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EUROPEAN UNION'S DIGITIZATION POLICY – ASSUMPTIONS AND DIGITAL ACHIEVEMENTS OF MEMBER STATES

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Purpose: The European Union is setting increasingly ambitious objectives for digitization, aiming to be a global leader. This involves assessing the level of digitization among EU member states and identifying the key challenges facing the EU, given the priorities established.
Design/methodology/approach: An analysis of the level of digitization in EU countries was conducted using secondary data collected by the European Commission as part of its monitoring of digital policy with the Digital Economy and Society Index (DESI). This analysis included a descriptive evaluation of the overall index and its sub-indices. In addition, EU countries were grouped by similar levels of digital development through cluster analysis using Ward's method.
Findings: The level of digitization within the EU is high. The leaders in the overall DESI ranking include Finland, Denmark and the Netherlands. However, the countries least advanced in developing a digital economy are Romania, Bulgaria and Greece. The study's results reveal clear geographical differences. The gap between the leading country and the one in the lowest position is significant. While all countries are advancing in the four dimensions monitoring digital transformation, the distance to the 2030 goals is still significant, even among the digitization leaders. A key area of challenge includes human capital with insufficient digital skills, as well as the digital transformation of SMEs. A hierarchical clustering search for similarities between countries showed that the clusters formed depend somewhat on their place in the DESI ranking. Countries with low levels of digitization, such as Romania and Bulgaria, have the strongest clustering. Leaders in the development of the digital economy also exhibit strong clustering.
Research limitations/implications: By its very nature, this article has limitations, primarily arising from the complexity of the subject matter discussed and the restricted number of research methods utilized. These limitations are also due to changes in the DESI methodology, which complicates reference to statistics that have not been updated. In planning future research activities, a significant and intriguing direction will involve a detailed study of the dimensions of the DESI index.
Practical implications: The digital transformation impacts citizens and businesses across all EU countries. This understanding lends cognitive value to the current progression of the EU's digital transformation, indicating key challenges in this field.
Originality/value: This article employs an original DESI descriptive analysis approach, enriched by an examination of similarities between member states.

Keywords: digital single market, digital transformation, European Union digital goals, Ward's method.

Category of the paper: research paper.

1. Introduction

With the advent of the Internet and the digital economy, the European Union's internal digital market has gained prominence. Progressive European integration involves the construction of a single market, which eliminates all national trade barriers and ensures the enhancement of economic and social prosperity, all while respecting the environment. More specifically, the EU establishes an internal market among member states where the free movement of goods, services, people, and capital is guaranteed (Treaty on the Functioning of the EU, 2020). As per the Treaty, the concept of the internal market represents an "area without internal borders" with uniform competition rules (TFEU Article). The realization of the common market, officially functioning since 1993, continues unabated, yet national barriers persist in many areas, including legal, technical, or administrative aspects. A 2020 publication from the European Commission detailed 13 major user-perspective barriers (for businesses and consumers), some of which included practical obstacles. Attention was given to difficulties in obtaining information, intricate administrative procedures for selling goods and services abroad, rejection or diversion of orders in cross-border purchases, problems with skill shortages or mismatches, and language barriers (EC, 2020).

Over the decades of the EU's operation, cooperation among member states has expanded into various areas where collective action proves more beneficial than individual country efforts. One such area is the digital single market, which generally entails the removal of national barriers to online transactions. In keeping with the EU's vision, a digital single market can facilitate access to information, enable the development of superior business and administrative models, and contribute to productivity improvements through lower transaction costs, dematerialized consumption, and reduced environmental impact. The growth of e-commerce benefits consumers through the rapid development of new products, lower prices, a wider selection, and improved quality of goods and services. It also leads to an increase in cross-border trade, bolstering the development of the Community's internal market. Additionally, the proliferation of e-government services simplifies the process for EU consumers and businesses to access job opportunities, fulfill requirements, and explore other business prospects online. The EU's shared vision for digitization implies a widespread adoption of modern solutions in the expansive area of data and connectivity. This includes European cloud computing, ethical artificial intelligence, secure digital identities, and supercomputing infrastructure. Achieving this vision necessitates investment in all areas of

digitization, starting with digital skills, supercomputing, and high-speed connectivity as part of a comprehensive strategy.

The purpose of this article is to assess the level of digitization among the European Union member states and to identify the key challenges the EU faces considering the adopted priorities.

2. EU digital policy – assumptions and priorities for digital transformation:

EU member states, forming an integration group, have an open and competitive single market with a robust industrial base and skilled citizens. Globally, the Union asserts itself as a player in rules-based international trade. These strengths present an opportunity to leverage them towards achieving the community's ambitious digital policy goals. The presumption is that this policy should guarantee a prosperous, human-centric digital future for citizens and businesses that is sustainable, and upholds cybersecurity and democratic principles in both public and private sectors (Carlsson, Rönnblom, 2022).

However, the European economy is vulnerable, susceptible to risks, and lags considerably behind the United States and China in terms of investments in ICT technologies and citizen skills, including public administration personnel (EC, 2021; Dudzik et al., 2022; Olszewska, 2020). A significant weakness of the EU's digital space is that most digital technologies are developed outside the Community. This is evident in key technology areas such as processors, Internet platforms, and cloud infrastructure, where 90% of data is managed by U.S. companies and less than 4% of the leading Internet platforms are European. By contrast, European-made microchips account for less than 10% of the European market share (EC, 2021). The COVID-19 pandemic has emphasized the problems associated with dependence on critical technologies from outside, or reliance on a few large tech companies. It led to an influx of counterfeit products and cyber theft. Additionally, the pandemic highlighted the detrimental impact of misinformation on democratic societies. However, it also revealed a new digital divide stemming from disparities in the ability to fully benefit from an enriched, accessible, and secure digital space offering a comprehensive range of services, expanding beyond the previous divide between urban and rural or geographically remote areas. A similar scenario is seen among businesses, some of which have not fully digitized and are thus unable to reap the benefits of a modern digital environment (EC, 2021). The previously mentioned lack of digital capabilities and skills among employees serves as a significant barrier to maximizing the use of digital technologies in companies, especially small and medium-sized enterprises (SMEs) (Scuotto et al., 2021; Wiktor, et al., 2021; Łukaszuk, 2022; Grzyb, 2019).

Therefore, the EU must pursue an active digitization policy to maintain its position on the international stage and to ensure the fulfillment of its integration goals. This framework is established by adopted documents in which the Community defines development priorities based on diagnosed internal and external conditions. These efforts aim to create a digital single market – a free and secure space where citizens can shop online in other countries, and companies can sell goods and services across the Union regardless of location (EU Council and European Council Portal; Cenamor et al., 2019).

The concept of a single market is included in the "Europe 2020 Strategy". Among the seven guiding initiatives for its implementation, the "European Digital Agenda" was adopted, underscoring the role of information and communication technologies in achieving the strategy's goals. Subsequent Community documents have upheld this importance, identifying the digital single market as one of the EU's priorities. The Digital Single Market Strategy for Europe adopted solutions for a swift transition from a global to a digital economy. The document identifies 16 key actions based on three pillars: (1) better consumer access to digital goods and services, (2) creating conditions and a level playing field for the development of digital networks and innovative services, and (3) maximizing the growth potential of the digital economy (EC, 2015). These measures are implemented through legislative initiatives of the European Commission and address issues such as unjustified geographical blocking, cross-border parcel delivery services, digital content delivery, and the operation of online platforms (Ratcliff et al., 2023). In 2018, a plan for coordinated support of artificial intelligence in all countries (the "Artificial Intelligence for Europe" strategy) was established. In 2020, a white paper titled "Artificial Intelligence: a European Approach to Excellence and Trust," along with communications on shaping Europe's digital future and a European data strategy, were adopted. The COVID-19 pandemic and its aftermath contributed to the adoption of additional solutions. The European Commission issued a recommendation for a common EU set of tools to facilitate the use of technology and data to combat the ensuing crisis. It also announced a communiqué, "A Decisive Moment for Europe: Repairing and Preparing for the Next Generation," positing that the recovery of the European economy will be achieved through a digital single market, among other means. Central to these efforts are investments in better connectivity, strategic components of the digital supply chain (AI, cybersecurity, 5G, cloud computing infrastructure), and a data-driven economy in a fair environment conducive to doing business.

The EU outlined a roadmap for digitization over the next decade in the EC's communication "Digital Compass for 2030: Europe's Path in the Digital Decade." This document sets out a guide for the Community's transformation in this area, along with a monitoring system and key milestones and measures to achieve the goals. The digital compass identifies four significant developments: (1) a digitally skilled society and highly skilled digital professionals, (2) secure, efficient and sustainable digital infrastructure, (3) digital transformation of businesses, and (4) digitization of public services. The first two developments aim at fostering digital capabilities in the form of skills and infrastructure, while the latter two focus on the

digital transformation of companies and public services. Specific ambitious goals to be accomplished by 2030 have been assigned to the adopted directions (EC, 2021). The EU's approach is to achieve these goals by implementing joint, multinational projects funded by the Instrument for Reconstruction and Enhanced Resilience (European Commission, 2023). The EU also highlighted the basic principles of its digital transformation: a level playing field in digital markets, a secure cyberspace, and upholding fundamental rights online. These principles promote the Community's core interests and values while ensuring the construction of an open digital economy based on investment and innovation flows.

The EU's digital transformation is carried out based on so-called general goals and digital objectives defined at the EU level, linked to specific areas where joint progress is expected. These priorities are outlined by the "Road to the Digital Decade" policy program until 2030 (European Parliament and Council Decision (EU) 2022). This program obliges member states to submit national strategic action plans to the European Commission, which must align with the overall and digital goals and specify how these ambitious objectives will be achieved.

The digital objectives target the four main directions delineated in the aforementioned Digital Compass Communication: digital skills, digital infrastructure, digitization of businesses, and digitization of public services.

The first objective involves cultivating a digitally skilled society and highly skilled digital professionals, with an emphasis on achieving gender balance. The goal is to ensure that by 2030, at least 80% of people between 16–74 years old have basic digital skills, and at least 20 million ICT professionals are employed within the Union. This also includes encouraging women's participation in the field and increasing the number of ICT graduates.

The second objective focuses on developing a secure, resilient, efficient, and sustainable digital infrastructure. The plan entails that all stationary end users will have access to a gigabit network, all populated areas will be covered by a next-generation ultra-high-speed wireless network performing at least as well as 5G, and the EU's production of state-of-the-art semiconductors will constitute at least 20% of the value of global production. In addition, at least 10,000 climate-neutral edge nodes will be deployed, regardless of business location, by 2025, and the EU is expected to launch its first quantum-accelerated computer.

The third objective pertains to the digital transformation of businesses, with the expectation that at least 75% of EU companies will utilize at least one of the following: cloud computing services, big data, or artificial intelligence. Furthermore, over 90% of EU small and medium-sized enterprises (SMEs) should reach a basic level of digital intensity. The EU plans to facilitate the development of innovative scale-up companies and improve their access to financing, potentially doubling the number of "unicorns" — a term referring to (a) companies established after December 31, 1990, which have either surpassed a $1 billion valuation at the initial public offering or sale to an industry investor or (b) achieved such valuation in the most recent round of private venture capital financing, including if the valuation was not confirmed by a subsequent transaction (European Parliament and Council Decision (EU) 2022).

The fourth objective is the digitization of public services. Target: 100% of key public services are to be available online for both citizens and businesses in the EU. Additionally, all citizens should have access to their electronic medical records and electronic identification (eID) measures recognized throughout the EU, granting them control over transactions that require identity verification and sharing of personal data.

Broadly speaking, the general objectives to be achieved at the European Union level include promoting, strengthening, and developing: a human-centered, inclusive, transparent, and open digital environment that respects fundamental rights; collective resilience and narrowing of the digital divide; strategic EU digital sovereignty; digital capabilities; online participation in democratic life; a secure online public service environment; and sustainable, resilient, and energy-efficient infrastructures and technologies, including supply chains, fair and non-discriminatory conditions for users. A total of 11 such goals have been defined, all of which represent areas of cooperation for all member states in terms of compliance with the principles and digital rights contained in the document "European Declaration of Digital Rights and Principles in the Digital Decade".

It's worth noting that the EU also views the development of digital technologies as a means to achieve the goals of the European Green Deal. Digital technologies can help transition to a climate-neutral and more resilient circular economy. The application of digital technologies in fields such as agriculture, energy, construction, industry, urban planning, and services can lead to greener processes and better environmental protection. Companies can utilize digital technologies to achieve higher (energy and material) efficiency with a smaller environmental footprint. Accelerating and maximizing the effects of policies addressing climate change and environmental protection can, according to the policy agenda of the Road to the Digital Decade by 2030, be realized through the use of digital technologies such as artificial intelligence, 5G network, 6G network, blockchain, cloud and edge computing, and the Internet of Things (Decision of the European Parliament and Council (EU), 2022). It is acknowledged that the ongoing digital transformation will enhance the positive impact of EU activities on the environment, climate, and the European economy. Significant benefits are anticipated within the EU industrial sector through alterations in production processes and the implementation of environmentally friendly decisions by consumers and producers. These include changes in the community labor market and the skill level of citizens (Windys, 2021).

3. Monitor progress toward digital decade goals

Monitoring the progress toward the general and digital goals is the responsibility of the European Commission, which uses the DESI and the KPIs (key performance indicators) for each digital objective, defined by an implementing act. The KPIs should be updated as

necessary for continuous effective monitoring and to accommodate technological changes (EP and Council (EU) Decision, 2022). The Digital Economy and Digital Society Index (DESI) is a tool that has monitored digitization since 2014, its methodology is adapted to the current conditions and EU development goals in this area. Specifically, DESI is an annual set of analyses and measurement indicators by which the European Commission tracks the overall digital accomplishments of the EU and member states across various policy dimensions, including progress toward digital goals (EP and Council Decision (EU), 2022). Annual country profiles according to the index are becoming an instrumental resource to support member countries in their digital transformation.

Starting in 2019, DESI includes a scoreboard on women in the digital sector. This assesses the performance of EU countries in the areas of Internet use, Internet user skills, as well as specialized skills and employment, based on twelve indicators. The approach is designed to monitor the digital divide between men and women.

The current enhanced Digital Economy and Society Index allows the tracking of the EU's trajectory in terms of the pace of digital transformation, gaps in European strategic digital capabilities, and implementation of digital principles. The index measures the realization rates of the most important aspects in the four major development directions (EC, 2021).

The effectiveness of implementing digital transformation in the EU depends on the efficacy of the actions taken at the community level and cooperation between the national and community actors involved. According to the provisions of the Road to the Digital Decade, effective and efficient cooperation between the European Commission and member states will be ensured by national strategic action plans for the digital decade covering the period up to 2030 (so-called national action plans). These documents propose nationally measurable, projected trajectories, describing all planned, adopted, or implemented measures to contribute to the achievement at the Union level of the overall goals and digital objectives. These plans should be developed in consultation with key stakeholders such as business organizations, SME representatives, social partners, and civil society.

The monitoring and cooperation mechanism adopted for the Road to the Digital Decade program is designed to create an environment conducive to meaningful innovation and investment by setting a clear direction for the community's digital transformation. The mechanism aims to structure and stimulate cooperation between the European Parliament, the EU Council, the European Commission, and the member states. More broadly, it will promote consistency, comparability, transparency, and completeness of EU monitoring and reporting. An integral part of the monitoring system is the Digital Decade Report, which the European Commission submits and presents annually to the European Parliament and the EU Council The Digital Decade Report should offer an assessment of the progress of the digital transformation toward the digital goals, as well as the status of compliance with the overall goals. An assessment of the progress made will also identify significant gaps or deficiencies in the efforts to date. It also recommends policies, measures, or actions for member states to implement in areas where progress has been insufficient.

4. Research methodology

The study of the level of digitization of EU member states was conducted on the basis of an analysis of secondary data collected by the European Commission as part of its monitoring of digital policy using DESI. The first stage involved a descriptive analysis of the overall Digital Economy and Digital Society Index and its four sub-dimensions. In the second stage, a classification of European Union countries by similar levels of digital development was carried out using cluster analysis. It assumes the segmentation of data in order to extract homogeneous objects from the studied population. Therefore, the community is divided into different groups to obtain clusters in which elements in the same group are similar to each other and distinct from the elements in other groups (Gatnar, Walesiak, 2004). Ward's method, which belongs to the hierarchical methods of object classification, was used to group European Union countries into clusters. This method is unique in the hierarchical group of methods as it uses analysis of variance to determine the distance between clusters. The key to this method is to minimize the sum of squares of deviations within clusters, which ensures homogeneity within clusters and heterogeneity between clusters. As a result, Ward's method is considered the most effective. However, it's worth noting that it tends to cluster a relatively small number of observations and distinguish clusters of similar sizes (Ward, 1963; Młodak, 2006; Szkutnik et al., 2015).

The examination of the digital economy of EU countries using Ward's method was conducted based on 33 standardized variables. Euclidean distance was employed for clustering. The results of the analysis are presented as a cluster tree – a dendrogram, using Statistica 13.3 software. Using Ward's method, it was possible to group into clusters the EU countries that are most similar to each other and are at the same time maximally different from other countries in terms of the selected characteristics. In this study, a critical value was determined based on an analysis of the agglomeration schedule. During the process, after observing the largest increment, in which many clusters are formed at approximately the same bond distance, a cutoff is made that divides the set into classes.

The selection of variables adopted for the study, which characterize the phenomenon under investigation, was determined by the data available from DESI statistics. The source of information was the DESI report, which is prepared by the European Commission based on Eurostat data, information sent by member countries, and with the aid of specialized research and analytical methods. As mentioned earlier, DESI is a composite index that summarizes relevant indicators on the digital performance of EU member states in terms of digital competitiveness. For the implementation of the study, all sub-indicators that constitute the DESI were used, based on the most recent data available (as of July 2023), that is, the DESI 2022 Report (Table 1).

Table 1.
Structure of DESI 2022

Dimension	Sub-dimension	Indicator
Human capital	Internet user skills	At least basic digital skills. % of individuals Beyond basic digital skills. % of individuals At least basic digital content creation skills. % of individuals
	Advanced skills and development	ICT specialists % of working individuals aged 15-74. Women ICT professionals. % of ICT professionals Companies providing ICT training. % of enterprises ICT graduates. % of graduates
Connectivity	Fixed broadband take-up	General use of fixed broadband. % of households Use of fixed broadband connections of at least 100 Mbps. % of households Use of connections of at least 1 Gbps. % of households
	Fixed broadband coverage	High-speed broadband coverage (next-generation access). % of households Coverage of fixed networks with very high bandwidth. % of households Fiber-to-the-premises (FTTP) technology coverage. % of households
	Mobile broadband	5G spectrum. Allocated bandwidth as % of total harmonized 5G spectrum 5G network coverage. % of populated areas Use of mobile broadband services. % of individuals
	Broadband prices	Broadband price index. Score (0–100)
Integration of digital technology	Digital intensity	SMEs with at least a basic level of digital technology use. % of SMEs
	Digital technologies for businesses	Electronic information exchange. % of enterprises Social media. % of enterprises Large datasets. % of enterprises Cloud. % of enterprises Artificial intelligence. % of enterprises ICT for Environmental Sustainability. % of enterprises carrying out pro-environmental activities with the use of ICT that have achieved a medium/high rate of digital technology use E-invoicing. % of enterprises
	e-Commerce	SMEs with online sales. % of SMEs E-commerce turnover. % of SME turnover Cross-border Internet sales. % of SMEs
Digital public services	e-Government	Users of e-government services. % of Internet users. Pre-filled forms. Score (0–100) Digital public services for citizens. Score (0–100) Digital public services for businesses. Score (0–100) Open data. % of maximum score

Source: Digital Economy and Society Index 2022.

The 2022 DESI reports for member states are primarily based on 2021 data and track the progress made in EU countries (in a few instances, missing data was supplemented by 2020 and 2018 data). It's crucial to note that this edition is closely linked to the conditions of the COVID-19 pandemic (European Commission Portal, 2023).

5. The state of digitization in the European Union – DESI 2022

The level of digitization in the European Union varies significantly (Figure 1). Finland and Denmark have the most advanced digital economies, with the overall DESI index value nearing

70. The Netherlands, Sweden, Ireland, Malta, and Spain also demonstrate a significant level of digital development, with indices surpassing 60.

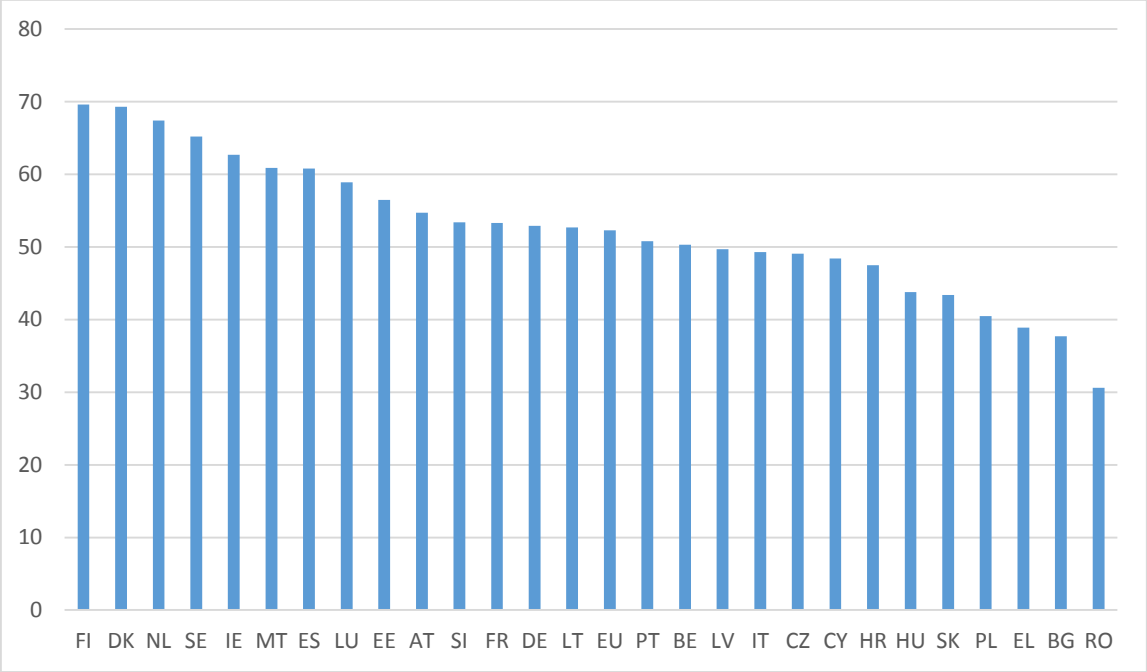

Figure 1. Digital Economy and Society Index (DESI) 2022.

Source: own compilation based on European Commission data.

At the other end of the spectrum, Romania, Bulgaria, and Greece's indices did not exceed 40. Thirteen EU countries fell below the EU average of 52.3, with Lithuania and Portugal closest to this average. There's a significant gap of 39 between the leading and the lowest-ranking countries. Finland scored 2.3 times better than Romania.

Considering the first of the dimensions that compose the DESI – Human Capital – Finland exhibits the highest level of development (Figure 2). The index, consisting of seven sub-elements, reached 71.4 for this country. Finland significantly surpasses the next countries, namely the Netherlands, Ireland, and Sweden (indices ranging between 62-63.1). Romania and Bulgaria have the lowest human capital scores, with indices not exceeding 33. The EU average is 45.7, dividing the member countries nearly 50-50. Thirteen countries fall below the EU average, performing poorly in digital skills, ICT professionals, including women, and ICT training provided by companies.

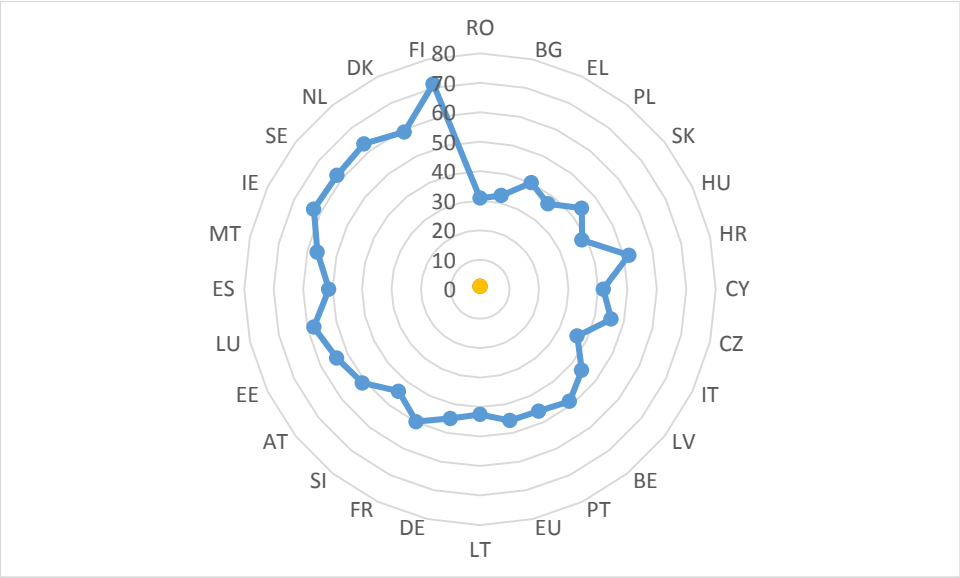

Figure 2. Human capital – DESI 2022.

Source: own compilation based on European Commission data.

Digital infrastructure (connectivity) forms the second dimension of DESI. It comprises ten individual indicators describing next-generation broadband coverage and usage, including 5G, mobile, and broadband services. This dimension demonstrates the least variation among member countries (Figure 3)

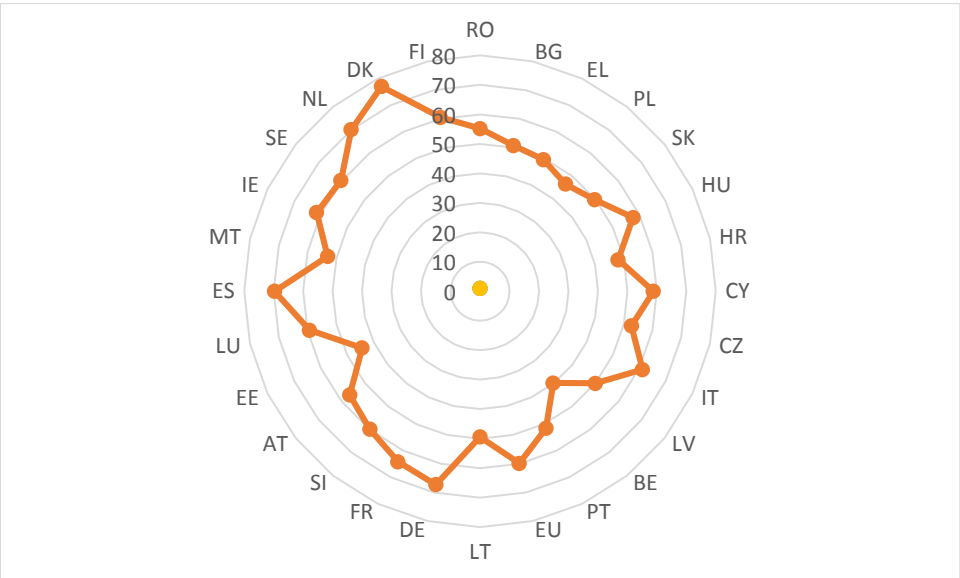

Figure 3. Connectivity – DESI 2022.

Source: own compilation based on European Commission data.

The distance between Denmark (leader) and Bulgaria (last position) is 37.3. Besides Denmark, the Netherlands, Spain, and Germany register the best results in terms of digital infrastructure development, meaning that the overall DESI ranking leaders hold weaker positions. Sweden, Finland, and Ireland rank just above the European average (59.9), taking positions 9, 8, and 7, respectively. Digital infrastructure is least developed in Bulgaria, Estonia,

Poland, and Croatia, with indices below 49. Notably, as many as 18 countries ranked below the EU average.

In the third dimension of DESI – Integration of Digital Technologies, seventeen member countries rank above the EU average (36.1) (Figure 4).

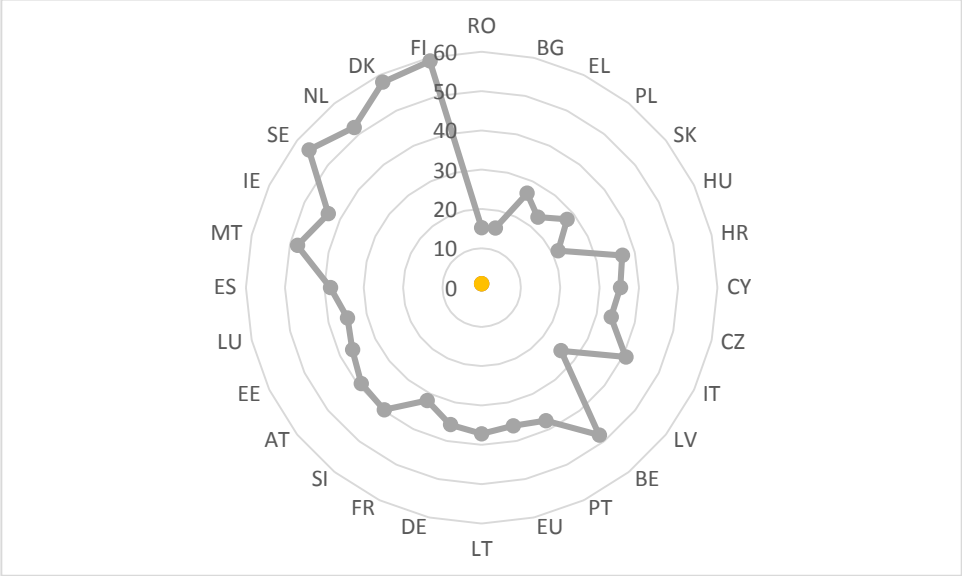

Figure 4. Integration of digital technology – DESI 2022.

Source: own compilation based on European Commission data.

There's a large distance between the leader, Finland, and the lowest-ranked country, Romania, with a gap of 43.9 points, almost four times Finland's score in this area. Denmark, the Netherlands, and Sweden also exhibit high levels of digital integration. In contrast, apart from Romania, Bulgaria, Hungary, and Poland record the lowest scores in the 11 individual indicators that comprise this DESI dimension.

Estonia is the clear leader in the development of digital public services, recording a score of 91.2 (Figure 5). Finland, which ranked next, achieved a significantly lower score of 87.4. The EU average was 67.3, and 15 countries ranked above this score. The fourth dimension of the DESI consists of five indicators that characterize access to and use of public services for citizens and businesses. This is the area that differentiates member states the most out of all DESI dimensions. The gap between Estonia and Romania exceeds 70, indicating that the leader in this category performs over four times better than the country at the bottom of the ranking. Romania's score in terms of digital public services was only 21. The next country from the bottom, Greece, reached an index level of 39.4. Notably, a significant gap also separates Greece from the next-ranked country, Bulgaria, which had an index of 51.9.

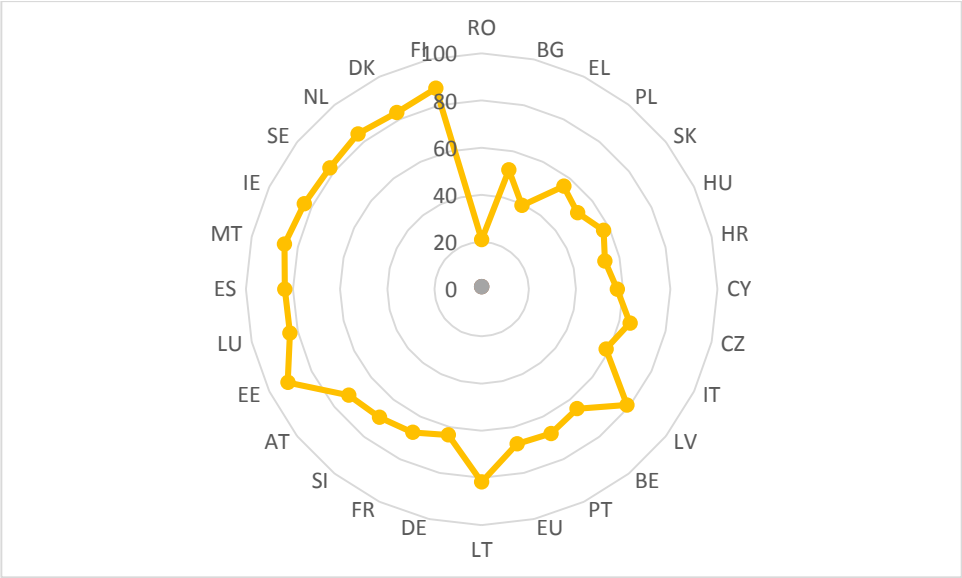

Figure 5. Digital public services – DESI 2022.

Source: own compilation based on European Commission data.

From 2017 to 2022, a clear increase in the level of digitization in member states can be seen (Figure 6).

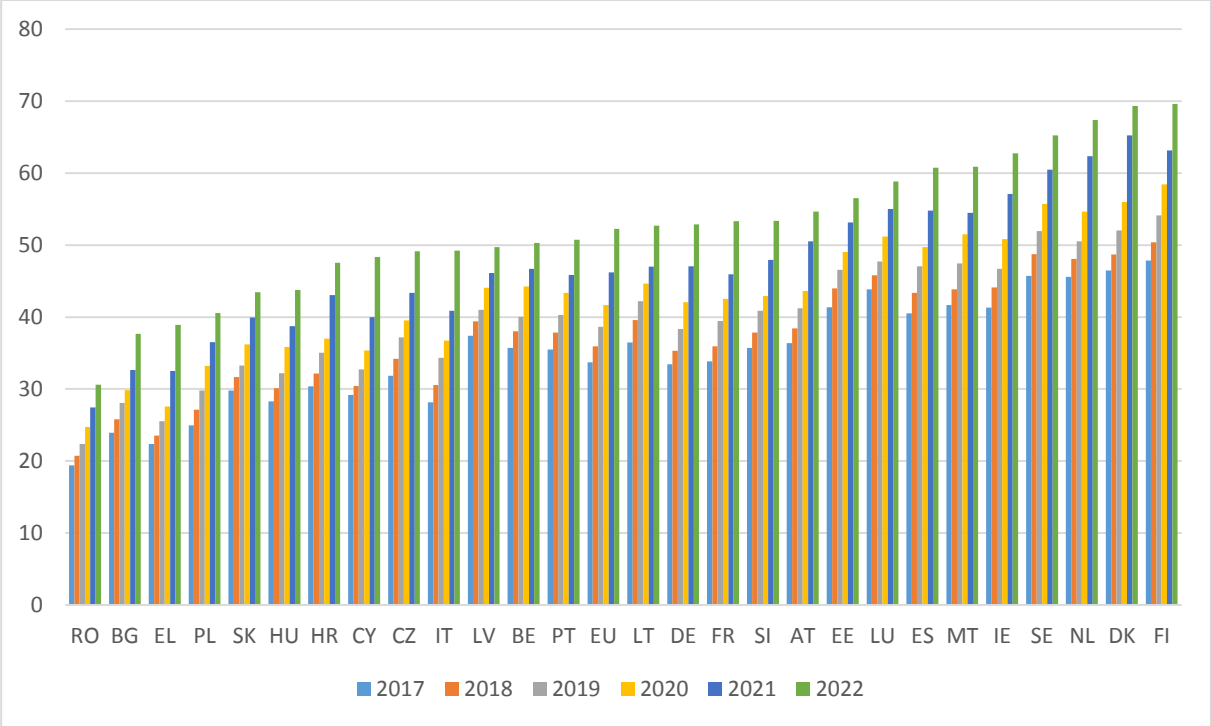

Figure 6. DESI 2017-2022.

Source: own compilation based on European Commission data.

Most countries are progressing in building a digital economy and digital society. The highest growth rates between 2017 and 2022 are evident for Greece, Cyprus, Italy, Poland, Germany, and France. The leaders in digital development are consistently the same countries. However, a significant group of member states ranks near the EU average. Crucially, most of

the member states that had lower levels of digitization at the beginning of the analyzed years are making faster progress than other countries. This may indicate a general trend toward equalization in the digital field in the EU.

Despite the accelerating digital transformation, most countries that ranked below the EU average have not made significant progress in digitization development. This is particularly problematic with regard to digital education and digital skills. Only 54% of EU citizens aged 16-74 have at least basic digital skills. Even the countries at the top of the DESI ranking have considerable ground to cover to meet the EU's targets for 2030, which aim for a rate of 80% (European Commission Portal, 2023a; European Parliament and Council Decision (EU) 2022). A weakness in EU digitization is the percentage of ICT graduates, which averages 6.50% in the EU, while in Ireland and Estonia it is more than twice as high (14.3% and 14%, respectively). There are over six times as many graduates in ICT in Finland (leading position) than in Italy (last position). The shortage of such specialists significantly impacts the adoption of digital technologies by businesses and the underutilization of the potential of the digital economy. (European Commission Portal, 2023).

The transformation of businesses hinges on their ability to quickly and fully adopt new digital technologies. However, the level of implementation of key digital technologies by EU companies remains unsatisfactory. Artificial intelligence (AI) is used by 8% of EU companies. The technology is least developed in Romania, where only 1% of companies are implementing AI. Slightly higher rates are seen in Bulgaria, Cyprus, Estonia, Hungary, and Poland (3% each). The leader in implementing AI technology is Denmark, where 24% of companies use artificial intelligence. In Portugal and Finland, the ratio is 17% and 16%, respectively. The use of big data technologies also remains at a low level in the EU (14% of companies on average). It is least used in Romania (5%), while the highest number of companies use big data technology in Malta (30%), Denmark, and the Netherlands (27% each). Digital transformation for companies assumes that by 2030 at least 75% of EU companies will use at least one of the activities, i.e., cloud computing services, big data, artificial intelligence (Decision of the European Parliament and Council (EU) 2022). EU companies must, therefore, become more proactive in implementing key digital technologies in business operations.

6. Similarities of European Union countries in the level of development of the digital economy based on the Ward method

To identify and group similar entities, a cluster analysis was conducted to assess the similarity of digitalization levels among the studied countries. A hierarchical agglomerative method was used, progressively grouping EU countries into larger clusters. An integral component of this process is the dendrogram cutoff, which determines the number of clusters

in the analysis. During the proceedings, a dendrogram is generated as a graphical representation. In this study, the critical value was determined based on an analysis of a line graph of bond distances relative to successive stages of the bonding process.

The analysis of the 2022 agglomeration flow chart indicates that the dendrogram division should be at the 25th step (Figure 7), i.e., the bonding distance is positioned between 11 and 16.

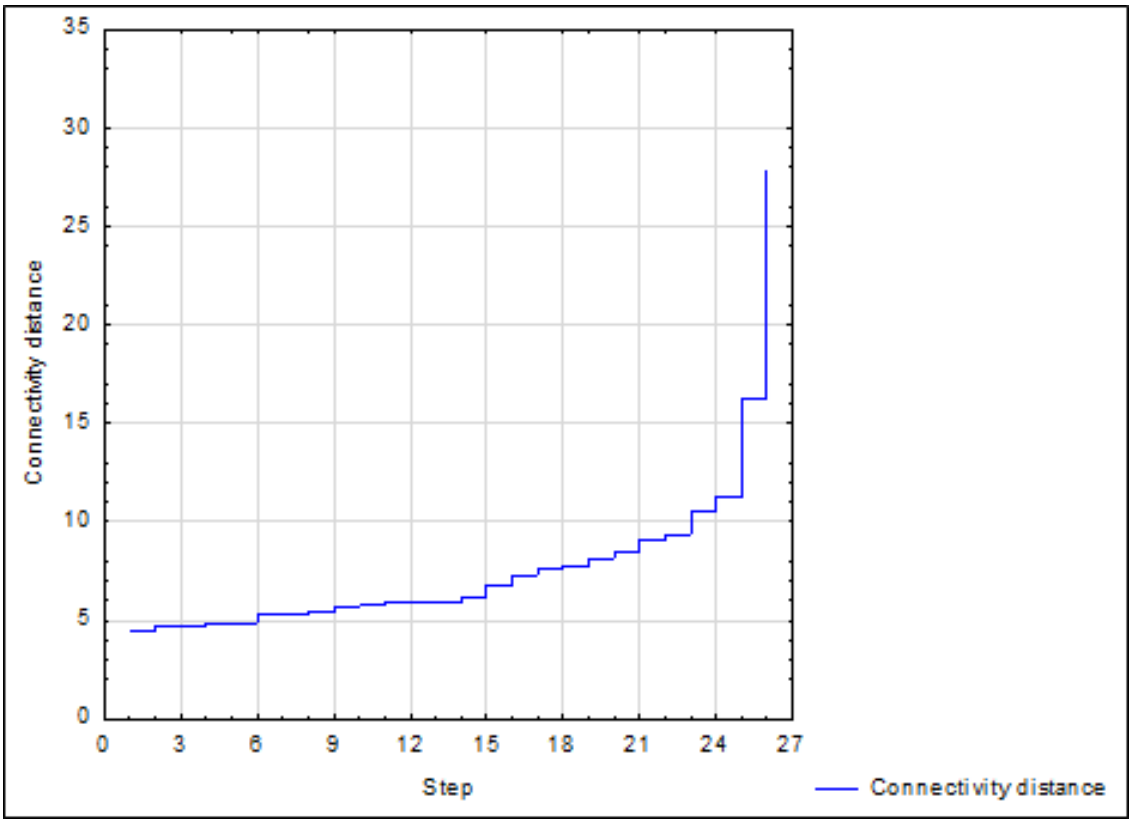

Figure 7. Agglomeration flow chart.

Source: own development.

At a bond distance of 11, four distinct clusters appear, comprising fourteen, two, five, and six relatively homogeneous entities. Meanwhile, at a bond distance of 16, three groups emerge: clusters of fourteen, two, and eleven elements (Figure 8).

Considering the first scenario, i.e., three clusters, there is a noticeable variation in their size. The classification of EU countries yielded the following groups: clusters of eleven, two, and fourteen elements. The second scenario produced clusters of six, five, two, and fourteen elements.

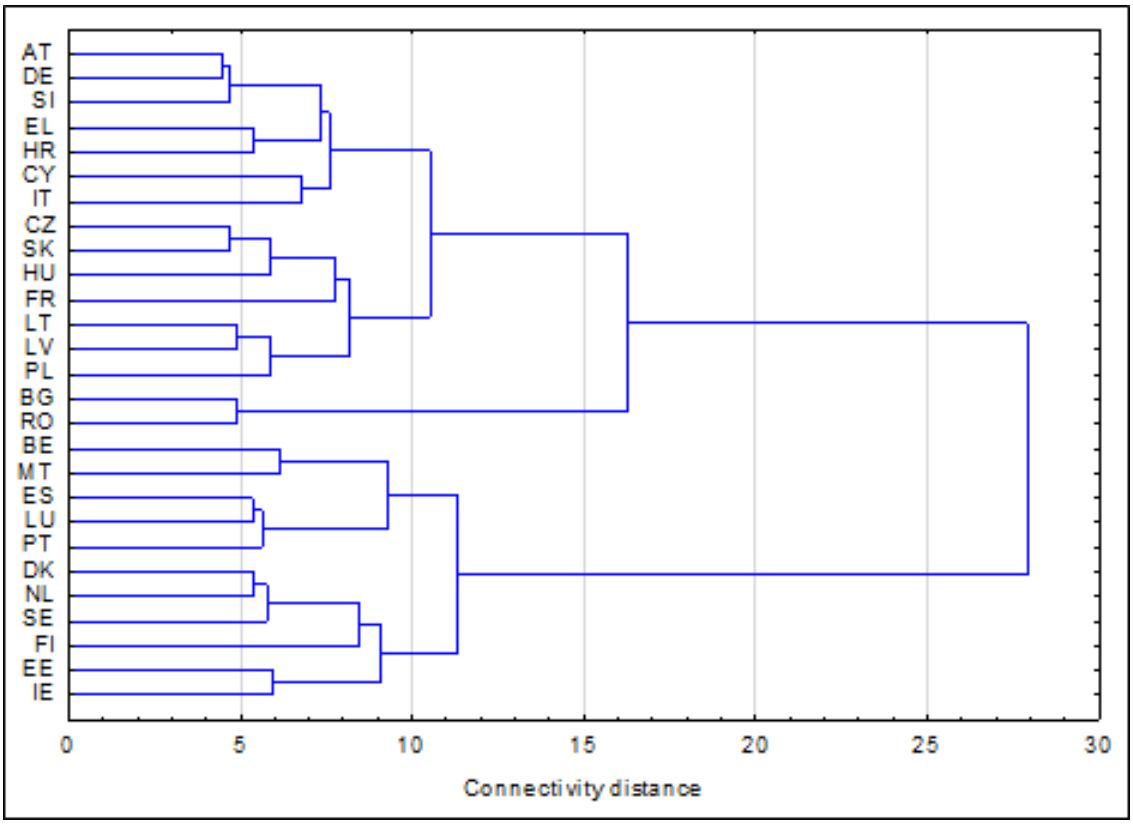

Figure 8. Grouping of EU countries with similar levels of development of the digital economy and digital society.

Source: own development.

In both scenarios, 14 countries were singled out: Austria, Germany, Slovenia, Greece, Croatia, Cyprus, Italy, Czech Republic, Slovakia, Hungary, France, Lithuania, Latvia, and Poland. This is the most populous and diverse grouping. Within this cluster, countries display varying levels of digitization. These countries are characterized by medium to low development of the digital economy and digital society, ranking between 10 and 25 on the overall DESI index. Given the size of this group, it is challenging to discuss structure similarities within the DESI sub-dimensions.

A separate two-element group, appearing in both scenarios, consists of Romania and Bulgaria, representing the so-called "new" EU countries. This group's formation seems to hinge largely on these countries' status as the least digitized within the EU, suggesting a high structural similarity. This demonstrates the high similarity of structures. These countries rank last and second to last on the overall DESI index, clearly distancing themselves from more digitized economies, particularly Romania, which is emphasized above. Examining the four DESI dimensions, the Digital Technology Integration category stands out, where these countries rank last, a full four points behind the next country, Hungary. Similarly, for the DESI Human Capital dimension, Romania and Bulgaria occupy the final two positions. The only contrast appears in the Digital Infrastructure category, where these countries occupy more varied positions, albeit closer to the EU average.

In the three-cluster scenario, the last group consists of eleven elements: Ireland, Estonia, Finland, Sweden, the Netherlands, Denmark, Portugal, Luxembourg, Spain, Malta, and Belgium. These are countries with high and medium digitization levels (based on DESI). These countries, barring Portugal and Belgium, all have an overall DESI above the EU average. Portugal and Belgium, however, have an index above 50, ranking them near the EU average of 52.3. This group predominantly consists of Western and Northern European countries, with Estonia, a Central and Eastern European country, as the exception. It's also worth noting that except for Malta and Estonia, this group comprises so-called "old" EU countries.

In the four-cluster scenario, the previously mentioned group splits into two sets: one with six elements and one with five. The first is the top of the DESI ranking: Ireland (5th), Estonia (9th), Finland (1st), Sweden (4th), the Netherlands (3rd), and Denmark (2nd). Apart from Estonia, all these countries are part of the EU-14, the "old" EU. The structural similarities of these countries are especially apparent in the DESI Human Capital and Digital Public Services dimensions. These countries rank between 1 and 8 in terms of digital economy human capital development. In the DESI Digital Public Services dimension, all six countries rank among the EU's top nine. Noteworthy in this context is Estonia, which boasts the most advanced development of public services, ranking first and outpacing its closest competitor, Finland, by 3.8 points.

The second cluster includes countries such as Portugal, Luxembourg, Spain, Malta, and Belgium. These nations can be categorized as having a medium to medium-high level of digitization. With the exception of Malta, all these countries are part of the EU-13 (the "new" EU). Similarities among their structures are observable in the DESI Human Capital dimension. These countries showcase comparable levels of human capital development, ranking between 6th and 14th in this category. Simultaneously, all these countries scored above the EU average.

7. Challenges for the EU in the digital economy and digital society

The COVID-19 pandemic has compelled European Union countries to bolster their digitization efforts. Some of these endeavors have significantly accelerated the use of digital technologies by citizens and businesses (Georgescu, et al., 2022). Nevertheless, all member states must address the challenges that accompany the global diffusion of advanced digital technologies. As the EU internal market embraces the digital age, it must evolve into an instrument for building a modern, high-tech, digital-based EU economy (Brodny, Tutak, 2022).

A key challenge confronting member states is the issue of human capital with insufficient digital skills. As previously mentioned, just over half of Europeans aged 16-74 possess at least basic digital skills. Digital tools have become an integral part of daily personal, professional

life and societal participation. Thus, EU citizens lacking adequate digital skills are increasingly at risk of digital exclusion. The EU has set a digital target for at least 80% of people to have basic digital skills by 2030. Additionally, reaching 20 million ICT professionals will be a significant hurdle. Although 500,000 ICT specialists entered the labor market between 2020 and 2021, the current total of 9 million EU ICT specialists is still far from the target. This creates a serious shortage of qualified personnel that companies must contend with. According to European Commission data in 2020, more than half of EU companies (55%) reported difficulties in filling ICT specialist positions. To overcome this, significant efforts must be made to retrain and upskill the workforce. Otherwise, this deficiency will pose a serious obstacle to the recovery and competitiveness of EU businesses (Digital Economy and Society Index, EC Representation in Poland, 2022). The disappointing performance of countries in terms of basic digital skills and the pool of ICT professionals necessitates a fundamental shift in the digital skill level of EU citizens. This presents a key challenge for the EU economy. This is true for countries with the lowest levels of human capital development, as well as for leaders. Countries such as Finland, Denmark, the Netherlands, and Sweden, despite leading in terms of citizen skills and ICT professionals, also face widespread skills shortages that hinder progress and contribute to digital exclusion.

The digital transformation of SMEs is another critical area that requires more progress from member states. Many digital solutions were implemented during the COVID-19 pandemic. For example, cloud computing usage reached 34%. However, according to the DESI 2022 report, the use of AI and big data technologies in enterprises is only 8% and 14% respectively, while the Union's target for 2030 is 75%. This ambitious goal is based on the belief that these key technologies carry significant potential for innovations and productivity gains among companies, including SMEs. Yet, only just over half of EU SMEs (55%) have achieved at least a basic level of digitization (the target by 2030 is at least 90%). This indicates that nearly half are not capitalizing on the key technologies and opportunities provided by digitization. It will also be challenging for member states to reach a level of 75% usage of advanced digital technologies, such as AI and big data technology. As previously mentioned, European countries maintain a low level of implementation of artificial intelligence and big data technologies. Even the leading countries (Finland, Denmark, the Netherlands, and Sweden) struggle with a persistently low adoption rate of key digital technologies, measuring below 30% (Digital Economy and Society Index, EC Delegation to Poland, 2022).

Significantly intensified efforts on the part of EU countries are required to ensure the full deployment of ICT infrastructure, particularly 5G networks, which are essential to support high-tech services and applications. Unleashing the potential of 5G networks could pave the way for new services with significant economic and social value, such as network-based and automated mobility, advanced manufacturing, smart energy systems, and e-health. In terms of connectivity, the Union's goal is that by 2030, all European households will have access to a high-speed Gigabit network, and all populated areas will be within the range of a 5G network.

However, realizing this goal appears challenging due to substantial issues in securing timely and investment-friendly access to 5G radio spectrum, as well as delays in issuing the necessary permits for building very high-capacity networks. The broad implementation of ultra-high-capacity networks involves the use of new technological solutions and the execution of substantial investments, presenting a significant financial challenge for telecom operators. In 2021, the penetration of gigabit connections in the EU increased considerably. Networks connecting buildings using fiber optics accounted for 50% of household connections, raising the overall percentage of very high-capacity networks to 70%. Meanwhile, the proportion of 5G networks increased to 66% for populated areas within the EU. However, the allocation of spectrum—an essential prerequisite for the commercial deployment of 5G networks—is still incomplete, with only 56% of the total harmonized spectrum for 5G networks so far allocated across a majority of EU countries. These circumstances do not yet permit full-scale use of advanced applications and could impede the achievement of the desired goals.

The success of the Digital Decade program hinges on the collaborative efforts of member states. Each country, depending on its resources, potential, and factors such as population and economic scale, will contribute differently to the adopted goals. Accelerating digitization through both reform and investment can be achieved via national recovery and resilience plans, for which the EU has allocated €127 billion. These resources will facilitate the digital transformation in member states, which, on average, allocated 26% of their funds to this end—surpassing the mandatory threshold of 20%. However, only a few countries—Austria, Germany, Luxembourg, Ireland, and Lithuania—have chosen to devote more than 30% of their allocated funds to digital transformation (European Commission Portal, 2023a). Failing to meet these challenges could disrupt the development of a modern, intelligent, climate-neutral economy and hinder the achievement of greater economic and social cohesion.

8. Conclusions

Digital transformation in the EU is implemented based on so-called digital objectives defined at the EU level. These are linked to specific areas—namely, human capital, connectivity, digital technology integration, and digital public services—in which collective progress is anticipated. These priorities are outlined by the Road to the Digital Decade 2030 policy program.

The level of digitization in the European Union is high, and the pace of digital transformation is accelerating. Most member states are progressing in building a resilient digital economy and society, thereby strengthening the EU's global standing. The digitization leaders, according to the overall DESI 2022 rankings, are Northern and Western European countries: Finland (1), Denmark (2), the Netherlands (3), Sweden (4), and Ireland (5). Conversely,

the least advanced in the development of the digital economy and society are Romania (27), Bulgaria (26), Greece (25), and Poland (24), representing Southern and Central-Eastern Europe.

The study's results reveal clear territorial differences in the level of member states' digitization. The gap between the ranking leader and the country in the lowest position is significant— Finland's level of digitization is more than twice that of Romania. All countries are making progress in the four dimensions of digital transformation. However, even for the leading countries, reaching the goals set by the European Union for 2030 is a considerable distance away. A significant challenge facing member states involves not only human capital with insufficient digital skills but also the digital transformation of SMEs and the underdeveloped digital telecommunications infrastructure.

When searching for similarities among EU countries regarding the level of development of the digital economy and digital society, using hierarchical clustering, we found that the clusters formed depend on the country's position in the overall DESI ranking. The most solid grouping is that of countries with low levels of digitization, specifically Romania and Bulgaria, which formed the least populous two-element cluster. The cluster analysis reveals a clear distinction between these two countries, particularly in the integration of digital technology and human capital. Denmark, the Netherlands, Sweden, Finland, Estonia, and Ireland cluster together tightly. As leaders in the development of the digital economy and digital society (according to the overall DESI index), these countries share similarities, forming a common class. The structures of these six countries are most noticeably similar in terms of human capital and digital public services. In other aspects, structural similarities are less pronounced. It's worth noting that some similarities exist among member states due to their membership in the so-called old EU-14 or countries that joined the Community in 2004 and later. Similarities are also evident with regard to the location of countries in Western and Northern Europe compared to those in Central and Southern Europe. The clustering observed here is not as distinct as in the case of DESI.

The European Union must rise to the challenges posed by the global diffusion of advanced digital technologies. This particularly involves enhancing citizens' digital literacy, facilitating the digital transformation of SMEs, and ensuring the full implementation of ICT infrastructure. There is a need to bolster concerted efforts by member states to make significant investments through both EU funds and national expenditure. This approach will empower the community to develop key technologies that promote productivity growth and socioeconomic development, fully aligning with its environmental values and objectives. Achieving the overall digital goals by 2030 could position the EU as a frontrunner in the global digital race. The Road to the Digital Decade program undeniably facilitates cooperation between member states and the EU, fostering progress in all areas of digital transformation. This, in turn, strengthens the collective power of the 27 countries on the international stage.

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