

**ASSESSMENT OF THE DIGITAL ECONOMY'S LEVEL AMONG
THE EU COUNTRIES – AN EMPIRICAL STUDY****Kiseláková D., Šofranková B., Širá E., Fedorčíková, R.***

Abstract: The development of new technologies brings a boom in global business and trade and increases demands on knowledge and skills, which is reflected positively in economic growth. The aim of the research is to investigate the best EU countries in the digital economy, using two representative approaches. The attention is focused on the DESI index in 2014-2021 and the Global Digital Competitiveness Index. Using multidimensional approach and multi-criteria methods, the best countries were identified as Denmark, Finland and the Netherlands and also driving forces, both significant in statistical and economic contexts. The significant correlations between the dimensions of the DESI index were also demonstrated. The identified key factors for managerial implications in the strategy of digital transformation of the EU are human capital, integration of digital technology and digital skills, based on the best practices from the best EU countries.

Key words: Digital Economy and Society Index, Digital Competitiveness Ranking, Human Capital, Digital Skills.

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Introduction

Today, with the development of the digital field, the world and Europe are offered a wide range of opportunities for business and societal (Jenčová et al., 2021) growth. Economies around the world are heavily affected by the expansion of the mobile internet, social networks and commercial online platforms. These are all common elements of the global concept of digitization (Afonasova et al., 2019), which is currently contributing more and more to economic growth (Milošević et al., 2018). The digital economy is currently perceived as an economic sector with the potential to release impulses to kick-start economic growth and modernize the economy

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(Kiseľáková et al., 2021; Dahmani et al., 2022). Today, according to the European Commission, new challenges in the digital economy will emerge in the coming years. Digital development in Europe needs to be ensured, in particular on the following four main points: the digitally skilled population and the highly skilled digital professions, secure and sustainable digital infrastructures, digital business transformation and digitization of public services (DESI, 2021). To achieve the 4 main areas of support outlined, goals have been set that help them achieve them. Monitoring progress towards EU-level targets as well as digitization trends is part of the Enhanced Digital Economy and Society Index (DESI, 2021).

When evaluating the development of the digital economy, the authors focused mainly on the European Union countries. The study observed and evaluated the development of these countries from 2014 to 2021. As these economies are linked by several agendas with specifically objectives (e. g. 2030 Digital Compass for the EU's digital decade, The 2030 Agenda-SDGs and others), it proved appropriate not to include other countries in the sample. There are several approaches from different institutions to assess the development of the digital area. With regard to the sample of countries, the choice of ranking, which evaluates the EU countries, is in the first place. However, to interpret the results in a broader context, it is decided to evaluate another ranking with a broader scope for the countries studied. The final comparison of the obtained results has a higher informative and managerial value.

Literature Review

In recent decades, competitiveness has become one of the most widely used terms in the process of national and regional politics (Ivanová and Čepel, 2018). It can be considered as a response to dynamic changes, globalisation processes and global epidemiological risks increase (Gavurova et al., 2020). From a long-term perspective, it is also good to think about sustainable competitiveness (Grigorescu et al., 2019), where productivity is represented as the driving force of prosperity and economic growth. Competitiveness is also described with emphasis on quality or technology under the Industry 4.0 concept. In this way, the authors mean technological competitiveness (Štefko et al., 2021) and quality competitiveness (Laitsou et al., 2020). The emergence of new technologies often leads to significant transformations in society and industry (Nwaiwu, 2018).

Nowadays, perhaps no one doubts the importance of the digital economy for business, services and value creation of the country. These technologies transform how we live, work (Rusly et al., 2021), consume and produce goods and services (Brynjolfsson and Kahin, 2002). Investments in the digital economy are an important success determinant (Balcerzak and Bernard, 2017). The technologies are fundamentally changing the relationships between producers and consumers. Many consumers, retailers or the professional public perceive it as a new marketing channel or way of trading. But, the internet is the technical and technological basis for the digital economy (Severvic, 2007).

Since 1996, research in the digital economy has begun to grow, and the concept of the digital economy has improved (Zhang et al., 2021; Kersan-Skabic, 2021).

Many prominent experts have led and continue to lead debates about the benefits of the digital economy. However, they agreed that the most important basis was to define the nature and terminology of this phenomenon. The broader definition introduces the digital economy as a post-industrial global economy based on internet commerce and modern technology (Balejová, 2015). The digital economy consists of markets based on digital technologies that facilitate trade in goods and services through e-commerce (Ivanová et al., 2019). Dahlman et al., (2016) also interconnected the digital economy with digital technologies, but their approach also includes information networks and the activities that people carry out through these networks. When defining the term, Novikova and Strogonova (2020) focus on naming the means used by the digital economy, e.g. they mention mobile and wireless networks as well as cloud and big data technologies. According to Borowiecki et al. (2021), the digital economy represents the economy of goods and services whose development, production, sale or supply depend completely on digital technologies.

Defining the digital economy is associated with the problem of its quantification. The definition is based on what we include in the measurements. Another problem pointed out by Barefoot et al. (2018) is the speed and nature of the changes in the technologies that make it up.

From the many definitions of the digital economy, we have finally chosen the definition given by OECD (2020). It says that the digital economy includes all economic activities dependent on or significantly influenced by digital inputs. This concept includes digital technologies (Stankovic et al., 2021), digital infrastructure, digital services and data. As it is a comprehensive definition, it applies to all producers and consumers, government as well as end users of digital inputs.

The digital revolution is important for all countries without distinction (Dahlman et al., 2016). Taking advantage of the global digital economy is important for developing, advancing and increasing a country's competitiveness.

Among the main driving forces of the digital economy, we can include factors of economic, political but especially technological innovation (Brynjolfsson and Kahin, 2002). However, at the turn of the 21st century, the development of information and communication technologies, in particular, was a major driver of economic change. This includes, in particular, advances in the functions and use of mobile phones, tablets, notebooks, digital services, and the development of automation and robotics (Bukht and Heeks, 2017).

Thanks to these attributes, we can proceed in datafication, digitalisation (Goldfarb et al., 2015), virtualisation (Bukht and Heeks, 2017) etc., which we found very important in these days affected by COVID-19 pandemic.

Major changes in the functioning of global economies related to the development of information and communication technologies are called digital transformation (Borowiecki et al., 2021). It results not only in changes in the behavior of consumers

and businesses but also in communities and regions. Digital technologies have the potential to drive efficiencies (Brynjolfsson and Kahin, 2002) and provide opportunities for firms to increase earnings and market share (D'Souza and Williams, 2017). Improved access to information to the market with new customers (Colin et al., 2015), possibly in other regions and thus a possible increase in sales. This also results in an increase in turnover, an increase in employees, and other multiplications for company, region and country. The advantage is that the development of the digital economy can support inclusive growth regardless of the country's stage of development, as demonstrated by Dahlman et al., (2016). Borowiecki et al. (2021) stated that the key trends include cloud technologies, big data, artificial intelligence and cyber security.

However, the rise of the digital economy is not without difficulties and negatives. On the one hand, digitalisation creates new jobs, but on the other hand, it changes the composition of existing jobs (Ivanová et al., 2019) and increases employee demands. Because no country is immune to digitization (Masárová et al., 2018), such a change is focused on skills as well as further qualification of employees and associated expenses (Dahlman et al., 2016). Many of the activities that workers perform today will be automated or even partially automated and thus replaced to some extent. However, on the other hand, the impact of technology will create new jobs, thus compensating for those that are threatened by automation (Holford, 2019). Digitization is understood as the integration of data and the internet into production processes (Borowiecki et al., 2021). Milošević et al., (2018) pointed out that digitalization is about creating value. According to D'Souza and Williams (2017), digitization can be measured using the following attributes: ubiquity, affordability, reliability, speed, usability and skills.

Digitization, according to Zhang et al., (2021), represents the constant integration of information technologies into various sectors of the national economy, ultimately creating the digital economy's added value.

However, if we want to compare countries in terms of their level of digital economy, the challenge is how to quantify their digital performance. Several indicators are used to measure the digital economy and compare outputs between countries. They often compare European Union countries with average of the EU, such as European Commission in DESI index, or provide an overall comparison of the regions of the world, such as International Telecommunication Union in the document measuring digital development facts and figures 2021, International Institute for Management Development in the Digital Competitiveness Ranking or OECD in Going Digital Toolkit (OECD, 2020).

Digital competitiveness is only one of many sub-areas of competitiveness, so we can find fewer studies published on it on competitiveness. On the DESI index, as one of the many tools for measuring digital competitiveness, since its focus is only on the EU countries, limited studies can be found. But despite this, several studies can be found with different views on the index and its interpretation.

Analyzes of the outputs of the DESI index, i.e. the ranking or development of countries, can be found in the authors Bánhidi et al., (2020), Russo (2020), Stoica, and Bogoslov (2017), Zoltan et al., (2019). This type of study within the DESI index is the most common. The authors focus only on the position of the country or of the set of countries in the given index.

The relationship or connection between DESI and selected indicators, most often macroeconomic, is mentioned by Parra et al., (2020), Basol, and Yalçın (2021), Vyshnevskiy et al. (2021) and others.

How individual parts of the index affect each other is analyzed by Kovács et al. (2022). Within one hypothesis, these authors also examine the relationships between individual parts of the DESI index. Bánhidi et al., (2020) analysed the linear relationships between the DESI dimensions. However, such analyzes are not frequent. Therefore, it is decided to focus on the given area and examine it as part of hypothesis 1 (our research question 1).

Clustering between countries in the context of digital competitiveness and the DESI index is the next area where the gap for further research can be seen. Clustering of countries can be found in Kovács et al. (2022). They examined the position of countries on the plane of principal components but not in the form of a cluster analysis. Cluster analysis can be found by Stankovic et al. (2021) and Sevgi (2021), but there is a lack of visual representation of the created clusters, and also by the authors Zaharia and Balacescu (2020), Bánhidi et al., (2020), but there are analyzes of older data.

Research Methodology

In the context of the mentioned facts, it was decided to combine in this investigation an examination of the significance of individual parts from DESI and, on the other hand, a cluster analysis as an answer to the question, which countries are similar to each other in the development of DESI.

The aim of the paper is to investigate the position of EU countries in the digital economy, and detect the leaders of countries in this area and key factors using two multidimensional approaches. This study evaluates the development between the years 2014 and 2021. Although the United Kingdom was still a member of the EU at the time, it is no longer included in the evaluation. The sample contains only 27 countries. To evaluate the country's digital economy level, the authors chose from published global indices and rankings. This is because these rankings contain outputs for several indicators. From this point of view, they are more complex. On the other hand, the institutions that perform such rankings already have several years of experience and a sophisticated methodology. Therefore, such an assessment of countries is more complex, with a higher informative value.

One of the best indicators of digital transformation is the DESI composite index, according to Esses et al., (2021). Because International Institute for Management Development (IMD) is an institution with several years of experience in publishing various rankings and comparisons, it is seen as appropriate to select Digital

Competitiveness Ranking for comparison. So, the digital economy was evaluated on the basis of these 2 approaches.

The first, more comprehensive, is the European Commission's approach. Through the DESI index, it compares and measures the performance of EU countries in the digital area. In this approach, the authors focused on analysing the 27 EU countries and compared the individual values with the EU average from 2014 - 2021.

The second approach was published by IMD in 2017 and referred to as Digital Competitiveness Ranking. In this assessment, more countries, not only from Europe but from all over the world, are analyzed in the area of digital competitiveness. Another difference with the above evaluation is that both hard and soft data are used. However, the greater complexity of the countries being compared is also associated with difficulties with data availability. As Digital Competitiveness Ranking has three main components, not all have reached the complete data for 2014-2021. In this approach, the authors have chosen to analyze EU countries for comparability with the results of DESI index in 2017-2021. However, Malta is not included in the IMD database, so this ranking does not include this country.

The detections of empirical studies from literature review, several approaches and different results of rankings motivated to conduct of this research. When analyzing the results of rankings, the researchers were also interested in key factors, which they formulated into research questions (RQ). For the DESI index, these were RQ 1 and RQ 2, for the Digital Competitiveness Ranking RQ 3, and the overall evaluation of the countries' success in the digital economy, RQ 4.

Research question 1: How significant are the relationships between the DESI dimensions?

Research question 2: Which clusters can the analysed countries be divided into?

Research question 3: How significant are the relationships between the parts of Digital Competitiveness Ranking?

Research question 4: Which country is the best at the digital performance level? Which factors are set as key factors influencing the position in rankings?

Different methods were used to find answers to the research questions, especially according to the nature of the analyzed problem. The study uses methods of empirical analysis, correlation and cluster analysis and from the MCDA group, the method of distance from an imaginary object. The data are presented in tables and graphs for better clarity of the data.

Methods of multicriterial analysis originated in the 1960s, but today are becoming more and more popular (Borza et al., 2018). Multicriterial analysis provides a systematic approach, combining different data to evaluate and compare different approaches, respectively, alternatives (Širá et al., 2021). There are many approaches that fall under the MCDA, each of which contains different structures for their representation, algorithms for their combination, and processes for interpretation (Huang et al., 2011; Vavrek, 2019).

One of the methods belonging to the MCDA group is the method of distance from an imaginary object. By imaginary object, the authors mean an abstract object that

would achieve the best value of each indicator. This method aims to replace the analysed indicators with a synthetic, aggregated indicator, according to which the analysed countries can be arranged from the best to the weakest. For each country, the study calculates the average distance from the imaginary object and based on these values, the best countries with the lowest distance are determined. Because indicators can be expressed in different units and different scales, it is advisable to work with standardized variables.

Research Results and Discussion

The digital economy and its influence on national competitiveness in the EU is analysed by the European Commission. Firstly, it tries to introduce this opinion on the digital economy performance of the countries.

The European Commission constantly monitors Member States' progress in various areas of the economy. In the field of digital technologies, this progress has been focused on since 2014 through the DESI index (Bánhidi et al., 2020; Stavitsky et al., 2019). The ranking of individual countries and progress, whether in the country's overall position or in individual sub-indices, is the subject of the Annual Report on the Digital Economy and Society Index (DESI). Developments in the DESI index have a significant increasing trend.

At present, many factors have a significant impact on what is happening in the economy, as well as in the field of digital technologies. Thanks to technical progress, many factors have changed, simplified, and therefore arose, the need to include the latest technological changes in this index.

Research question 1: How significant are the relationships between the DESI dimensions?

To answer it, the authors used correlations. The authors correlate the results at a significance level of 5%, as shown in Table 1. The values given with * are the values tested at the significance level of 1%. Table 1 shows the medium and strong correlations between the individual DESI dimensions. All correlation values are positive, indicating that the movement of variables goes in one direction. We consider this finding to be a significant result. The question arises, how do each of these dimensions add value to our evaluation?

Table 1. Correlations between the DESI dimensions

		Connectivity	Integration of digital technology	Digital public service
Human capital	Correlation	.6252	.8398	.7358
	p (value)	.000*	.000*	.000*
Connectivity	Correlation		.5439	.4668
	p (value)		.003*	.014
Integration of digital technology	Correlation			.7040
	p (value)			.000*

From the calculated correlations, the highest correlation was between Human capital and Integration of digital technology, in the amount of 0.8398. This means that there is probably some causal relationship between these two dimensions. Another high correlation is between Digital public service and Human capital (0.7358) and Integration of digital technology (0.7040). Low correlation values were detected between Connectivity and Digital public services.

In analyzing the results of the DESI index, the study continues to address another research question. It looks for answers to the question of what countries are similar to each other in the development of DESI so that they can form clusters.

Research question 2: Which clusters can the analysed countries be divided into?

The study uses the cluster analysis method to solve this research question. This method presents a wide range of techniques on a statistical and mathematical basis. Its primary goal is to find such groups of objects in which objects with similar properties are included. A cluster represents a group of objects whose distance or dissimilarity is less than the distance between objects that do not belong to a cluster. Clusters of hierarchical methods of cluster analysis are presented in the form of dendrograms.

The cluster analysis is a multidimensional method that allows to group of objects. The researchers evaluated 27 EU countries through 4 dimensions of the DESI index. Countries are divided into clusters based on similar points. The results of the cluster analysis are summarized in Figure 1. The figure also shows how each group is created. The study used Euclidean distance, which is the most commonly used measure. It formed clusters using the unweighted average method of groups of pairs.

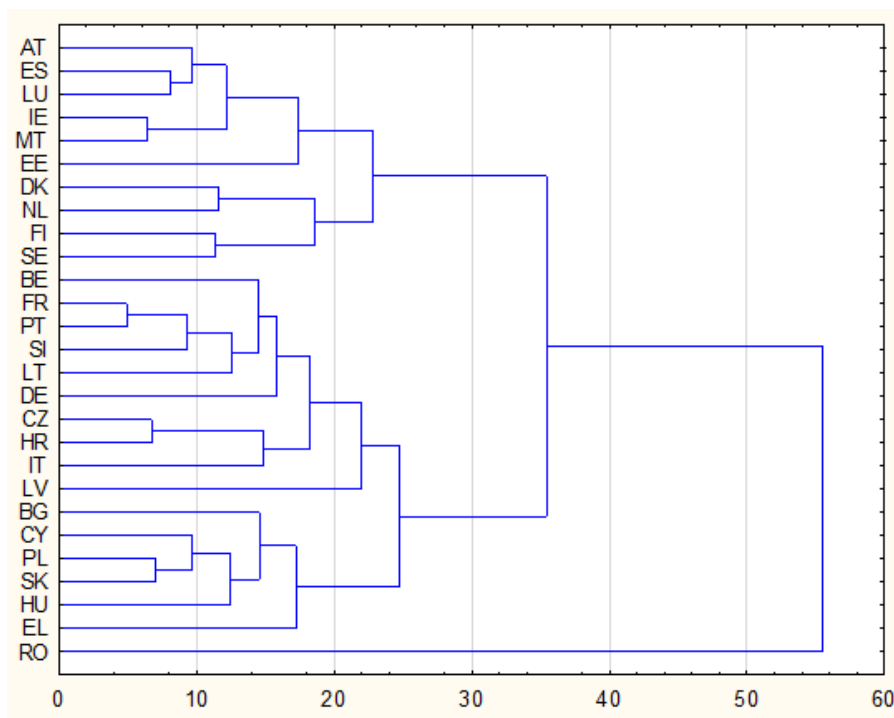


Figure 1: Cluster analysis

Source: Authors' processing

In the first division, it is clear that Romania is singled out as a separate entity compared to the other countries analyzed. Romania also achieved the lowest DESI values, a country with a significantly lower level of the digital economy than others. Therefore, it is also excluded from the cluster analysis. It is an interesting finding because Zaharia and Balacescu (2020) identified Bulgaria in this way as an individual country. However, their research is based on data from 2014, which of course, does not reflect new developments in recent years. But, some similarities can be found here, as both countries, Romania and Bulgaria, are among the weakest economies in the EU at all. This situation can also be seen in Bánhidi et al., (2020), where both mentioned countries formed a relatively independent cluster together with Greece.

At the next level, the clusters split into two large groups. In contrast, in Zaharia, Balacescu (2020) and Bánhidi et al., (2020), three strong clusters of countries with a similar composition can be seen. The clusters are not completely identical due to the differences in the analyzed area in individual studies. The EU's strongest economies in the digital economy are Sweden, Finland, the Netherlands and Denmark. These are countries at a comparable level with minimal differences. To these are added Estonia, Malta, Ireland, Luxembourg, Spain and Austria.

Other countries achieved lower to average or average values. It can also be identified as a clear cluster of the weakest among the analyzed countries: Greece, Hungary, Slovakia, Poland, Cyprus and Bulgaria.

In conclusion, the study has identified clusters of countries according to the different levels of maturity of the digital economy measured by the DESI index. One independent country also appeared during the clustering, which was not included in any cluster. In this case, it was the weakest country in this area.

Research question 3: How significant are the relationships between the parts of Digital Competitiveness Ranking?

The second approach by which it assesses the level of digital economy in the EU countries is Digital Competitiveness Ranking. World Competitiveness Ranking, published by IMD, is a unique and comprehensive database. It compares the Digital competitiveness between countries all over the world, non-only European. The IMD's methodology differs from the established practices of other institutions, which deal not only in the digital field. IMD considers hard and soft data when evaluating competitiveness (IMD, 2022).

The authors compare developments in one part of Digital Competitiveness Ranking, specifically in Digital skills. This part was chosen due to the fact that data for this part was available for the whole monitored period 2017-2021. If we look at the development of Digital skills in general, its growth trend is not as definite as we could see in the case of DESI. The achieved values of either the best (Finland) or the weakest (Hungary) country are fluctuating, with only a slight trend of overall growth. According to this finding, this ranking has a more significant impact on the environment.

We had to make some corrections to find the answer to this question. Due to the incomplete data of individual components of this ranking, we could only analyze the last year, 2019, because no newer data were available especially in the E-participation section. The authors used correlation at a significance level of 5 % to answer this research question. The results are shown in Table 2.

Table 2. Correlation between individual parts of Digital Competitiveness Ranking

		Mobile Broadband	E-participation
Digital / Technological Skills	Correlation	.1761	.0714
	p (value)	.389	.729
Mobile Broadband	Correlation		.1397
	p (value)		.496

The analyzed correlation among the individual parts of Digital Competitiveness Ranking was not confirmed. In all cases, the results were not statistically significant. It cannot be claimed that there is a correlation between the individual parts of Digital Competitiveness Ranking (limitations of the research).

Research question 4: Which country is the best at the digital performance level? Which factors are set as key factors influencing the position in rankings?

To find the answer, the DESI index and Digital Competitiveness Ranking rankings must be compared. But due to the lack of data in the second evaluation, we could only evaluate the year 2019. If we evaluated the year 2021 with incomplete data, the informative value of the results would be very low. The second problem was the lack of data from Malta in Digital Competitiveness Ranking. Therefore, this country is not evaluated in this research.

It is challenging to evaluate countries based on two different rankings. Although both rankings are focused on the same issue, the choice of indicators, the methodological procedure of calculation, or even the data collection itself are different. For this reason, we decided to evaluate both approaches on the basis of using the multicriterial evaluation method, the method of distance from an imaginary object. Such similar research is found by Stankovic et al. (2021), but there was used another multicriterial evaluation method – TOPSIS method. This method is based on a similar concept because a common feature is that TOPSIS takes the shortest distance from the positive ideal solution into account. The difference is that TOPSIS also considers the longest geometric distance from the negative ideal solution. For this reason, the study cannot compare its results with Stankovic et al. (2021) results. There are many supporters on the side of one and the other method; it's just a point of view on the result.

Due to the different units in which the analyzed indicators are presented in both approaches, the authors chose to work with standardized variables, as seen in Table 3, to get the results from the method of distance from an imaginary object.

Table 3. Standardized values of indicators

2019	DESI				Digital Competitiveness Ranking		
	Human Capital	Connectivity	Integration of digital technology	Digital public services	Digital / Technology skills	Mobile Broadband	E-participation
AT	0.770811	-0.6595	0.084049	0.699622	-0.59809	0.155466	1.269533
BE	0.420849	-0.72107	1.088232	-0.07851	-0.18816	-0.28304	-1.55036
BG	-1.43319	-0.90827	-1.62288	-0.74138	-0.0341	-0.01881	0.538677
CY	-0.58713	-1.5305	-0.6554	-0.45488	-0.54607	-2.35188	1.060717
CZ	-0.17086	-0.3822	0.05153	-0.54245	-0.34639	0.262281	-0.92391
DE	0.751086	0.08293	-0.2568	-0.09521	-1.43234	-1.26124	-0.7151
DK	1.361889	1.464966	1.57151	1.198958	0.927179	1.375408	1.165125
EE	0.829978	0.323242	-0.0499	1.468181	-0.96482	0.256659	1.478349
EL	-1.14794	-2.23985	-0.73602	-1.56076	-0.14699	-0.49667	-0.40187
ES	-0.12417	1.281176	0.29589	0.76125	0.028892	0.430937	0.120167
FI	2.054735	0.169737	1.962914	1.15729	1.679684	1.448492	1.060717
FR	-0.08056	-0.04894	-0.39782	0.261659	0.049538	0.352231	0.643085
HR	0.093337	-1.03403	-0.20141	-0.99256	-1.72261	0.644567	0.538677
HU	-0.80423	0.049792	-1.36276	-1.02553	-2.08929	1.156156	-1.34155
IE	0.207571	-0.76715	1.083638	0.867769	0.300022	-0.21558	0.224575

IT	-1.23329	-0.44898	-0.29593	-0.33771	-1.15847	-0.91269	-0.08865
LT	-0.31913	0.033844	0.44756	0.585701	1.831911	-0.73279	-0.81951
LU	0.69804	1.428133	0.169852	0.787873	-0.28812	-1.09821	-1.13273
LV	-0.72414	1.47162	-1.32776	0.696339	0.624341	0.824467	-2.17769
NL	1.358238	0.712752	1.392932	0.727323	1.374544	0.678298	1.165125
PL	-1.08561	-0.95355	-1.27392	-0.82464	-0.64235	0.217306	1.165125
PT	-0.58506	0.433984	0.141839	0.133855	0.87674	-1.56482	-0.08865
RO	-1.75479	0.725918	-1.42258	-2.84531	0.425447	-1.25	-0.19306
SE	1.811779	1.672124	1.440667	1.033925	0.989876	0.723273	-0.08865
SI	-0.04596	0.544679	0.537049	-0.05578	0.773343	1.729585	0.224575
SK	-0.26225	-0.70086	-0.66448	-0.82502	0.276277	-0.06941	-1.13273

Table 4. Ranking of the EU countries

DK	1.	ES	6.	LT	11.	LV	16.	BG	22.
FI	2.	EE	7.	LU	12.	SK	17.	CY	23.
NL	3.	IE	8.	PT	13.	DE	18.	HU	24.
SE	4.	AT	9.	BE	14.	HR	19.	EL	25.
SI	5.	FR	10.	CZ	15.	PL	20.	RO	26.
						IT	21.		

Based on a comparison of standardized values in both indicators, the study obtained the final ranking of countries shown in Table 4. Denmark became the best country, followed by Finland, the Netherlands, Sweden and Slovenia. Bulgaria, Cyprus, Hungary, Greece and Romania were the five weakest countries in the digital area. In this case, a partial similarity with Stankovic et al. (2021) can be seen. They identified Finland, the Netherlands and Denmark as the strongest countries. The weakest countries were Romania, Bulgaria, Hungary, Greece and Poland. All three of the strongest countries, although in a different order, were also evaluated by the researchers through the research. Also, even with the weakest countries, 4 countries out of five were the same as in the proposed approach. However, it should be noted that Stankovic et al. (2021) used a different method (TOPSIS) and also different input data (based on DESI only).

It must be pointed out that the study analyzed the results from the year 2019. Thus, the present situation in the digital area may already change, as well as the level of individual countries.

Mentioned results are very interesting. Because of the DESI approach, Denmark was the best country and performed the best in this method. In the second approach, Digital Competitiveness Ranking, Finland was the best country. Finland was the second best in this overall evaluation. So even in this context, we can consider these results confirmed.

To answer the second question, which factors are set as key factors, we must look detailed at the best countries. The best results were achieved by the top countries in

the areas of human capital and integration of digital technology and skills (in Table 3).

Conclusion

From a theoretical point of view, this study contributes to the body of knowledge by analyzing the digital economy through selected indices. It also contributes concrete proposals and examples of how managers can use the acquired knowledge in business.

The researchers analyzed the digital economy in the EU countries. Due to incomplete data, some analyzes had to be reduced, e.g. reduced sample of countries, excluding Malta and for the period 2019 and not for the last analyzed year 2021. In the field of digital economy and its quantification, the research finds several indices that accurately express the level of individual countries and compare them with other countries. In this way, each country can assess its competitiveness in this area.

From several indices and rankings, the authors chose DESI and Digital Competitiveness Ranking. DESI index is performed and published by the European Commission for EU countries. This index identified its overall growing trend in all countries and confirmed the correlation between its individual dimensions in 2021. The cluster analysis results in 2021 also show a strong position of the leading countries in the field of digital economy. Among the competitive countries, we can mention Denmark, Netherlands, Finland and Sweden. The development in the monitored area is very similar between these countries.

Nowadays, when we encounter technologies daily, both in everyday life and in business practice, it is good to know which countries are leaders in this field. Because doing business in them will be much easier. Perhaps everyone is aware of what the digital economy means for the country. And not only for the country but also for businesses and households. Doing business is easier in countries that are advanced in the digital economy and digital investments. It enables managers to manage processes more effectively when they can use innovative solutions, digital platforms and e-government services, quickly communicate and rely on new technologies and digital models. Information networks are a significant advantage for managers, as they are the ones who constantly work with information. The right information found in time has a high value for the manager.

The second analyzed index was the Digital Competitiveness Ranking published by IMD. In this ranking, the increase in the values of the analyzed countries was not as significant as in the previous one, but we can still talk about increasing the digital competitiveness of EU countries.

Digital economy also brings positives in the form of internet connectivity and coverage. This is a key factor for managers. Managing the company, processes, employees, and doing business are currently transferred to the virtual sphere. Besides, that is needed to have good and stable internet connectivity.

According to the limits that the combination of these two indices brought, we could evaluate the best country based on the results from both approaches only in 2019.

According to results from the multi-criteria evaluation, the best countries also achieved leading positions in both approaches. Denmark, Finland and the Netherlands can be considered among the most successful countries in the digital economy, probably in the future, too. We can take examples of best practices from abroad as managerial recommendations. The most important key factors set as driving forces for the next digital decade are human capital, integration of digital technology, digital skills in all areas of economy and business worldwide.

It is known that 2019 was also the year when the Covid-19 pandemic and its associated limitations and restrictions appeared. Governments had to reconsider their expenses, and various transfers between planned expenses occurred. Surely each country has felt the effects of the pandemic differently. It is certain that the development trend has changed, and thus progress in the digital technology field has also been slowed down. In the future, it will be interesting to examine the impact of this pandemic on digital technologies, especially on driving forces in this area. Also, quantify how Covid-19 has affected the digital competitiveness of individual countries, either positively or negatively, if this pandemic has any effect on the performance of digital factors and their influence on economic growth. During the Covid-19 pandemic, opportunities have arisen for managers and entrepreneurs. In the form of a greater expansion of e-commerce, especially in countries with a long-term lockdown. In this case, management could take advantage of the digital economy and thus strengthen and improve its business.

It may also be interesting to evaluate the EU countries for further study, e.g., using the aforementioned MCDA method, as the order of the strongest and weakest countries changed in the following years. However, it is necessary to supplement the missing data and to give it sufficient time to point out possible changes.

As a last limitation arising from the issues analyzed here, the authors can mention the variability of approaches to evaluating the digital level of countries. It is worth mentioning to conduct broader research while considering more rankings and evaluations. Perhaps, with the possible expansion of the sample of countries, greater variability of economies may show interesting connections.

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OCENA POZIOMU GOSPODARKI CYFROWEJ W KRAJACH UE – BADANIE EMPIRYCZNE

Streszczenie: Rozwój nowych technologii powoduje gwałtowny wzrost w globalnym biznesie i handlu oraz zwiększa zapotrzebowanie na wiedzę i umiejętności, co pozytywnie odbija się na wzroście gospodarczym. Celem badania jest identyfikacja najlepszych krajów UE pod względem gospodarki cyfrowej, przy użyciu dwóch reprezentatywnych podejść. Uwagę zwraca indeks DESI za okres 2014-2021 oraz Global Digital Competitiveness Index. Stosując podejście wielowymiarowe i metody wielokryterialne, za najlepiej rozwinięte kraje pod względem realizacji gospodarki cyfrowej zostały uznane: Dania, Finlandia i Holandia, dodatkowo zidentyfikowano siły napędowe tej sytuacji, istotne w kontekście statystycznym i ekonomicznym. Wykazano również istotne korelacje między wymiarami wskaźnika DESI. W oparciu o najlepsze praktyki przodujących pod względem cyfryzacji krajów UE zidentyfikowano kluczowe czynniki o implikacjach zarządczych

w strategii transformacji cyfrowej UE do których zaliczono: kapitał ludzki, integrację technologii cyfrowej i umiejętności cyfrowych.

Słowa kluczowe: Indeks Gospodarki Cyfrowej i Społeczeństwa Cyfrowego, Ranking Konkurencyjności Cyfrowej, Kapitał Ludzki, Umiejętności Cyfrowe.

欧盟国家数字经济水平评估——一项实证研究

摘要：新技术的发展带来了全球商业和贸易的繁荣，增加了对知识和技能的需求，这在经济增长中有积极的体现。该研究的目的是使用两种具有代表性的方法调查数字经济中最好的欧盟国家。重点关注2014-2021年DESI指数和全球数字竞争力指数。使用多维方法和多标准方法，最佳国家被确定为丹麦、芬兰和荷兰，以及在统计和经济背景下都具有重要意义的驱动力。还证明了 DESI 指数维度之间的显著相关性。根据最佳欧盟国家的最佳实践，确定的对欧盟数字化转型战略的管理影响的关键因素是人力资本、数字技术和数字技能的整合

关键词：数字经济与社会指数，数字竞争力排名，人力资本，数字技能