. All of these industries are represented by large corporations, hence Germany's clear advantage in terms of the share of large companies in the employment structure.

6. Conclusions

In a dynamically changing market environment, small and medium-sized enterprises are the main group of employers in all EU countries analysed. However, small changes in the structure of employment can be observed. In the group of enterprises employing up to 9 persons, the largest decrease was observed in Denmark, Romania, Estonia and Lithuania. In terms of employment structure, the number of small businesses has fallen in these countries respectively 1.95 pp, 1.94 pp, 1.77 pp, 1.44 pp respectively.

In the employment structure, the share of enterprises employing between 10 and 19 persons increased in 10 countries. Of which the largest increase was in Malta, Lithuania and France. In turn, the increase in the proportion of small companies was insignificant and did not exceed 0.4pc in these countries. Even smaller changes of less than 0.1 pp were observed in Finland and Slovenia in the group of companies employing 20-49 people. In the case of 15 countries, the proportion of companies employing between 50 and 249 people decreased, whereas the largest increase was observed in Finland and amounted 0.13 pc. For the largest companies, employing more than 250 people, there was little change in all countries analysed.

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