CLUSTER ANALYSIS OF E-COMMERCE IN THE EUROPEAN UNION COUNTRIES

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Abstract: E-commerce is the fastest growing segment in the trade sector and is of ever-increasing importance to the economy of the European Union. However, huge imbalances occur between individual countries when measuring the intensity of this type of trade. In the context of the new realities, the aim of the present study is, based on cluster analysis, to segment and identify the differences between the EU Member States in the field of e-commerce, and on this basis to formulate corresponding conclusions. Cluster analysis is applied to selected indicators (I) for measuring e-commerce in the European countries—I1. "E-commerce sales of enterprises"; I2. "Value of e-commerce sales"; I3. "Internet purchases by individuals". The clustering of the studied data refer to 2024. Technical processing and calculations are made using IBM SPSS Statistics. As a result of the study conducted, the 27 Member States are differentiated into four homogeneous clusters, which allows them to be interpreted as: leading countries in the e-commerce segment; countries catching up with the leaders; countries moderately advancing in e-commerce; countries in an unenviably lagging position.

Keywords: cluster analysis, clusters, e-commerce, EU Member States.
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Introduction

The revolutionary development of the Internet and digital technologies is fundamentally changing and transforming the way goods and services are sold and bought. Commercial transactions are increasingly taking place online. In view of this, conventional trade is rapidly being displaced by e-

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commerce, which is becoming an integral part of the global trade network for buying and selling goods and services. Moreover, this is the “new trade” in the European Union, which creates opportunities for increasing the level of customer satisfaction and expanding the scope and efficiency of purchase and sales channels. In economic terms, due to the activities of enterprises selling online and the change in consumer behaviour, significant progress has been made in the development of e-commerce in the European Union. Despite the positive aspects, there are huge imbalances and asymmetries occurring between the individual Member States.

The aim of the present study is to segment and identify the differences between the EU Member States in the field of e-commerce, based on cluster analysis, and to formulate corresponding conclusions thereof. Essentially, this study aims to answer the following research questions (RQ):

RQ1: What is the number of clusters from the 27 EU Member States generated based on the indicators characterizing e-commerce?

RQ2: What is the grouping of the 27 EU Member States in the relevant clusters according to the level of the determined quantitative indicators?

RQ3: What are the disparities and differences between the European Union countries by cluster in implementing e-commerce and how can they be identified and measured?

1. Literature Review

E-commerce leads to radical and qualitative changes in commercial processes based on increased digitalization and accelerated technological development. The literature review shows the existence of numerous studies highlighting the advantages of e-commerce compared to the traditional method of buying and selling (Gupta et al., 2023; Jain et al., 2021; Rizaldi & Madany, 2021; Gu et al., 2021; Taher, 2021; Li & Zhang, 2021; Brzozowska & Bubel, 2015; Qin, Chang, Li, & Li, 2014).

In essence, the focus is on opportunities for businesses to sell online by adopting a customer-centric approach and thus demonstrating “intelligent” market behaviour (Shah & Murthi, 2021; Hunter & Perreault Jr, 2006; Petrova & Tairov, 2022). The paper emphasizes the importance of integrating and using a wide range of digital technologies in the commercial activities of enterprises ensuring a continuous cycle of data processing and

exchange, through which online sales are optimized, reducing the time and costs for their implementation (Nicola & Setiawan, 2024; Hagsten, 2022; Lu, 2019; Goyal, et al., 2019; Ahearne, et al., 2013; Kuruzovich, 2013; Marshall et al., 2012). Besides, the benefits are indicated as a result of improving the orientation towards consumer demands, through the implementation of new models for managing the strategic and operational aspects of sales processes, which increases the competitiveness of enterprises and multiplies the beneficial effects (Pascucci, et al., 2023; Jain, et al., 2021). Despite the diversity of positions, researchers believe that e-commerce creates a new perspective for carrying out commercial transactions, through which enterprises generate higher economic and financial results, achieve better market positioning and realize greater efficiency of the overall commercial process.

On the other hand, there are a number of studies proving that modern consumers increasingly prefer to purchase goods and services for personal purposes over the Internet (Ren et al., 2025; Figueiredo et al., 2025;Yang, et al., 2023; Balacescu, et al., 2023; Zhang, et al., 2022). In this context, online consumers who participate in electronic transactions are provided with opportunities for global accessibility, a wide selection of goods, and parallel comparison of many goods and prices (Shah & Murthi, 2021). E-commerce is considered to be the more convenient and attractive segment for consumers seeking practicality and flexibility (Duch-Brown et al., 2017; Yu & Wu, 2007). Emphasis is placed on the role of e-commerce in transforming consumer behaviour and increasing satisfaction and commitment at every touchpoint in the customer experience lifecycle (Petrova, et al., 2022; Gimpel & Roglinger, 2015).

The literature review confirms the existence of numerous views, opinions and discussions on the impact, influence and significance of e-commerce. Research interest in this direction is constantly expanding. This is not accidental, since the relevance of the issue under consideration is undeniable.

2. Research Methodology

The systematic review of the various formulations in the outlined research area is a basis for adopting the position that e-commerce is becoming an indispensable part of the global trade network, which is developing extremely rapidly. At the same time, it should be emphasized

that significant variations in the main indicators characterizing e-commerce are manifested, especially between the EU countries.

In view of this, in the present paper, the focus of the study is placed on the segmentation and identification of differences in terms of e-commerce in the EU Member States using cluster analysis. For the purposes of the analysis, three indicators are used, which are included in the main sub-indicators of the Digital Economy and Society Index—DESI[2], characterizing the penetration of digital technologies into the economy and society. Specifically, these are the indicators (I) for measuring e-commerce in the EU countries: *I1. "E-commerce sales of enterprises"; I2. "Value of e-commerce sales"; I3. "Internet purchases by individuals".* In addition, the first two indicators characterize the relative share of enterprises with 10 or more employees that have sold goods online and generated turnover in the previous 12 months. The third indicator is brought to the relative share of individuals aged 16 to 74 who have purchased goods and services for personal purposes over the Internet in the last 12 months. It is important to note that the main source of statistical data used to conduct the study is Eurostat. The statistical data are the result of business surveys reported in 2024.

In methodological terms, the analysis is based on the application of clustering methods. In this regard, the three basic methods and the sub-methods included in them are implemented—Hierarchical Cluster Analysis, Non-Hierarchical Cluster Analysis and Two Step Cluster Analysis. With the help of the IBM SPSS Statistics, a preliminary measurement of the distances between the clusters is performed, using all alternative clustering methods (Ganeva, 2016). In this specific study, the Squared Euclidean Distance is taken as a measure. For this purpose, the values of the variables are standardized with the z-scores function (i.e. they have a mean value of 0 and a standard deviation of 1) (Ganeva, 2016). The most appropriate hierarchical clustering method Average Linkage (Between Groups) is selected, forming an optimal number of clusters for the current study. The selection is made based on the highest measured value of the contingency coefficient (0.866) compared to the approved methods.

[2] The Digital Economy and Society Index (DESI) is an annual report published by the European Commission that monitors the progress of the EU Member States in the field of digital technologies.

3. Results and Discussion

E-commerce is developing and establishing itself as one of the main trade segments within the European Union. The relative share of enterprises in the EU countries that sell goods and services online in 2024 amounted to 23.8%, and the annual turnover from online sales amounted to 19.1%. The European Union is the third largest online market after China and the United States, with 77.0% of internet users having purchased goods and services online for personal purposes (Eurostat, 2024).

The data studied show that enterprises in the European Union are increasingly participating in digital markets and are striving to satisfy diverse preferences and increase added value for consumers. In this context, enterprises offer direct and fast access to goods and services, without geographical and time constraints, provide multiple choices, implement special services and personalized campaigns that meet the unique requirements of individual online consumers. On the other hand, consumer behaviour in the European Union is changing towards increasing the use of the Internet, as well as online ordering or purchasing of goods or services. Due to greater flexibility, convenience and confidentiality in online transactions, more than 7 out of 10 internet users make online purchases (Eurostat, 2024).

Despite the positive changes reported, there are ***huge differences in intensity and significant variations in the level of the main indicators for measuring e-commerce between the individual EU Member States of the European Union.***

In view of this circumstance, cluster analysis is implemented, which allows to identify the differentiation of the studied objects into separate groups (clusters) in terms of e-commerce.

For the specific study, the optimal grouping based on the identified similarities and differences between the selected indicators allows for the generation of a total of ***four clusters***, consisting of a different number of Member States, in 2024.

The clustering is visualized using the dendrogram graphical tool. Each Member State of the Community is assigned a number ranging from 1 to 27, which facilitates the graphical representation: see Figure 1.

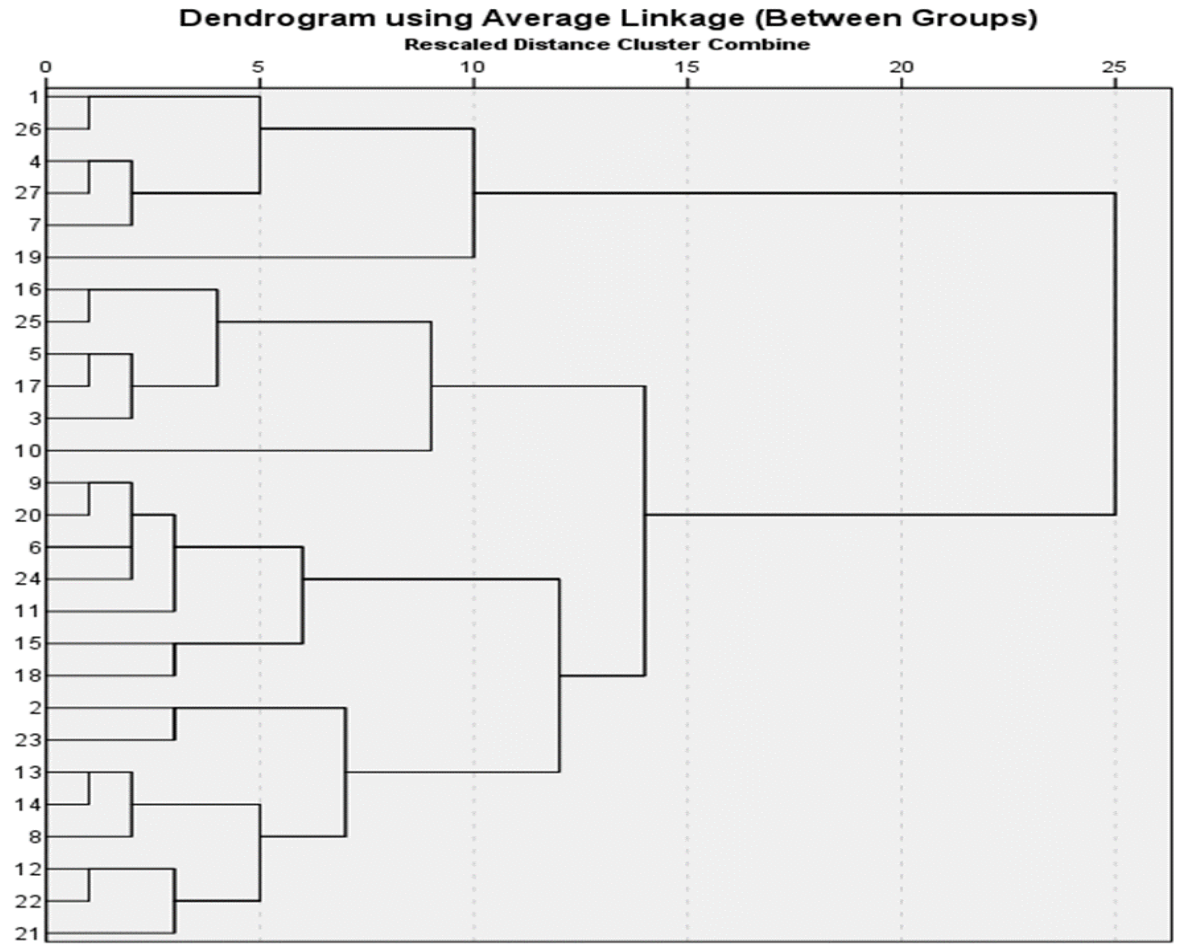

Figure 1. Dendrogram for generating clusters of the 27 EU Member States based on data on the three indicators characterizing e-commerce in 2024

Source: Eurostat and author's own calculations.

Figure 1 presents the four clusters generated by the applied software method. The further interpretation of the data for the three examined indicators characterizing e-commerce allows for the grouping of the individual Member States of the Community. In this analytical context, and in accordance with the attained level of e-commerce, it is appropriate to distinguish the following groups of countries: First cluster "Leading countries in the e-commerce segment"; Second cluster "Countries that are in an unenviably lagging position"; Third cluster "Countries catching up with the leaders"; Fourth cluster "Moderately advanced countries in e-commerce". The representation of the thus identified clusters is provided in Table 1.

Table 1
Clustering of the 27 EU Member States based on three indicators characterizing e-commerce in 2024

Cluster name	Countries
First cluster "Leading countries in the e-commerce segment"	Belgium (1), Finland (26), Denmark (4), Sweden (27), Ireland (7), Netherlands (19)
Second cluster "Countries that are in an unenviably lagging position"	Bulgaria (2), Romania (23), Cyprus (13), Latvia (14), Greece (8), Italy (12), Portugal (22), Poland (21)
Third cluster "Countries catching up with the leaders"	Luxembourg (16), Slovakia (25), Germany (5), Hungary (17), Czech Republic (3), France (10)
Fourth cluster "Moderately advanced countries in e-commerce"	Spain (9), Austria (20), Estonia (6), Slovenia (24), Croatia (11), Lithuania (15), Malta (18)

Source: Eurostat and author's own calculations.

As can be seen from the table, the leading countries in the e-commerce segment are included in the first cluster, among them Ireland, Denmark, Sweden, and others. These are countries where 9 out of 10 internet users purchase goods and services online, and a significant part of enterprises are very active in e-sales and generate cumulatively high turnover through internet transactions.

It is observed that the second cluster is the most numerous, consisting of countries in a rather disadvantaged position, such as Bulgaria, Romania, Italy, and others. Primarily businesses in these countries cannot take advantage of the opportunities offered by various online sales methods. As a result, they have a harder and slower time influencing the behaviour of active online users. Online interactions are still very weak.

The third cluster includes the countries that are catching up with the leaders, Czech Republic, Germany, Slovakia, and others. It should be emphasized that in these countries e-commerce is developing extremely rapidly. There is a constant positive trend of growth of enterprises with online sales and consumers making online purchases, which opens opportunities for further convergence with the leading countries.

The fourth cluster comprises the moderately advancing countries in e-commerce, such as Austria, Spain, Slovenia, and others. These countries have seen a gradual change in e-commerce, with a degree of variation around the average values for the EU-27. In fact, the online sales enterprises from the countries in the cluster have a development potential that should be built on and expanded. Overall, this will affect the commercial relations with consumers and will lead to an increase in their online consumption.

At the same time, an important part of the cluster analysis algorithm is to find out the role of individual indicators in the formation of clusters. In this aspect, the value of the significance level (Sig.) for each of the determined quantitative characteristics should be tracked. As a rule, a check is performed that provides the ability to control the risk of error based on a certain acceptable level, most often assuming α = 0.05. In cases where the values of Sig. are less than the selected risk of error, the feature is considered significant in distinguishing the units, conversely—with values of Sig. higher than the risk of error, the variable is not important for the formation of clusters.

The results of testing the three indicators, the values of which for 2024 are included in determining the clusters, show that all, without exception, have statistical significance, which is confirmed by the data in Table 2.

Table 2
Determining the participation of indicators in the distribution of the 27 EU Member States by cluster in 2024

ANOVA Table

		Sum of Squares	df	Mean Square	F	Sig.
Value of e-commerce sales* Average Linkage (Between Groups)	Between Groups (Combined)	605.587	3	201.862	13.797	<0.001
	Within Groups	336.500	23	14.630		
	Total	942.087	26			
E-commerce sales of enterprises* Average Linkage (Between Groups)	Between Groups (Combined)	1366.663	3	455.554	23.950	<0.001
	Within Groups	437.478	23	19.021		
	Total	1804.141	23			
Internet purchases by individuals* Average Linkage (Between Groups)	Between Groups (Combined)	2939.194	3	979.731	30.151	<0.001
	Within Groups	747.377	23	32.495		
	Total	3686.571	26			

Source: Eurostat and author's own calculations.

The data presented in Table 2 show that the significance level of the three indicators (Sig.) is less than the selected risk of error (α = 0.05), therefore their role in distinguishing the four clusters is significant.

In parallel, it is necessary to determine the degree of significance of the individual indicators in clustering. For this purpose, the coefficient of determination (Eta Squared) is used, which is shown in Table 3. According to the data in Table 3, reported in 2024, the one with the greatest contribution to the formation of the clusters is I3. "Internet purchases by individuals". Second comes I1. "E-commerce sales of enterprises". With the smallest contribution is I2. "Value of e-commerce sales".

Table 3
Determining the contribution of indicators in the distribution of the 27 EU Member States by cluster in 2024

Measures of Association

	Eta	Eta Squared
Value of e-commerce sales* Average Linkage (Between Groups)	0.802	0.643
E-commerce sales of enterprises* Average Linkage (Between Groups)	0.870	0.758
Internet purchases by individuals* Average Linkage (Between Groups)	0.893	0.797

Source: Eurostat and author's own calculations.

In the context of the analysis conducted, it is found that the average values reported in 2024 for the individual indicators that form the four clusters vary widely. In addition, huge differences in the average values of the indicators between the individual clusters are found, which is evidence of major imbalances. Specific data in this regard are presented in Table 4 (See Table 4).

As can be seen from the table, the indicator with the highest average value in the first cluster "Leading countries in the e-commerce segment" is indicator I3. "Internet purchases by individuals" with 87.23%. I1. "E-commerce sales of enterprises" comes second with 35.39%. I2. "Value of e-commerce sales" is third with 26.18%.

The results illustrated in Table 4 show that in 2024 the indicators have a similar structure within the second, as well as within the fourth cluster. The highest average value in the second cluster "Countries that are in an unenviably lagging position" is taken by I3. "Internet purchases by individuals"—60.10%, followed by I1. "E-commerce sales of enterprises"—

19.44%. The lowest value is for I2. “Value of e-commerce sales”—13.41%. In the fourth cluster “Moderately advanced countries in e-commerce”, the average values are as follows: I3. “Internet purchases by individuals”—67.41%, I1. “E-commerce sales of enterprises”—31.83% and I2. “Value of e-commerce sales”—17.18%.

Table 4
Determining the average values and standard deviations of the indicators in the distribution of the 27 EU Member States by cluster in 2024

Report

Average Linkage (Between Groups)		Value of e-commerce sales	E-commerce sales of enterprises	Internet purchases by individuals
First cluster “Leading countries in the e-commerce segment”	Mean	26.1750	35.3867	87.2300
	N	6	6	6
	Std. Deviation	4.06869	3.55228	7.77607
Second cluster “Countries that are in an unenviably lagging position”	Mean	13.4137	19.4413	60.1025
	N	8	8	8
	Std. Deviation	4.16883	3.37233	6.40396
Third cluster “Countries catching up with the leaders”	Mean	21.0017	19.4550	78.6900
	N	6	6	6
	Std. Deviation	4.52393	4.53250	2.57261
Fourth cluster “Moderately advanced countries in e-commerce”	Mean	17.1786	31.8300	67.4143
	N	7	7	7
	Std. Deviation	2.22653	5.65771	4.56205
Total	Mean	18.9119	26.1996	72.1570
	N	27	27	27
	Std. Deviation	6.01948	8.33007	11.90761

Source: Eurostat and author’s own calculations.

Only in the third cluster “Countries catching up with the leaders”, the average values of the indicators are in a different structural relation. The average level of I3. “Internet purchases by individuals” is the highest—78.69%, I2. “Value of e-commerce sales” takes the second place with 21.00%, and I1. “E-commerce sales of enterprises” ranks third with 19.46%.

In fact, comparing the values of the indicators for the individual clusters in Table 4 proves the presence of huge differences and disproportions in the development of e-commerce. For example, the data for I1. “E-commerce sales of enterprises” show that the countries in the first cluster are the undisputed leader, since in 2024 they have a level 15.95 percentage points higher than the countries in the second cluster, 15.93 percentage points higher than those in the third cluster and 3.56 percentage points higher than the countries in the fourth cluster. From the point of view of the parameters of the indicator, there is an imbalance, since the average value of the indicator for the countries in the first cluster is 9.19 percentage points higher than the average level for the EU-27, and for the fourth cluster it is 5.63 percentage points higher. While in the second and third clusters, the level of the indicator is below the EU-27 average, by 6.76 and 6.74 percentage points, which is an indication of significant lagging behind.

There is also a large difference in I2. “Value of e-commerce sales” The countries in the first cluster are ahead of those in the second cluster by 12.77 percentage points, in the third cluster by 5.18 percentage points and in the fourth cluster by 9.00 percentage points. It should be emphasized that the average values of the indicator for the first and third clusters are above the average level for the EU-27, respectively by 7.27 and 2.09 percentage points. While for the second and fourth clusters they are below the average level for the EU-27 by 5.50 and 1.73 percentage points.

Regarding I3. “Internet purchases by individuals” an identical situation is observed, but with a more pronounced difference. The analysis of the data in Table 4 shows that in 2024 the indicator for the countries in the first cluster is 27.13 percentage points higher than the second cluster and 19.82 percentage points higher than the fourth cluster, while for the third cluster it is 8.54 percentage points higher. It is striking that the imbalances indicated are the largest, since the countries in the first cluster are 15.07 percentage points and the third cluster are 6.53 percentage points above the average level for the EU-27. The negative fact is that the indicator for the countries in the second and fourth clusters is 12.06 and 4.75 percentage points below the average for the EU-27.

To support the interpretation of the research results and to provide clearer visualization, Figure 2 is presented below.

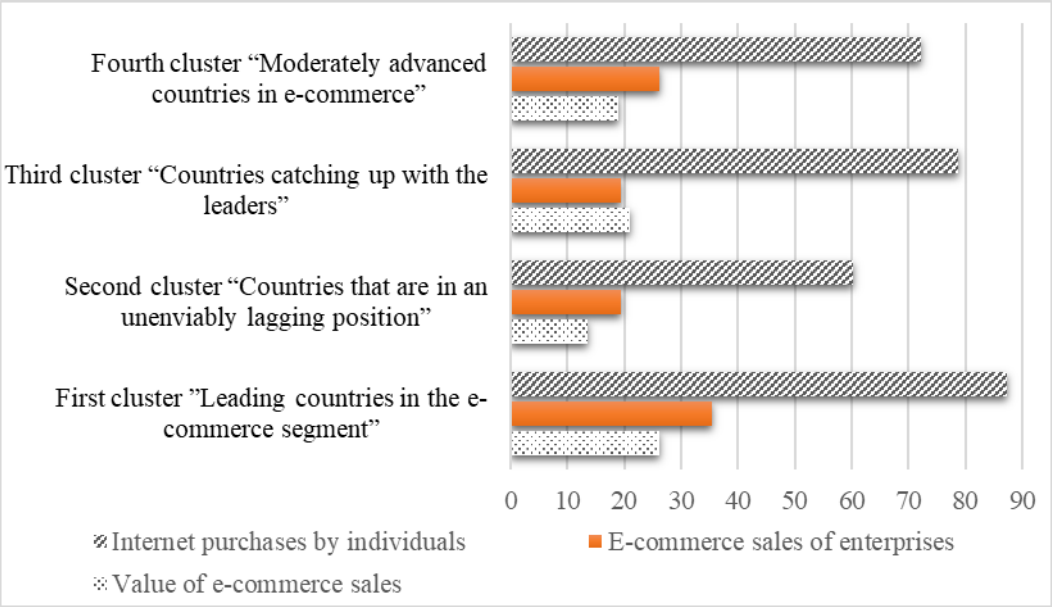

Figure 2. Average values of the indicators measuring e-commerce, by cluster, in 2024

Source: Eurostat and author's own calculations.

The figure shows the existing differentiation among the four clusters in terms of the average values of the measured indicators characterizing: e-commerce sales of enterprises; value of e-commerce sales generated by the enterprises; and internet purchases by individuals in the European Union.

In the outlined research area, there is an opportunity for discussion and comparison of the results of other researchers, including at the European level. The conducted cluster analysis reveals a clear distinction between countries with a high level of digitalization and a well-developed online markets—such as Sweden, Denmark, Finland, Ireland, the Netherlands, and Belgium—and countries with lower levels of e-commerce development, predominantly from Southern and Eastern Europe. Similarly, the European E-commerce Report highlights significant regional disparities in online trade within the EU, despite an overall steady growth trend (European E-Commerce Report, 2024). Analogous observations have been made by researchers in their empirical studies using the cluster approach, highlighting, on the one hand, the qualitative differences in e-commerce practices among European enterprises (Zoroja et al., 2020; Scutariu et al., 2022), and on the other hand, the existence of distinct clusters based on consumer behaviour (Brcanov, et al., 2025). In this context, the present study confirms and builds upon existing research, offering new perspectives

for reducing disparities among European Union Member States in the field of e-commerce.

Conclusions

E-commerce is developing extremely dynamically within the European Union. Regarding individual Member States, the conducted cluster analysis confirms the huge differences in intensity and significant variations in the level of the main indicators for measuring e-commerce.

In view of the results obtained from the analysis and the ensuing findings, it should be emphasized that the research questions posed are largely answered. Specifically:

First. Four homogeneous clusters are generated from the 27 Member States of the European Union, because of the identified similarities and differences between the selected indicators characterizing e-commerce.

Second. Grouping the countries in the European Union into clusters, according to the level of the determined quantitative indicators, allows them to be interpreted as: leading countries in the e-commerce segment; countries catching up with the leaders; moderately advancing countries in e-commerce; countries in an unenviably lagging position. The highest measured values of the analysed indicators are reached by countries such as: Ireland, Denmark, and Sweden, etc.

Third. There are huge differences in the average values of the indicators between the individual clusters. The countries in the second cluster lag significantly, especially in I2. “Value of e-commerce sales” and I3. “Internet purchases by individuals”. Countries such as Bulgaria, Romania, Latvia, Greece have unrealized opportunities in the area under study.

Fourth. The average values reported for the individual indicators that form the four clusters vary widely, which is evidence of large imbalances. Although the countries in the third cluster indicate a convergence to the leaders in two of the indicators, the leading countries in the first cluster are significantly differentiated from those in the fourth cluster and especially from the countries in the second cluster.

Therefore, the focus should be on accelerating the digitalization of trade processes and increasing the implementation of electronic transfers of goods and services, especially in the countries of the second cluster. Otherwise, the imbalances would worsen and deepen to the point of

insurmountability. Continuing research in this area allows us to reach relevant and practically significant economic instruments for overcoming the differences between the European countries studied.

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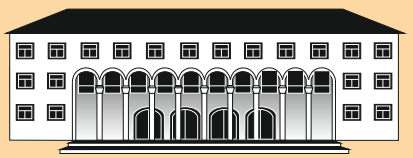

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