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The Digital Divide in the European Union in 2021

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Abstract

The main research question is to explore whether there is a digital divide in the European Union and to suggest a scientific method to define the member states' digitalization performance in 2021. The methodology includes hierarchical clustering approach based on data from the annual Digital Economy and Society Index (DESI) of the European Commission. The goals of this study are: 1/ To make a comparative study of the EU countries according to their performance in each of the four dimensions of the DESI, which is presented graphically. This proves the existence of a deep digital divide in the EU in all four digitalization dimensions, where the difference between the best and worst performing countries is from 2 to 4 times. 2/ To further explore the digital divide through hierarchical clustering analysis, implemented in SPSS, which groups the EU countries in clusters according to the proximity of their performance in the four DESI dimensions. The applied method, presented by a dendrogram, suggests that at a reasonable cluster distance (less than 5) there are four clusters of EU countries in terms of digitalization performance, which the author has named "digitalization leaders", "strong digitalizators, moderate digitalizators and modest digitalizators". The data used is for 2021.

Keywords: digital divide, digitalization, DESI, European Union

JEL: O33, F02

Introduction

There are a lot of studies concerning the divergence in the performance of the EU member states in the economic and social sphere, but not much concerning the divergence in the sphere of technological development and digitalization. However, this is an important issue, since the level of digitalization of the contemporary economy and society is a key factor for their development in the digital era. The significance of the digitalization performance of the countries is continuously growing, which necessitates finding ways to evaluate it.

The objectives of this study are to analyze the digital divergence between the EU member states, to explore whether there is a digital divide in the European Union and to suggest a scientific method to classify the member states' digitalization performance in 2021.

The research contribution of this study is that it makes an insight into the EU member states' digital performance through clustering.

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As long as clusters consist of countries with common characteristics, this classification presents the leader countries as reference and a good example for the member states that lag behind and need to catch up in the sphere of digitalization.

The main research question of this study is to explore whether there is a digital divide in the European Union and to suggest a scientific method to define the member states' digitalization performance through clustering.

The research tasks of the paper are: 1/ To make a comparative study of the EU countries in their digital performance according to each of the four dimensions of the Digital Economy and Society Index (DESI), which is presented in figures. 2/ To explore the existence of a digital divide in the EU through hierarchical clustering analysis, implemented in SPSS, which groups the EU countries in clusters according to the proximity of their performance in the four DESI dimensions.

The methodology of this study lies on the European Commission's data for measuring the Digital Economy and Society Index (DESI), which uses data from Eurostat and specialized studies. This index measures the EU member states' performance in the digital sphere and is used as a basis for the empirical study. The data used is for 2021.

The key finding of the study is that it proves the existence of a deep digital divide in the EU in all four digitalization dimensions, where the difference between the best and worst performing countries is 2, 3 or 4 times. In addition to it, the applied method of clustering suggests that there are four main clusters of EU countries in terms of digitalization performance, which can be named "digitalization leaders", "strong digitalizators, moderate digitalizators and modest digitalizators". The belonging of each of the countries in these clusters suggests that these countries need to take appropriate measures to either keep their leading place in the digitalization rating or to catch-up with the EU leaders in the long run.

The value added generated by this study is that it presents another perspective to countries classification in terms of digitalization. The results obtained are a signal to stakeholders and policy-makers, as well as to researchers in comparative studies and digitalization fields.

The structure of the paper contains four sections as follows: 1/ Introduction; 2/ Literature review; 3/ Data, methodology, results, and 4/ Conclusion.

Literature review

The following literature review refers to the studies that concern the main aspects of the present paper – the digital divide and its definition, the classification of EU member states in terms of their digital performance and the potential impact of the digital divide on certain aspects of the European economy and society.

The first problem with the study of the digital divide is the general lack of a clear definition of what it actually represents. One definition of the term "digital divide" suggests that this is the gap that exists in most countries between those with ready access to the tools, information and communication technologies (ICTs), and those without such access or skills (Cullen, 2001). It can be due to socio-economic factors, geographical factors, educational factors, factors resulting from the peculiarities of different attitudes and generations, as well as physical disabilities. Cuervo and Menendez (2006) identify two forms of digital divide: within a country (domestic) and between countries (international).

Gunkel (2003) considers the term "digital divide" as deeply ambiguous in the sharp dichotomy to which it refers. Van Dyck (2003, 2005) states that this term has numerous drawbacks: 1/ it implies a simple division between two clearly separated groups with a large gap between them; 2/ it suggests that this gap is very difficult to bridge; 3/ it suggests that the divide is about absolute inequalities between the included and the excluded, when in fact most observed inequalities in access to digital technologies are relative; 4/ it assumes that the digital division is a static state, when in fact it is constantly changing. Both researchers emphasize that the term is primarily associated with gaining physical access to digital technologies.

Riccardini and Fazio (2002) mention different indicators, which are important for the digital divide evaluation. First, it considers the usage of ICT technologies by the different groups - individuals, households, businesses and other groups. Secondly, the infrastructures access, human capabilities, knowledge and education, and IT expertise should be analyzed. Household's size, type, age, gender, racial and linguistic backgrounds and location as well as differences in the profile of countries and business could indicate differences in using the new technologies and the Internet.

OECD (2001) makes important reference to the digital divide in households stating that it depends primarily on two variables - income and education. Largely through its effects on income, the higher the level of education, the more likely individuals are to have access to ICTs. Other variables, such as household size and type, age, gender, racial and linguistic backgrounds, and location also play an important role.

Sorj (2008) identifies five factors of the digital divide that determine the level of equality of access to information technology systems: 1) the availability of physical transmission infrastructure; 2) availability of connecting equipment such as computer, modem and access line; 3) training for working with computers and the Internet; 4) intellectual abilities and social inclusion of users (a result of the educational and intellectual level, profession and social network, which determines the effective use of information and the needs of Internet communication); 5) the production and use of specific content adapted to the needs of different segments of the population. While the first two criteria refer to the passive dimensions of Internet access, the last three dimensions identify areas of potential active uptake and development. Starting from the first, each subsequent level is a prerequisite for the next.

The problem with the definition of the digital divide is even broader as there is not a single definition of the digital economy as well.

Bukht and Heeks (2017) try to develop a definition of the digital economy, and to estimate its size. They argue that the digital economy has three scopes of relevance – core (the IT/ICT sector producing foundational digital goods and services), true (the digital sector plus emerging digital and platform services) and the widest (the 'digitalized economy').

An analytical framework for measuring the digital economy was developed by Ahmad and Ribarsky (2018) that highlighted the lack of statistics that explicitly reveal the role of digitalization in production and consumption. Doong and Ho (2012) developed a framework to reduce multivariate raw data into an ordinal number representing a country's ICT

development level. The methodology behind the framework involves data clustering and multi-dimensional data ranking. On that basis they explored the ICT development paths of different countries, and they showed that countries with different GNI levels have different ICT development paths.

A more recent research concerning the digital divide in the European Union in the period 2008 – 2010 (Cruz-Jesus et al. 2012) proved the existence of a digital divide in the EU. The factor and cluster analysis in it classifies the EU member states into five groups. The paper suggests that the digital gap in the EU is evident and it is mainly the consequence of the process of European integration and the differences between the countries in terms of economic wealth.

Three clusters of EU countries were identified by the level of digital economy development in the empirical study of Bilozubenko et al. (2020) - leaders, followers and outsiders. The paper compares digital economy development parameters of the EU countries based on cluster analysis and determines the most significant of them for bridging the digital divide between the EU countries. The parameter chart shows for each country what parameters it needs to increase in order to move to a cluster with more successful states.

Similarly, another study defines three levels of the digital divide on the example of the Eastern European countries: the spread and use of the Internet (first level of digital divide), the level of digital skills (second level of digital divide), and digital services used by citizens to improve their quality of life (third level of digital divide). The article specifically focuses on the third level of digital divide, by analyzing on a macro level three tangible outcomes - eGovernment service completion and use, eHealth services, and eCommerce. The study reported discrepancies among countries of East Europe, as well as a distinct difference between some countries and the overall European Union averages, suggesting the existence of two groups of countries in the digital divide (Ragnedda and Kreitem, 2018).

In the scientific literature, the digital divide in e-government services is also explored. Pérez-Morote et al. (2020) confirmed the differences in the use of e-government services across the European countries and focused on the differences in income and education as a main reason for the existence of digital divide.

A new study (Castelo-Branco et al, 2023) explores the existence of a digital divide as it concerns the concept of the Fourth industrial revolution. In it cluster analysis is used that consequently leads to five homogeneous profiles of Industry 4.0 performance across different industries and European countries. The empirical finding of the study reveals a significant Industry 4.0 divide across (and within) European countries and industries. Furthermore, it suggests that Industry 4.0 is much more determined by the industry than by the country.

Szeles (2018) analyses regional- and country level determinants of the regional digital divide in the EU and concludes that the stimulating of regional economic growth, increasing the tertiary education attainments, boosting R&D expenditure, and discouraging early leaving from education are regional- and national level policy measures that can reduce the regional digital divide in the EU.

The classification of countries in terms of digital performance is important because the level of digitalization has serious implications on countries' economic development, growth and competitiveness. The positive impact

of digitalization was also acknowledged on welfare (Pelinescu et al, 2021) and on the reducing of the risk of poverty and social exclusion in the European Union (Kwilinski et al. 2020).

The present paper supplements the findings made by the above-mentioned previous studies concerning the existence of a digital divide in the European Union. It presents an alternative methodology for classification, based on DESI and the most recent data available (for 2021) and further highlights the need for specific measures for overcoming the digital gap between the European member states.

Data, methodology and results

Data description

This section explains the sources and properties of the data used in the empirical research. As a first step, it is necessary to present the methodology of DESI (Digital Economy and Society Index) of the European Commission. The index is based on four dimensions (with weight of 25 %), each of which has sub-dimensions comprising different indicators.

Table 1. Structure (dimensions, sub-dimensions and indicators) of DESI

Dimension and weight (%) in overall DESI	Sub-dimension and its weight (%) in the dimension	Indicator
1. Human capital (25 %)	1a Internet user skills (50 %)	1a1 At least basic digital skills
		1a2 Above basic digital skills
		1a3 At least basic software skills
	1b Advanced skills and development (50 %)	1b1 ICT specialists
		1b2 Female ICT specialists
		1b3 Enterprises providing ICT training
		1b4 ICT graduates
2. Connectivity (25 %)	2a Fixed broadband take-up (25 %)	2a1 Overall fixed broadband take-up
		2a2 At least 100 Mbps fixed broadband take-up
		2a3 At least 1 Gbps take-up
	2b Fixed broadband coverage (25 %)	2b1 Fast broadband (NGA) coverage
		2b2 Fixed Very High Capacity Network (VHCN) coverage
	2c Mobile broadband (40 %)	2c1 4G coverage
		2c2 5G readiness
		2c3 5G coverage
		2c4 Mobile broadband take-up
	2d Broadband prices (10 %)	2d1 Broadband price index

Dimension and weight (%) in overall DESI	Sub-dimension and its weight (%) in the dimension	Indicator
3. Integration of digital technology (25 %)	3a Digital intensity (15 %)	3a1 SMEs with at least a basic level of digital intensity
	3b Digital technologies for businesses (70 %)	3b1 Electronic information sharing
		3b2 Social media
		3b3 Big data
		3b4 Cloud
		3b5 AI
		3b6 ICT for environmental sustainability
		3b7 e-Invoices
	3c e-Commerce (15 %)	3c1 SMEs selling online
		3c2 e-Commerce turnover
		3c3 Selling online cross-border
4. Digital public services (25 %)	4a e-Government (100 %)	4a1 e-Government users
		4a2 Pre-filled forms
		4a3 Digital public services for citizens
		4a4 Digital public services for businesses
		4a5 Open data

Source: European Commission, 2021a

The Digital Economy and Society Index (DESI) summarises indicators on Europe's digital performance and tracks the progress of EU countries. It is a compound index using the Eurostat working database, which is derived from the results from the surveys on the usage of information and communication technologies in enterprises and households/ by individuals[1].

In the present study, the results of the Digital Economy and Society Index (DESI) for 2021 are used as a basis for the application of the hierarchical clustering approach.

Statistical data

In 2021 the DESI showed progress in all EU countries and in all dimensions - human capital, broadband connectivity, integration of digital technologies by enterprises and digital public services. All countries are advancing in digitalisation, but the overall picture shows large variations between countries, despite a weak convergence (Fig. 1).

Regarding the Human Capital indicator, in 2021 only 56% of the people in the EU have at least basic digital skills. The best performing country – Denmark – has a value of this indicator at over 17, while the worst performing is Bulgaria - 8,2. Thus, the difference between the individual European countries exceeds 2 times (Fig. 2).

As it concerns digital skills, in 2020 there are 8.4 million ICT professionals in the EU but over half of the businesses find it difficult to hire such (European Commission, 2021c). The EU's 2030 targets are at least 80% of the

[1] The comprehensive Eurostat working database https://ec.europa.eu/eurostat/web/digital-economy-and-society/data/comprehensive-database

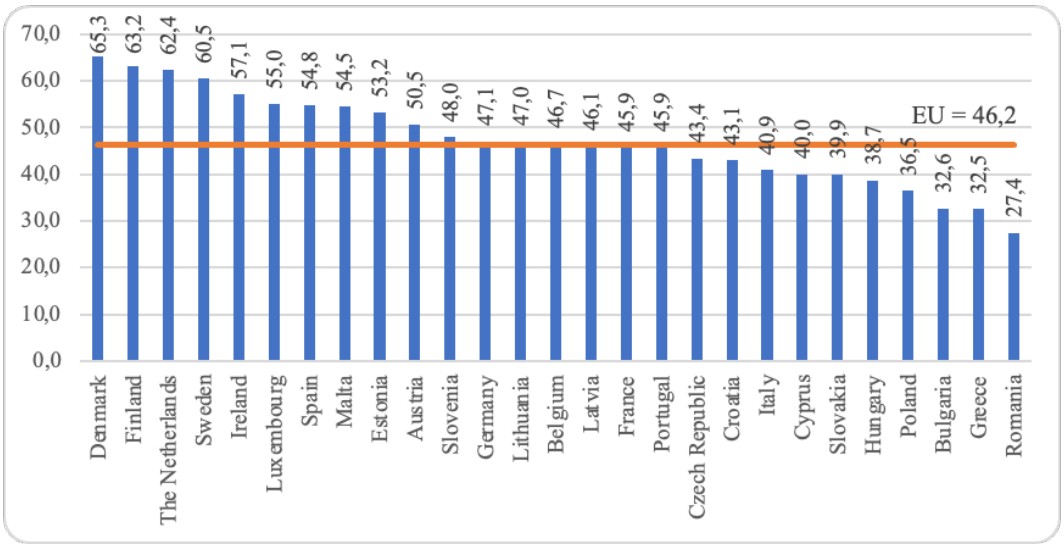


Figure 1. Performance of EU countries in the overall DESI in 2021
Source: Based on data of the European Commission, 2021b

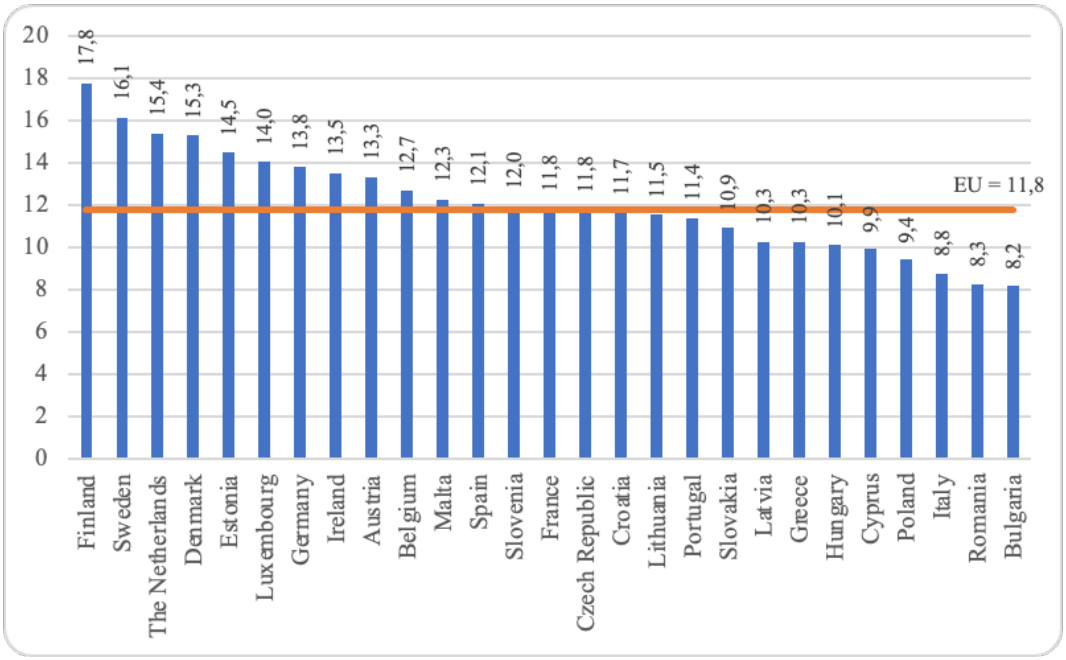


Figure 2. Performance of EU countries according to the "Human capital" dimension in 2021
Source: Based on data of the European Commission, 2021b

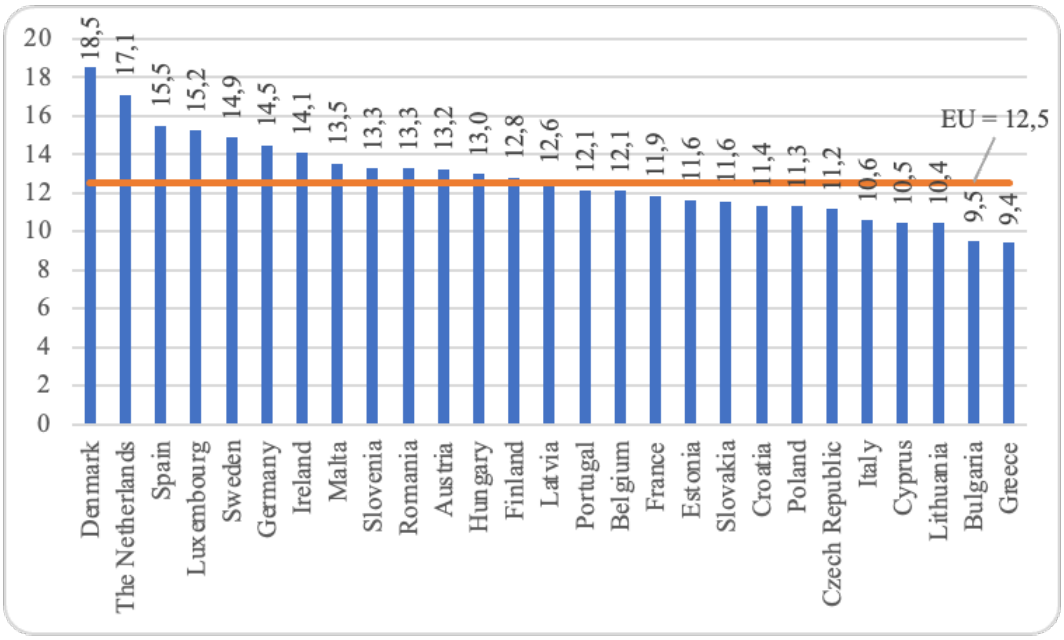


Figure 3. Performance of EU countries according to the "Connectivity" dimension in 2021
Source: Based on data of the European Commission, 2021b

EU population to have at least basic digital skills and to have at least 20 million ICT professionals.

In terms of connectivity, Denmark has the highest score, while Greece and Bulgaria - the lowest. The difference in their performance is more than 2 times (Fig. 3).

In the EU the use of fixed broadband is increasing, reaching 77%, and the coverage of fixed very high-capacity networks (VHCN) is available to 59% of the households in the Union. The EU's Digital Decade sets two broadband targets for 2030: gigabit coverage for all households and 5G in all populated areas.

In terms of the integration of digital technologies, Finland and Denmark are the best performers, while Bulgaria and Hungary are the worst (Fig. 4). The difference between them is almost 3 times.

Denmark and Finland are the only EU countries where the share of enterprises with a very high Digital Intensity Index - DII[2] (i.e. having at least 10 of the 12 digital technologies) is over 5%, followed by Belgium, Malta and the Netherlands with over 2%. In contrast, in Bulgaria, Romania, Latvia, Hungary and Cyprus most enterprises (over 50%) have invested only a little in digital technologies (they have a very low DII).

[2] The Digital Intensity Index (DII) is a composite indicator, derived from the survey on ICT usage and e-commerce in enterprises. It includes 12 variables having a score of 1 point,each and distinguishes four levels of digital intensity for an enterprise: 0 to 3 points - a very low level of digital intensity, 4 to 6 – low, 7 to 9 – high and 10 to 12 points – very high DII. Source: Eurostat, https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20211029-1

It is mainly the big enterprises in the EU that use digital technologies - 80% and 35 % of them have implemented ERP systems and cloud computing software, respectively, while this is so in only 48% and 25% of the European SMEs. The current state of digital adoption is far from the EU Digital Decade goals for 2030, where the target is 90% of the SMEs to have at least a basic level of digital intensity and at least 75% of enterprises to use advanced digital technologies.

Regarding the digital public services, the EU data for 2021 do not show a significant increase in e-government services. The difference in the performance of the member states increases to 4 times, with Estonia in first place and Romania in last (Fig. 5).

In the first year of the pandemic, several Member States have built or improved digital platforms to provide more services online. The eGovernment Benchmark 2021, which is a survey of citizens in 36 European countries about their use of digital public services, shows that more than 8 in 10 government services (81%) are delivered online, but more just under half (43 %) of these are granted to foreigners in these countries, due to linguistic barriers and non-acceptance of foreign identification documents (European Commission, 2021d).

So far it can be concluded that there is a deep digital divide in the EU across all four dimensions, with a large number of countries lagging well behind the best performing countries in all digital aspects. The difference between the strongest and the weakest performance in the four separate dimensions of the DESI is between 2 and 4 times. To achieve the stated digitalization goals, countries have earmarked a minimum of 20% of the funds in their recovery and resilience plans to be spent on digitalization (European Parliament, 2022), but given that some countries have allocated more, it can be expected that differences between countries may not only not decrease, but further grow.

Research methodology

Cluster analysis is a common technique for statistical data analysis that represents the grouping of a set of objects in such a way that objects in the same group (cluster) are more similar to each other than to those in other clusters.

Hierarchical clustering (hierarchical cluster analysis) is an algorithm that builds models based on distance connectivity. It groups similar objects into groups called clusters, where each cluster is distinct from the others, while the objects within each cluster are similar to each other. In the hierarchical clustering approach the “objects” are connected to form “clusters” based on their distance. A cluster can be described largely by the maximum distance needed to connect parts of the cluster. At different distances, different clusters will form, which can be represented using a dendrogram.

A dendrogram is a diagram representing a tree. In hierarchical clustering, it illustrates the arrangement of the clusters produced by the corresponding analyses (Everitt, 1998). In a dendrogram, the y-axis marks the distance at which the clusters merge, while the objects are placed along the x-axis.

The comparative analysis of the countries’ performance in the previous point proved the existence of a significant digital divide in the EU. The goal of the following analysis is to further explore it by classifying countries in different groups according to their digitalization achievements. This is done by applying a hierarchical clustering method, implemented in SPSS, which groups the EU countries in

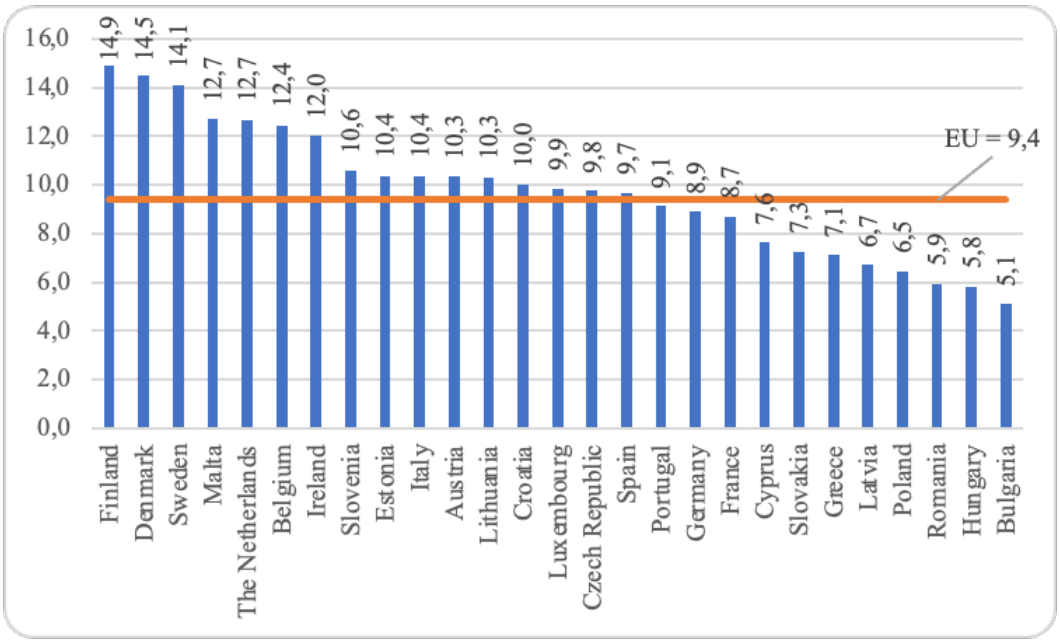


Figure 4. Performance of EU countries according to the "Integration of digital technology" dimension in 2021
Source: Based on data of the European Commission, 2021b

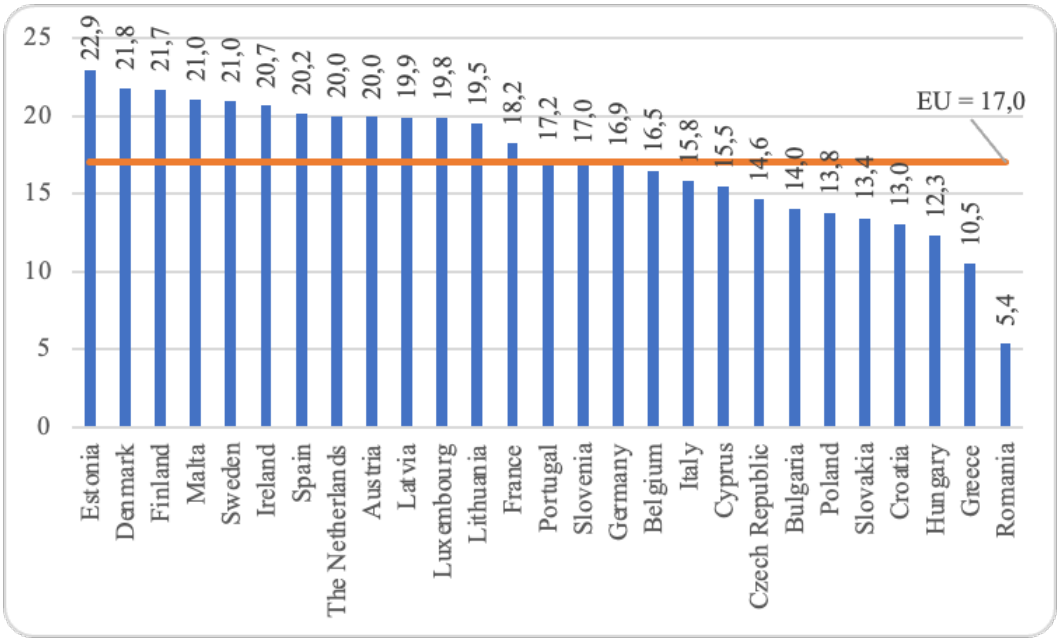


Figure 5. Performance of EU countries according to the "Digital public services" dimension in 2021
Source: Based on data of the European Commission, 2021b

clusters according to the proximity of their performance in the four DESI dimensions. The applied method suggests that at each level of distance there is a different number of country clusters in terms of similarity in their digitalization indicators.

The result from the analysis is illustrated by a dendrogram of EU countries' digitalization performance.

Empirical results

The result from the analysis is illustrated by a dendrogram of EU countries' digitalization performance (based on DESI data for 2021), fig. 6.

If we choose a cluster distance at less than 5 (illustrated by the red line), we have four clusters of countries according to their digitalization performance, which are:

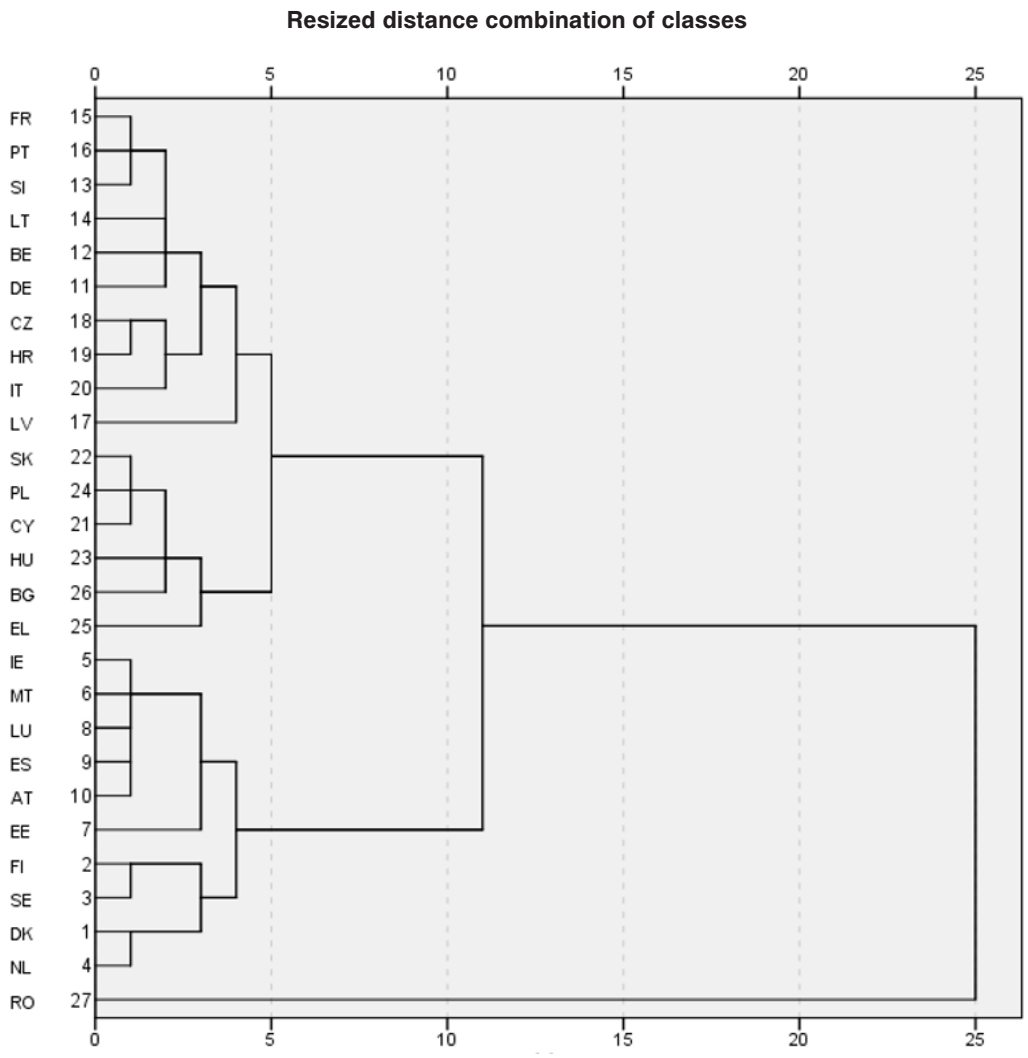
- First cluster: Denmark, Finland, Sweden the Netherlands, Ireland, Malta, Estonia, Luxembourg, Spain and Austria (10 countries).
- Second cluster: France, Portugal, Slovenia, Latvia, Belgium, Germany, Czech Republic, Croatia, Italy and Latvia (10 countries).
- Third cluster: Cyprus, Slovakia, Hungary, Poland, Greece and Bulgaria (6 countries).
- Fourth cluster: Romania (1 country).

Cutting the dendrogram like that shows four clusters based on similarity in the four DESI dimensions, which means that the distance between the countries' performance in each of the clusters is the smallest. The existence of these clusters identifies and further clarifies the state of digital divide in the EU and the countries that are the best and worst performers.

We can adapt the classification of the European Commission in the sphere of innovation (European innovation scoreboard)[3], in which the EU countries are grouped into four types - innovation leaders, strong innovators, moderate innovators and emerging innovators, to classify the EU countries in terms of their digitalization. In a similar way to the innovation division, and according to the present clustering analysis, we can classify the EU member states in terms of digitalization as "digitalization leaders" (countries in Cluster 1), "strong digitalizators" (countries in Cluster 2), "moderate digitalizators" (countries in Cluster 3) and "emerging digitalizators" (countries in Cluster 4). This classification is clearly representing the state of art of digitalization in the EU at the moment and gives an insight of the level of their performance in the digitalization sphere so far. It is evident that the worst performing country is Romania, and the countries, which are among the so called emerging digitalizators are mainly countries from Central and Eastern Europe. The Scandinavian countries are among the top leaders in digitalization. It is interesting to note also that some small (in terms of population or area) countries like Malta and Estonia for example, are among the top performers, which means that digitalization depends most of all on factors as state policy towards digitalization, investment measures, etc. The issue connected with the factors for successful digitalization should be a topic of future studies.

It is certain, however, that improving the digital inclusion of all European citizens is necessary to reduce the digital divide in the Union. It is of big importance, both for the development of a modern and competitive

[3] See https://research-and-innovation.ec.europa.eu/statistics/performance-indicators/european-innovation-scoreboard_en#european-innovation-scoreboard-2021



NB: Estimation is implemented using country data for DESI in 2021 (European Commission, 2021c)

Figure 6. Hierarchical tree (dendrogram) using average distance (between classes)
Source: Author's estimation in SPSS

economy and business, and for the integration of all Europeans in the labour market and society, where public services are increasingly provided online. The second serious challenge is the slow digitalization of the European SMEs. The digitalization of the public services is a third sphere, and in it the differences between the EU countries are the broadest. Investments in digitalization are planned by all EU states (minimum 20 % of the funds in their Recovery and Resilience Plans) but since some of them have envisaged much bigger

investments in digitalization[4], the differences in their digitalization performance and results are most probably going to deepen.

Conclusion

As a result of the two comparative and hierarchical clustering analyses, it became evident that in 2021 there is a significant digital divide between the EU member states.

The application of the hierarchical clustering analysis grouped the EU countries in clusters according to the proximity of their performance in the four DESI dimensions. At cluster distance less than 5, there are three main clusters of countries (and one more country alone – Romania) that show similar performance in their digitalization indicators (digitalization dimensions according to DESI). These results suggest that the EU member states can be divided into four groups and classified as "digitalization leaders" (Cluster 1), "strong digitalizators" (Cluster 2), "moderate digitalizators" (Cluster 3) and "emerging digitalizators" (Cluster 4). It is evident also despite that there is a certain geographical distribution of the different type of performers in specific European regions, the level of achieved digitalization is obviously more related to other factors that need further studies. The author also expects that, since the EU member states have envisaged different amounts of investments in digitalization in the medium-term, the differences in their digitalization performance will increase and the digital divide in the EU is going to deepen.

The limitations of the applied approach are connected with its non-comprehensive explanatory power. The factors for the significant digital divide, which were identified, cannot be outlined and described by this approach. That is why, future research could elaborate on the factors that cause the digital divide in the EU and the appropriate measures and investments needed to overcome them.

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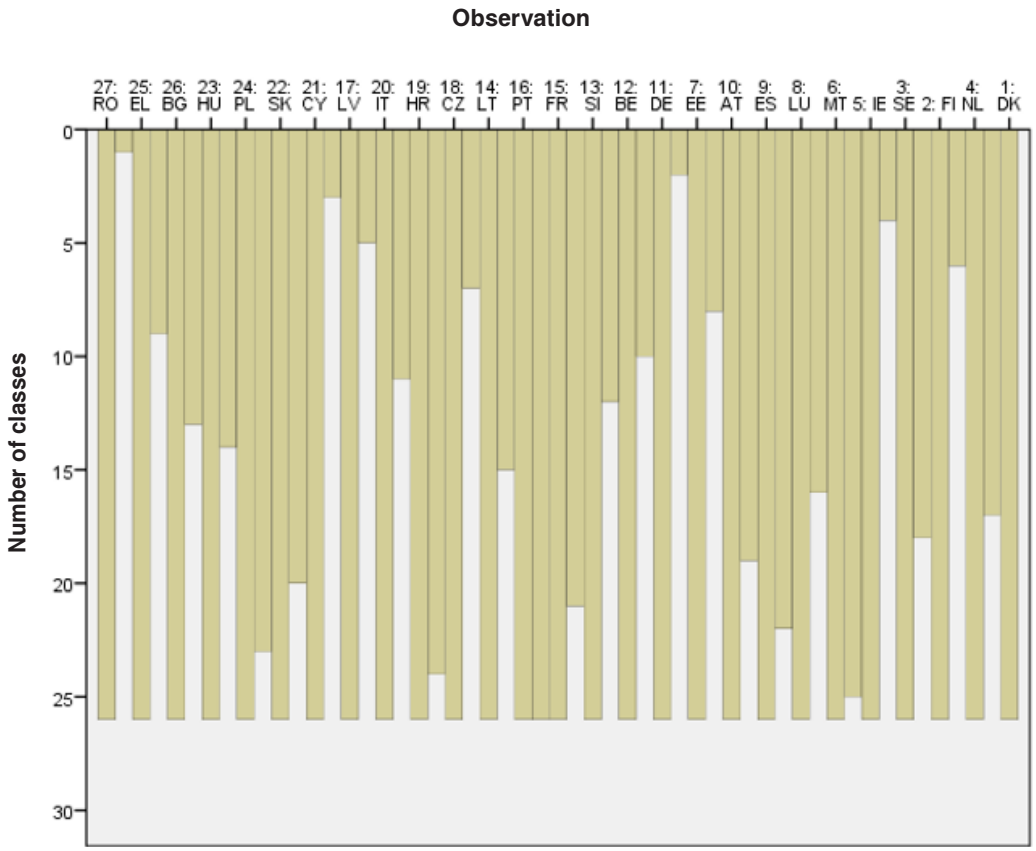
Annex 1

Chain of aggregations

Step	Grouping of classes		Coefficients	Step of appearance of the class		Next step
	Class 1	Class 2		Class 1	Class 2	
1	15	16	1,505	0	0	6
2	5	6	2,536	0	0	11
3	18	19	2,835	0	0	16
4	22	24	3,111	0	0	7
5	8	9	4,059	0	0	8
6	13	15	5,513	0	1	12
7	21	22	5,846	0	4	13
8	8	10	5,923	5	0	11
9	2	3	8,096	0	0	21
10	1	4	8,455	0	0	21
11	5	8	9,701	2	8	19
12	13	14	10,185	6	0	15
13	21	23	10,614	7	0	14
14	21	26	13,770	13	0	18
15	12	13	13,774	0	12	17
16	18	20	14,038	3	0	20
17	11	12	16,564	0	15	20
18	21	25	18,780	14	0	24
19	5	7	19,421	11	0	23
20	11	18	21,854	17	16	22
21	1	2	23,413	10	9	23
22	11	17	32,421	20	0	24
23	1	5	34,093	21	19	25
24	11	21	41,604	22	18	25
25	1	11	88,891	23	24	26
26	1	27	209,051	25	0	0

Source: Author's estimation in SPSS

Annex 2



Source: Author's estimation in SPSS