International Journal of
Information Systems and Project Management
ISSN (print):2182-7796, ISSN (online):2182-7788, ISSN (cd-rom):2182-780X
Available online at ijispm.sciencesphere.org

Digital Transformation in European Union: North is leading, and South is lagging behind

Ján Hunady
Matej Bel University in Banska Bystrica, Faculty of Economics
Tajovskeho 10, 97590 Banska Bystrica, Slovakia
jan.hunady@umb.sk

Dalia Suša Vugec
University of Zagreb, Faculty of Economics & Business
Trg J.F. Kennedyja 6, 10000 Zagreb
Croatia
dsusa@efzg.hr

Peter Pisár
Matej Bel University in Banska Bystrica, Faculty of Economics
Tajovskeho 10, 97590 Banska Bystrica, Slovakia
peter.pisar@umb.sk

Mirjana Pejic Bach
University of Zagreb, Faculty of Economics & Business
Trg J.F. Kennedyja 6, 10000 Zagreb
Croatia
mpejic@net.efzg.hr

Abstract:
The transformation of the economy into a digital environment has become a necessary step in recent years. The consequences of the COVID pandemic have accelerated the digital transformation and the growth of the digital economy. Intensive business engagement in the digital economy requires innovative digital solutions and online means of promotion and sale. European Union (EU) countries need to create the conditions for the gradual transformation. The paper analyses business readiness for the digital economy in EU countries. It aims to compare and assess the current situation of digital readiness based on the set of selected indicators. The analysis includes a multidimensional comparison of EU countries, classification based on cluster analysis, and ranking based on factor analysis results. Results show significant differences among EU countries. Newer member countries, mostly from South-Eastern Europe, are still lagging behind the EU average in e-Commerce activities, usage of social networks, and cloud computing. Furthermore, factor analysis has been conducted to determine underlining factors describing the overall digital readiness of EU countries and rank them accordingly. As well as in the cluster analysis, factor analysis revealed that Nordic EU member countries perform very well and show the highest digital readiness.

Keywords:
digital business solutions; digital economy; cluster analysis; digital transformation; EU countries classification.

DOI: 10.12821/ijispm100403

Manuscript received: 9 May 2022
Manuscript accepted: 8 July 2022

1. Introduction

In the last few decades, the development of new technology has been happening rapidly, which has brought many changes to the functioning of businesses, governments, and everyday life. In addition, such rapid technology development led to many innovations, which altogether led to the emergence of the digital economy, a term coined by Tapscott [1] to describe new business models, commodities, markets, and services, particularly those relying on digital technology as a core corporate infrastructure [2]. Consequently, the usage of digital technologies opened up many possibilities for developing innovative business models or making serious changes to existing ones, known as the digital transformation process [3].

The digital economy and digital transformation have been some of the most discussed issues among both professionals and academics for a long time. Named topics have been previously often explored in the context of transformation to Industry 4.0 and its support (e.g., Pejić Bach et al. [3], Ustundag and Cevikcan [4], Lee et al. [5], Rajnai and Kocsis [6], Ghobakhloo and Iranmanesh [7]). In that sense, it has been often argued that one of the most important aspects of digital transformation is having a clear digital strategy (e.g., Pejić Bach et al. [3], Gobble [8], Kane et al. [9], Suša Vugec et al. [10]). Moreover, even governments recognize the importance of having digital strategies. For example, European Union (EU) presented its Digital strategy in February 2020, which indicates that "everyone is experiencing the digital transformation in their life" and emphasizes that every European, EU business, and even the planet will benefit from the presented digital strategy [11]. Moreover, the importance of digital transformation for enterprises and policymakers has increased after introducing social distancing rules in the fight against the COVID-19 pandemic.

Furthermore, the digital economy is one of the main areas to which a significant amount of EU funding is allocated in the recovery instrument "Next-generation EU" and the Multiannual Financial Framework 2021-2027. The current business readiness for the digital economy determines its future success for the next years or decades. It could be argued that using innovative digital tools and digital transformation is unavoidable for most enterprises.

This paper deals with the problem of preparedness for the digital economy and the transition of EU businesses to digital business solutions, i.e., preparedness for digital transformation. Its main goal is to identify key similarities and differences in digital readiness among EU countries and point out the strength and weaknesses of these countries. To meet this goal, three research questions have been stated, aiming to compare the current popularity of innovative digital tools in EU countries, being: (RQ1) What is the intensity of e-Commerce activities and usage of selected innovative digital solutions by enterprises in EU countries?; (RQ2) How can the EU countries be classified based on their similarities in digital readiness?, and (RQ3) Which EU countries are leaders in digital readiness, and what is the ranking of EU countries according to their overall digital readiness? Answering stated research questions allows authors to assess the overall digital readiness of enterprises in EU countries and, therefore, contribute to the body of knowledge on this topic.

After this introduction, the rest of the paper is structured as follows. The next section presents a brief literature review, providing a theoretical background of the study. The methodology and data used in the analysis are described in the third part of the paper. Next, the fourth part of the paper shows the most important results following the discussion. Finally, a summary and conclusions are provided in the last part of the paper.

2. Literature review

Several recent studies have examined the digital transformation of business in the EU, for example, Kääriäinen et al. [12], Kinnunen et al. [13], Borowiecki et al. [14], and Bouwman et al. [15]. However, most of them are focused on the process problems related to digitalization, accumulation of digital capital, or the level of overall digitalization in the country. While this paper is based on mentioned previous research, it pays significantly more attention to indicators related to the digital readiness of enterprises. It classifies and ranks EU countries according to enterprises' digital readiness for digital transformation. To some extent, a similar approach was previously used by Kozhevina et al. [16].

However, they calculated aggregated digital economy index based on different indicators suitable for the Russian economy [16].

The European Commission [17] annually monitors digital progress in EU countries via Digital Economy and Society Index (DESI) reports. DESI captures country profiles and identifies areas requiring action. There are five main DESI key areas of concern, being: (i) Human capital, (ii) Connectivity, (iii) Integration of digital technology, (iv) Digital public services, and (v) Research & Development in information and communication technology (ICT) [17]. Based on the overall results in the DESI 2021 report, Denmark, Finland, and Sweden are ranked as the three top-performing countries, while, on the other hand, Romania, Bulgaria, and Greece are placed at the end of the ranking [17]. This paper's analysis focuses on a much narrower yet still complex definition of the problem. In that sense, the approach within this paper captures only indicators related to enterprises and their e-Commerce activities and the usage of innovative digital solutions.

According to Tomičić Furjan et al. [18], enterprises face many challenges in keeping up with the competition due to the digital transformation of the economy. Moreover, those enterprises that are undergoing the process of digital transformation are required to make significant changes to their business models [15]. To achieve digital transformation, enterprises should reconsider their current operations and business models from the perspectives of innovative digital technologies [12]. Furthermore, the global digitalization trend puts pressure on a business in the EU. According to Schweer et al. [19], it is likely that enterprises in the EU are already significantly lagging behind other main global players like China and the United States in sales related to ICT. Moreover, the current state of a digital economy is also significantly different among countries within the EU [13]. In particular, enterprises in several of the EU's newest member countries lag significantly in digital transformation. Hence, this problem needs to be examined to find solutions. In that sense, significant measures toward digital transformation are anticipated to be required in the business and government sectors.

In the past decade, most of the attention related to the digitalization of business has been paid to e-Commerce [20]. It can increase the growth of enterprises in developed and developing countries [21], and, due to its convenience for both sellers and buyers, it gradually became the preferred way of doing business [22]. However, digital transformation currently requires much more than the involvement of enterprises in e-Commerce. Nowadays, there are many innovative digital tools that enterprises can use to increase effectiveness, including, for example, data mining [23] or cloud computing services [24]. In that sense, this paper examines the e-Commerce activities and focuses on using relatively new digital technologies, such as Big Data analysis and cloud computing.

When discussing digital transformation and digital technologies, one should also consider the possible ways of online communication with customers that enterprises have at their disposal. Using a website can be considered more traditional than social networks. However, both schemes have their potential benefits as well as limitations. The utilization of social networks for Business to Business (B2B) and Business to Customers (B2C) communication and e-Commerce has been studied in more detail, for example, by Ballestar et al. [25] or Davidaviciene et al. [26]. Schwertner [27] argues that Big Data, cloud, mobile, and social technologies are critical parts of business infrastructure. It has also been stated that such technologies would have higher revenues in the short term and enable enterprises to gain a bigger market valuation [27]. Cloud computing allows convenient, on-demand network access to a shared pool of configurable computing resources such as networks, servers, storage, or applications. Its application can reduce costs and provide access to the best possible technology [27]. Big Data refers to large, diverse data sources and types that provide difficulties processing them by traditional systems. Nevertheless, enterprises using big data management tools can significantly benefit from Big Data analysis, such as process innovation, identification of customers' needs, product design, risk management, and quality management [28]. This paper also compares the popularity of websites and social media as two main ways enterprises use online communication with their customers.

In terms of digital readiness, there have been some indexes previously developed. For example, a certain type of digital readiness index has been previously constructed by Philipp [29]. However, Philipp's [29] index was applied to assess smart ports, aiming to examine how the digital performance of ports can be assessed. Finally, Philipp [29] concludes that all investigated ports show rather low digital readiness for using selected innovative digital technologies. Similarly, Zalite and Zvirbule [30] compared the digital readiness of higher education institutions in EU countries. The results

again confirmed the existence of a digital gap between the best performing Nordic European countries and the less developed Southern and Eastern European countries [30]. Pirola et al. [31] assessed the digital readiness of small and middle-sized enterprises (SMEs) in Italy using case studies with 20 enterprises. They conclude that Italian SMEs show intermediate readiness for Industry 4.0; however, they mostly need support to understand their path towards digital transformation [31]. Therefore, the analysis within this paper also considers technologies for ranking countries according to digital readiness.

3. Methodology and data

The main goal of this paper is to identify key similarities and differences in digital readiness among EU countries and point out the strength and weaknesses of these countries. To meet this goal, three research questions have been stated, as it has been pointed out in the introduction of the paper.

In this paper, the authors compare EU countries based on the variables related to readiness for digital transformation and the digital economy. Variables used in the analysis are summarized in Table 1. The observed variables have been selected to reflect the most important aspects of the digital transformation: e-Commerce, providing infrastructure to employees (such as providing a portable device for business purposes and providing ICT training), communication of the enterprise with the environment (over the website and social network), and usage of security measures, as well as advanced technologies (such as cloud computing services and big data). This research does not include the United Kingdom; hence, 27 EU countries are included in the analysis. Most data are valid for 2021 and some for 2019 and 2020 (according to availability). Although the data for different years have been used in the analysis, the proposed approach is valid since the usage of the information technologies does not significantly change within a few years, especially for the actions of the enterprises related to the technology usage, such as the training to the personnel to develop their ICT skills, having insurance against ICT security incidents, and for the analyzing the big data for smart devices, which were the only three items available for the years 2019 and 2020, while for all the other items the data were available for the year 2020.

Table 1. Description of variables used in the analysis

	Variable	Description	Year
A	Enterprises with at least 1% e-Commerce sales	Enterprises with e-Commerce sales of at least 1% turnover (% of enterprises with 10 or more employees in the economy without financial sector)	2021
B	Enterprises with any e-Commerce sales	Enterprises having any e-Commerce sales	2021
C	Enterprises' total turnover from e-Commerce sales	Value of e-Commerce sales: Enterprises' total turnover from e-Commerce sales (% of the total turnover of enterprises with 10 or more employees without financial sector)	2021
D	Persons employed with a portable device for business purposes	Persons employed were provided a portable device that allows mobile internet connection for business purposes (% of total employment)	2021
E	Enterprises provided training to their personnel to develop their ICT skills (%)	Enterprises that provided training to develop/upgrade the ICT skills of their personnel (% of enterprises with 10 or more employees in the economy without financial sector)	2020
F	Enterprises with a website (%)	Enterprises having their website (% of enterprises with 10 or more employees in the economy without financial sector)	2021
G	Enterprises using any social networks (%)	Enterprises using any social network (% of enterprises with 10 or more employees in the economy without financial sector)	2021
H	Enterprises having insurance against ICT security incidents (%)	Enterprises having insurance against ICT security incidents (% of enterprises with 10 or more employees in the economy without financial sector)	2019
I	Enterprises buying cloud computing services (%)	Enterprises buying cloud computing services used over the internet (% of enterprises with 10 or more employees in the economy without financial sec)	2021
J	Enterprise analyzing big data from smart devices (%)	Enterprises analyzing big data from smart devices or sensors (% of enterprises with 10 or more employees in the economy without financial sector)	2020

Source: Authors based on European Commission [17].

The analysis has been conducted in three stages. The business enterprise sector plays a crucial role in the digital economy, and enterprises' preparedness for digital transformation seems essential for future success. Hence, this paper is focused on this issue. It compares the usage of innovative digital tools and the overall digital readiness of enterprises in EU countries based on available secondary data. Therefore, the authors first examine the share of enterprises with e-Commerce sales, compare the usage of selected innovative digital solutions, and propose an alternative way to classify and rank countries according to the digital readiness of enterprises.

Secondly, a cluster analysis based on cross-sectional country-level data from the European Commission's Eurostat database has been conducted [32]. All variables have been transformed to Z-scores before the analysis. Hierarchical cluster analysis was performed using Ward's minimum variance classification method, and the linkage measure was the Euclidean distance. This method is useful for classifying countries into rather homogenous groups (clusters) based on their multidivisional similarity. A similar type of hierarchical cluster analysis has been recently used, for example, by Pejić Bach et al. [33] to identify obstacles to the introduction of e-Commerce in European Countries. Each cluster has certain characteristics concerning countries' overall readiness for the digital economy. Cluster analysis has also been used by Kinnunen et al. [13] or Borowiecki et al. [14] to determine the degree of digitalization in the EU countries.

Thirdly, all EU countries have been ranked based on the overall digital readiness of their enterprises. The same ten variables have been used as inputs in factor analysis. The factor analysis results significantly reduce the problem's dimensions, and the calculation of eigenvalues will determine the number of key factors. In this case, only one single factor has been identified, representing the unobserved (latent) variable that captures most of the overall variance of all original variables. Factor analysis has recently been applied in a similar context by Hrustek et al. [34], using factor analyses to reveal critical digital economy factors such as e-Commerce, e-Banking, e-Work, and e-Employment. Based on the results, it is possible to assess the overall digital readiness of EU countries and rank them accordingly.

4. Results

The readiness of enterprises for the digital transformation and the digital economy can be seen as a multidimensional and complex problem, and several indicators can be considered to capture this issue partly. Hence, a set of ten variables, presented in Table 1, have been used to capture different aspects of business digital transformation and this section presents the study results.

4.1 Comparison of selected indicators in EU countries

The first part of the analysis is focused on e-Commerce sales of enterprises in EU countries. This can be considered the financial output from an enterprise's engagement in e-Commerce. Different indicators can assess the importance of e-Commerce for enterprises. This analysis compares two variables capturing the intensity of e-Commerce from different points of view. Firstly, the share of enterprises having at least 1% turnover arising from e-Commerce and the share of total turnover from e-Commerce sales on the overall turnover of enterprises in each EU country. In both cases, the differences between EU countries are relatively large, as presented in Figure 1. Denmark, Ireland, and Sweden have the highest share of enterprises engaged in e-Commerce.

Furthermore, enterprises from Ireland, Czechia, and Belgium have the highest turnover from e-Commerce activities. On the other hand, Bulgaria and Romania appear to have a very low engagement of enterprises in e-Commerce concerning both indicators. Together with Cyprus, Greece, and Latvia, these two countries have the lowest turnover from e-Commerce in the EU. Some countries such as France, Hungary, and Slovakia have a high turnover from e-Commerce despite the lower engagement of enterprises in e-Commerce. This could mean that larger enterprises with high turnovers are mostly active in e-Commerce here.

In the next step, the usage of two selected digital solutions for e-Business, namely cloud computing and Big Data analysis, have been compared. The attention has been focused on the shares of enterprises using the named two tools in the EU countries. Figure 2 illustrates the comparisons of both variables, where, in this case, the authors present Big Data analysis from smart devices and sensors (shown on the right axis).

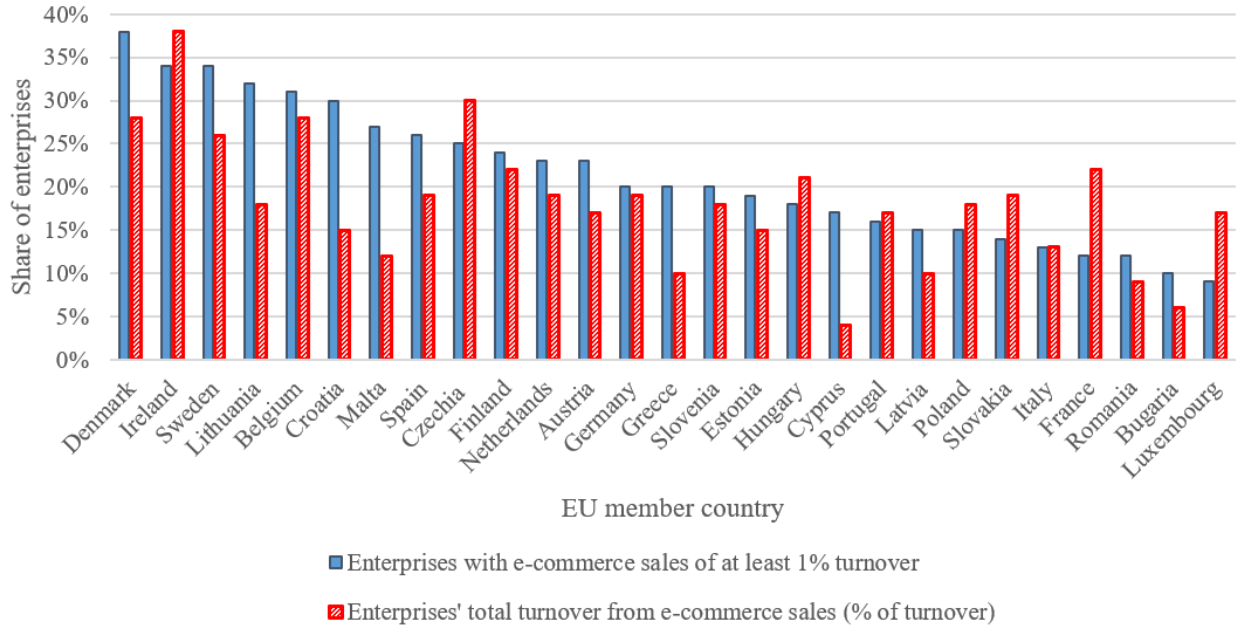

Fig. 1. The share of enterprises having e-Commerce sales (at least 1%) and share of turnover from e-Commerce sales in EU countries (2021)

Source: Authors based on data from the European Commission [17].

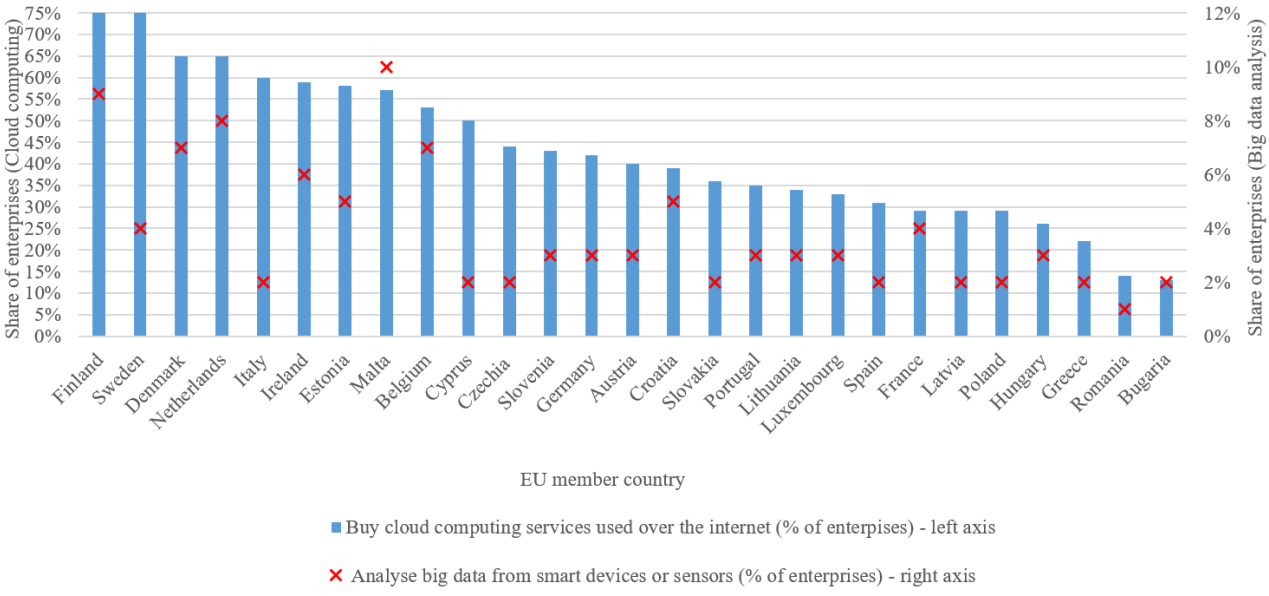

Fig. 2. The share of enterprises using two mentioned digital solutions for e-Business in EU countries (2020, 2021)

Source: Authors based on data from the European Commission [17].

As shown in Figure 2, cloud computing services are more popular than Big Data analysis from sensors and devices. This could be expected because cloud computing can be used for various purposes, while Big Data analysis, in this case, is related to certain devices. The highest usage of cloud computing services is found in Finland, Sweden, and Denmark. However, all three Nordic countries have various intensities of Big Data analysis. Big Data analysis from the sensors and devices is the most popular in Malta, followed by Finland and Netherlands. Romania and Bulgaria fail to keep pace with most countries in both indicators.

Furthermore, e-Business solutions and online promotion tools can likely lead to higher e-Commerce sales. Hence, this potential role of cloud computing services and social media usage is linked to the share of turnover from e-Commerce in Figures 3 and 4.

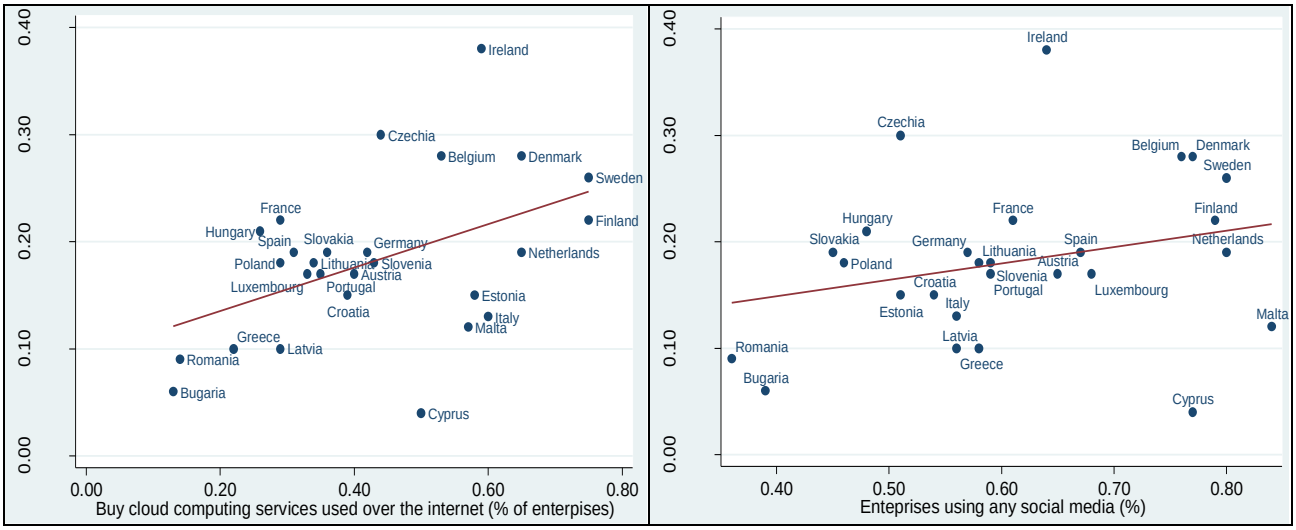

Fig. 3 and Fig. 4. The potential link between enterprises' turnover from e-Commerce and usage of cloud computing and social media (2021).

Source: Authors based on data from the European Commission [17].

The potential relationship to e-Commerce turnover seems to be more evident in the case of cloud computing. Countries with a higher share of enterprises using cloud computing have a higher share of enterprises' turnover from e-Commerce. The link seems to be also present concerning social media mentioned but is slightly less evident. Czechia and Ireland appear to be two of the most significant outliers in both cases. Despite a rather average usage of both tools, these two countries show a high share of e-Commerce turnover.

4.2 Cluster analysis of EU countries

This part of the analysis aims to classify EU countries into relatively similar groups according to their overall digital readiness. To achieve this goal, a hierarchical cluster analysis has been used. It is based on ten variables capturing digital readiness (shown in Table 1 in the Methodology section), taking into account indicators capturing the intensity of e-Commerce, turnover from e-Commerce, technical equipment for working from home, IT training, the existence of own website, usage of social networks, having insurance against ICT security problems, usage of cloud computing services and Big Data analysis. The dendrogram graphically illustrates the results of clustering in Figure 5. Countries with similar digital readiness have been included in the same clusters at a certain distance in multidimensional space.

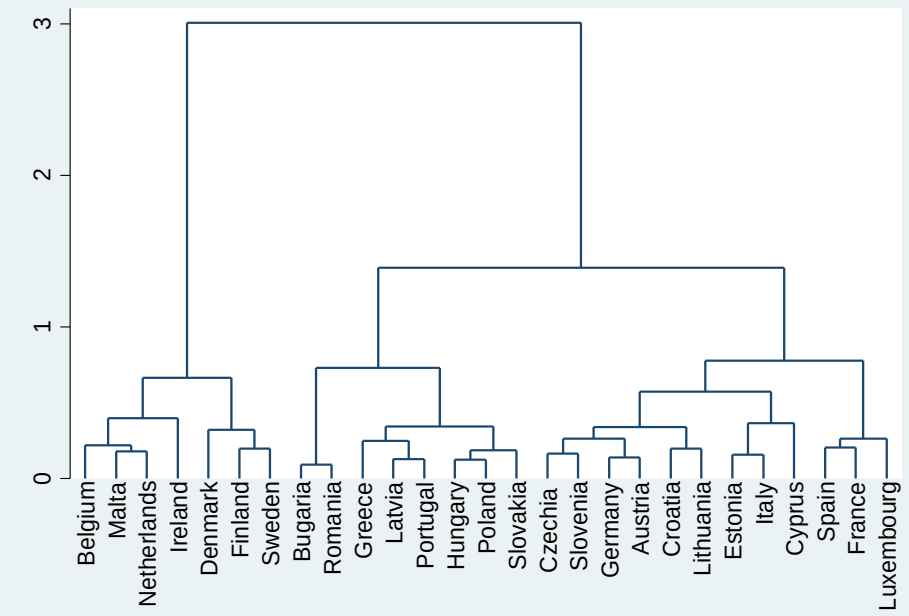

Fig. 5. Dendrogram of cluster analysis: similarity/dissimilarity in overall digital readiness of enterprises in EU countries

Source: Authors' work.

The optimal number of clusters has been determined based on the results of the Duda-Hart pseudo-t-squared test. The results of the named test are presented in Table 2.

Table 2. The results of Duda-Hart test to determine optimal number of clusters - lower pseudo T-squared statistics is desirable

Number of clusters	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Je(2)/Je(1)	0.54	0.65	**0.65**	0.42	0.54	0.62	**0.35**	0.17	0.55	0.59
Pseudo T-squared	21.7	9.6	**5.3**	8.0	4.3	4.3	**3.8**	5.0	3.2	2.8

Source: Authors' work.

Results of the cluster analysis with the ranking of the cluster in each indicator are shown in Table 3. There are three main clusters formed at relatively long distances. However, it can be useful to consider an even lower level of clusters where countries can be classified into a greater number of more homogenous groups. The optimum number of clusters can be determined by the inflection point of the Duda-Hart pseudo-t-squared test. The lower value of pseudo-t-squared statistics with higher Je(2)/Je(1) values is desirable in this case. This test is explained in detail in Rabe-Hesketh et al. [35]. According to mentioned approach, seven clusters appeared to be optimal. Hence, seven clusters have been determined at a lower level, and three can be identified at a higher level.

Table 3. Summarized results of cluster analysis, ranking of clusters in each variable, and overall ranking according to the level of digital readiness

Clusters		Countries	Variables – rank of each sub-cluster										Overall
I.	II.		A	B	C	D	E	F	G	H	I	J	
1.	C1	Belgium, Malta, Netherlands, Ireland	2.	2.	2.	3.	2.	2.	2.	3.	2.	1.	The highest digital readiness
	C2	Denmark, Finland, Sweden	1.	1.	1.	1.	1.	1.	1.	1.	1.	2.	
2.	C3	Bulgaria, Romania	7.	7.	7.	7.	7.	7.	7.	7.	7.	7.	The lowest digital readiness
	C4	Greece, Latvia, Portugal, Hungary, Poland, Slovakia	4./5.	6.	6.	5.	6.	6.	6.	4.	6.	6.	
3.	C5	Czechia, Slovenia, Germany, Austria, Croatia, Lithuania	3.	3.	3.	4.	3.	3.	5.	6.	4.	3.	Medium digital readiness
	C6	Estonia, Italy, Cyprus	4./5.	4.	4.	6.	4.	5.	4.	5.	3.	4./5.	
	C7	Spain, France, Luxembourg	6.	5.	5.	2.	5.	4.	3.	2.	5.	4./5.	

Note: Variables used in cluster analysis:
A - Enterprises with e-Commerce sales of at least 1% turnover (%) – 2021; B - Enterprises with any e-Commerce sales (%) – 2021; C - Enterprises' total turnover from e-Commerce sales (% of turnover) – 2021; D - Persons employed with a portable device for business purpose (% of employment) – 2021; E - Enterprises provided training to their personnel to develop their ICT skills (%) – 2020; F - Enterprises with a website (%) – 2021; G - Enterprises using any social media (%) – 2021; H - Enterprises having insurance against ICT security incidents (%) – 2019; I – Enterprises buying cloud computing services used over the internet (%) – 2021; J – Enterprises analyzing Big Data from smart devices or sensors - 2020.
Source: Authors' work.

It is possible to categorize countries into three groups with different digital readiness at a higher level. The first group of countries has the best digital readiness, and the second group identified by cluster analysis has the worst digital readiness. In contrast, the third group of countries has medium digital readiness.

However, it is also important to focus on seven lower-level clusters. The homogeneity within the separate clusters becomes much higher when using this classification. For example, cluster C2 consists of Denmark, Finland, and Sweden. This cluster appears to be the best in almost all indicators, and these countries have excellent digital readiness according to selected variables. Countries classified in cluster C1 also have very good digital readiness as well. This cluster has the highest share of enterprises using big data analysis from sensors or devices and scores the second-highest in most indicators. Belgium, Malta, Netherlands, and Ireland are included in the cluster.

Compared to the mentioned two, five clusters have significantly lower digital readiness. Cluster C5, including Czechia, Slovenia, Germany, Austria, Croatia, and Lithuania, appears to be third in most categories. However, enterprises in these countries have a rather low level of insurance against ICT security incidents and social media usage. On the other hand, countries in cluster C7 (Spain, France, and Luxembourg) perform very well in both categories. Moreover, this cluster also has a high share of employed people equipped with portable devices for communication. On the contrary, this share is low in cluster C6, Estonia, Italy, and Cyprus. This cluster performs moderately in almost all other categories.

The second worst performing cluster is cluster C4 (Greece, Latvia, Portugal, Hungary, Poland, Slovakia). The digital readiness, in general, is low here. This cluster performs at the average only in the share of enterprises having insurance against ICT security incidents. This could be due to higher security risks and lower ICT security in these countries.

The cluster with the lowest level of digital readiness is labeled C3 and consists of Bulgaria and Romania. This cluster performed the worst among all seven in all ten indicators included in the comparison.

4.3 Factor analysis and ranking according to overall digital readiness

The final part of the analysis aims to rank individual EU member countries according to their digital readiness. The factor analysis has been used to find a single ranking indicator of digital readiness. The analysis is based on all ten variables presented previously in Table 1. The main results of factor analyses are summarized in Table 4.

Table 4. Results of the factor analysis (eigenvalues and uniqueness of each variable)

Factor	Eigenvalue	Difference	Proportion	Cumulative
Factor 1	**6.3082**	**5.432**	**0.789**	**0.788**
Factor 2	0.877	0.386	0.109	0.898
Factor 3	0.491	0.098	0.061	0.959
Factor 4	0.393	0.301	0.049	1.009
Factor 5	0.0917	0.06	0.011	1.002
Variable included in Factor 1				Uniqueness Factor 1
Enterprises with e-Commerce sales of at least 1% turnover				0.819
Enterprises with any e-Commerce sales				0.854
Enterprises' total turnover from e-Commerce sales (% of turnover)				0.669
Persons employed with a portable device allowing communication (%)				0.761
Enterprises provided training to their personnel to develop their skills (%)				0.877
Enterprises with a website (%)				0.836
Enterprises using any social media (%)				0.818
Enterprises having insurance against ICT security incidents (%)				0.709
Buy cloud computing services used over the internet (%)				0.837
Analyze big data from smart devices or sensors (%)				0.735

Source: Authors' work.

Applied methods allow the authors to reduce dimensions of comparison significantly. In this case, only one factor sufficiently captures the overall variance of all ten variables. According to the eigenvalues (higher than 1), the optimum number of factors appears to be one. Hence, only one factor has been considered. Therefore, no rotation can be applied in this case. More than 78% of the variance is described by this factor alone. According to the uniqueness indicator, variables capturing insurance against ICT security incidents and big data analytics appear to be the two most unique. These variables are the least similar to the other eight variables included in a single factor; hence, their variability is captured only partially by a single retrieved factor.

Finally, each EU country's estimation of factor scores has also been provided. This score is a numerical value representing countries' relative standing on factor 1. Assigned factor scores allow the authors to compare countries' overall digital readiness captured by factor 1. All EU countries' factor scores and final rankings are summarized in Table 5.

As can be seen, Denmark, Sweden, and Finland are the top-performing countries according to the factor scores. These countries have the highest overall digital readiness, as captured by the selected variables. On the other hand, Bulgaria and Romania are the two worst-performing countries. The results are in line with the findings obtained from cluster analysis. Thence, two different approaches lead to similar results. Most Eastern European EU member countries have been placed in the last seven countries. Despite this, some examples of good practices among similar countries, such as Slovenia, Czechia, Croatia, and Lithuania.

Table 5. Ranking of the countries according to digital readiness based on the factors scores concerning Factor 1

Rank	Country	Factor score	Rank	Country	Factor score	Rank	Country	Factor score
1.	Denmark	1.868	10.	Slovenia	0.183	19.	Portugal	-0.573
2.	Sweden	1.707	11.	Czechia	0.073	20.	Italy	-0.598
3.	Finland	1.591	12.	Croatia	0.063	21.	Poland	-0.727
4.	Ireland	1.439	13.	Germany	0.023	22.	Hungary	-0.802
5.	Belgium	1.139	14.	Lithuania	0.013	23.	Greece	-0.815
6.	Malta	0.880	15.	Cyprus	-0.215	24.	Latvia	-0.825
7.	Netherlands	0.808	16.	France	-0.302	25.	Slovakia	-0.871
8.	Spain	0.267	17.	Estonia	-0.347	26.	Romania	-1.880
9.	Austria	0.214	18.	Luxembourg	-0.418	27.	Bulgaria	-1.898

Source: Authors' work.

5. Discussion

As mentioned in the literature review, the digital transformation process appears inevitable for most enterprises to maintain their competitiveness in a global market and digital economy. Several reports have shown that a significant amount of money has been directed toward the digital transformation market and investments into digital technologies, making it grow rapidly [36], [37]. Moreover, this trend is anticipated to persist. The Meticulous Research Report [38] reveals that the global digital transformation market is expected to grow at a compound annual growth rate (CAGR) of 22.7% from 2019 to 2025.

Considering the global situation in a recent period, it could be concluded that the COVID-19 pandemic outbreak had a very strong influence on the previously mentioned rapid development of the digital transformation market. Due to the strict social distancing measures that have been introduced as part of the fight against the virus, almost every aspect of human lives has gone digital. Some workers, such as healthcare or police, have been declared essential since their work could not be done from home, while every non-essential job has been either paused for a while or continued to be executed from home. In that sense, for employees to work from home, many enterprises had to introduce or speed up the digital transformation process of their business operations, which also drew the interest of many researchers. For example, Bogdandy et al. [39], Zalite and Zvirbule [40], and Händel [41] examined digital transformation in education, as well as digital readiness and competitiveness of the education institutions during the pandemic. At the same time, Savić [42] investigated the digital transformation of the workforce, concluding that enterprises that have improved their digital skills and remotely engaged their workers were in a far better position to not only survive exceptional conditions caused by the pandemic but also to face the short successfully- and long-term problems that are expected in the post-pandemic times, which is also confirmed by Soto-Acosta [43]. Previously mentioned examples of various studies confirm the importance of the topic of digital readiness, which has been investigated within this paper.

Nevertheless, even now, when the world is mostly returning to normal conditions, interest in digital transformation and investments in digital technologies do not fade. In their research, Sheridan et al. [44] reveal that 69% of executives believe that digital initiatives are crucial to the success of their enterprises. At the same time, the PWC report [45] states that 60% of senior executives recognize the digital transformation of their enterprises as crucial for business growth in 2022. Therefore, the significance of investigating enterprises' digital readiness in the transition to digital solutions is confirmed.

In the context of the EU, the European investment bank [46] indicated that the COVID-19 pandemic also hastened Europe's economic digital revolution since many enterprises invested in digitalization as a direct consequence of the pandemic conditions. The primary users of the disruptive digital technologies in the EU before the COVID-19 outbreak were the most innovative and modern businesses [46]. However, the COVID-19 pandemic and intensive social distancing measures extended the digital transition to the entire society, making digitalization essential to the survival of enterprises [46]. Therefore, from 2020 to 2030, the EU has employed a set of digital principles and long-term digital

targets for Europe's digital transformation, proposing a Digital Compass comprising four main areas: (i) government, (ii) infrastructures, (iii) skills, and (iv) business [47]. One of the EU's digital targets included in the Digital Compass is to have 75% of EU enterprises using cloud computing technologies and Big Data analysis by 2030 [47], two technologies recognized and examined within this research. In that sense, DESI is a monitoring system to measure the progress towards setting digital goals. Moreover, according to Baker McKenzie [48], one of the key investments in digital transformation is cloud computing, which is in line with the results of this research presented in Figure 2, revealing cloud computing to be more popular than Big Data analysis within the EU enterprises.

As stated in the introduction, the primary purpose of this study was to uncover major parallels and contrasts in digital readiness among EU member countries and highlight these countries' strengths and weaknesses. The study results suggest the existence of rather significant differences in readiness of the business sector for the digital economy among EU countries. However, the presented methodology within this paper allowed authors to classify similar countries into separate homogenous groups. The paper's main aim was to identify key similarities and differences in digital readiness among EU countries and point out strengths and weaknesses. The analysis fulfilled this aim by answering three research questions set at the beginning of the study. In this study, we compare EU countries based on user-selected digital tools and other variables related to readiness for the digital economy.

The first research question deals with the importance of e-Commerce and selected innovative digital tools for enterprises in EU countries. This study revealed that Denmark, Finland, and Sweden are the top three countries engaging enterprises in e-Commerce, which is in line with previous results. For example, the same countries (but in a different order) have been identified as the best for receiving online orders in the EU by Orviska and Hunady [49]. The findings of this study are also in line with those of Cheba et al. [50], who confirmed Denmark, Finland, and Sweden to hold the top positions when observing criteria related to the e-Commerce drivers, and Denmark and Sweden to be in the top positions in the ranking of countries having highest e-Commerce activities in cities. It is also important to notice that the leading countries are mostly in the top places on different indicators. They are in top positions according to innovative digital tools and communication via social networks. Such high positions of Finland and Sweden do not come as a surprise, considering that, according to the European investment bank [46], enterprises in those countries have invested between 51% and 60% of their funds towards becoming more digital due to COVID-19. In comparison, Denmark invested between 41% and 50%. All three named countries are frontrunners in the Corporate Digitalisation Index [46].

On the other hand, countries like Romania and Bulgaria are significantly lagging behind the average of the EU in almost all aspects. This gap can be related to factors affecting engagement in e-Commerce and using ICT infrastructure by enterprises. Countries with lower performance can have a problem with the lack of infrastructure. This is also confirmed by the European investment bank [46], which argues that digital infrastructure is vital for unlocking investments in digital transformation. Technical obstacles and lack of government action are also the main barriers to e-Commerce [20], [51]. The problem can also be related to insufficient online security, as reported by Halaweh [52]. The findings of this study also suggest that enterprises in the countries with under-average digital readiness tend to use insurance against ICT security incidence more often. This could be due to lower online security in these countries. Furthermore, the quality of legal and regulatory frameworks in the country seems to be also important for the growth of the digital economy [20], [53]. In addition, research by the European investment bank [46] shows that advanced digital technologies in Romania and Bulgaria are below 58%, placing them at the lowest two places within the modest group of EU countries according to the Corporate Digitalisation Index.

The second research question deals with classifying EU countries according to their similarities in digital readiness. As presented in Table 1, ten selected variables have been used as proxies for digital readiness. These variables capture different aspects of digital readiness. Hierarchical cluster analysis has been used to classify the countries into relatively homogenous groups based on all ten variables. Three main clusters and seven sub-clusters have been identified. Countries performing well in digital reediness are included in the first two sub-clusters, cluster C1 (Belgium, Malta, Netherlands, and Ireland) and C2 (Denmark, Finland, and Sweden). Countries in the other five clusters should improve in almost all aspects of evaluation to enhance their digital readiness. For example, those included in cluster C3 (Bulgaria and Romania) and cluster C4 (Greece, Latvia, Portugal, Hungary, Poland, Slovakia) have particularly low

digital readiness. As with the first research question, this study's results comply with some previous studies. For example, Kinnunen et al. [13] used cluster analysis based on different variables. They classified Denmark, Finland, Sweden, and the Netherlands in the same cluster and argued that these are the most digitalized EU countries.

Similarly, Borowiecki et al. [14] apply cluster analysis based on the DESI index. They classified Demark, Finland, Sweden, and the Netherlands in the same cluster based on data from the years 2015 as well as 2020. The results are similar to the one in this study, but the Netherlands has been included in a different sub-cluster. However, they decided to use only four main clusters instead of three and seven sub-clusters in this paper [14]. In addition, Kovács et al. [54] also used DESI in their analysis and revealed Denmark, Netherlands, Finland, and Sweden to have the highest internet services digital readiness. Nevertheless, the approach used in this paper is also unique due to the selection of variables. In this study, the analysis is focused on variables related to enterprises' e-Commerce activities and usage of innovative digital solutions have been used.

The third research question ranks EU countries according to their overall digital readiness. The factor analysis has been applied to determine a single factor repressing digital readiness. The estimated factor scores make it possible to rank all countries. The results have already been, to some extent, indicated by the clustering. However, this method allows the authors to classify and rank individual countries. Based on this approach top five performing countries are Denmark, Sweden, Finland, Ireland, and Belgium. The three top countries are in the same order, according to the DESI 2021 index [17].

On the other hand, the countries with the worst digital readiness in the EU are Bulgaria, Romania, Slovakia, and Greece. These results are somewhat similar to those achieved by Kinnunen et al. [13]. Named authors found that Romania appears to be the least digitalized country [13]. Hence, the main research questions within this paper have been answered, providing a scientific contribution to the literature and practical implications providing possible explanations for the noted differences among different EU member countries.

6. Conclusion

Digital transformation is considered one of the main trends in business which brings many opportunities, challenges, disruption and changes for enterprises in terms of business processes and infrastructure, products and services enhancements, new business roles and organizational structure, increased innovation etc. [56], [57], [58], [59]. The importance of this problem is increasing with Industry 4.0 transformation and the application of social distancing measures due to the COVID-19 pandemic. Therefore, this paper examined the digital readiness of enterprises in EU countries based on the set of variables capturing a different aspect of this problem. The main goal was to identify key similarities and differences in digital readiness among EU countries and point out these countries' related strengths and weaknesses. The methodology that has been used in the paper, including cluster and factor analysis, was set to target this goal.

This study revealed significant differences among EU countries regarding their digital readiness and usage of selected innovative digital tools, i.e., cloud computing, Big Data analysis, websites, and social media. The intensity of e-Commerce among enterprises is the highest in Denmark, Ireland, and Sweden, and these three countries mostly dominate in other indicators. On the contrary, Romania and Bulgaria are mostly placed on the other end of the ranking. Furthermore, based on the cluster analysis, Romania and Bulgaria are included in the same cluster. Some strengths and weaknesses related to each identified cluster have been pointed out. Despite the complexity of the digital economy, there is some obvious positive correlation among all ten variables used in the analysis. It allows the authors to determine a single factor describing digital readiness in general. EU countries have been ranked according to the factor scores. As has been previously mentioned, this study confirmed some of the previous findings of other authors, e.g., Kinnunen et al. [13], Borowiecki et al. [14], Orviska and Hunady [49], Cheba et al. [50], Kovács et al. [54], etc.

This study brings some new empirical insight into the digital economy problem and businesses' readiness for digital transformation in the EU. In that sense, several implications of this research must be pointed out. The EU policies have to address a significant gap between the best and worst EU countries, and regional support must be strongly focused

also on digitalization and innovation. Therefore, the findings of this study confirm the necessity of significant investments in the digital economy, especially in the Next-generation EU program and the new Multiannual Financial Framework. However, the exact allocation of resources is also important. Especially the following three main priorities seem to be crucial to support digital transformation: (i) elimination of administrative barriers and creation of economic incentives for business digitalization; (ii) further development of ICT infrastructure; and (iii) investments in digital skills, as also reported by Dobrolyubova et al. [55].

Although this study extends the body of knowledge, and despite the authors' best effort to use the appropriate methodology and find correct answers to stated research questions, certain limitations still need to be recognized. The first limitation is related to data availability. Most of the variables used in the analysis are available only for one or two years. Hence, examining trends or using panel data analysis was impossible, and only cross-sectional data could be used. However, some variables can be used as a proxy for digital readiness, which is available for longer.

Another potential problem is the correlation of variables used in this analysis. While the approach used in this paper took advantage of the correlation when using factor analysis, this data is not ideal for cluster analysis. Nevertheless, digital readiness is a fruitful area for future research. There are several directions of examining this topic in the future, one of which is the possibility of searching for the factors affecting e-Commerce and digital transformation and related trends.

Acknowledgment

This work was supported by the Slovak Research and Development Agency under contract No. APVV-20-0338 "Driving forces of economic growth and survival of firms in the sixth K-wave".

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Biographical notes

Ján Huňady
Jan Hunady is an associate professor in finance at the Faculty of Economics, Matej Bel University in Banska Bystrica, Slovakia. He has published several papers in journals such as Transportation Research Part A: Policy and Practice, Information Polity, and Engineering Economics. His research interests focus on public finance, public institutions, innovation, and emerging technology. He participates in several research projects in research policy and innovation. His expertise is also in econometrics. The author can be contacted at jan.hunady@umb.sk.

Peter Pisár
Peter Pisar is an associate professor of finance, banking, and investment at Matej Bel University. His research focuses on European public finances, especially innovative financing and the evaluation of regional policy and public expenditure programs. In practice, he is also a consultant for the development and implementation of projects supported by EU funds and is particularly concerned with public policies supporting innovation. The author can be contacted at peter.pisar@umb.sk.

Dalia Suša Vugec
Dalia Suša Vugec is a postdoctoral researcher at the Department of Informatics, Faculty of Economics & Business, the University of Zagreb, where she teaches business informatics, business process management, and knowledge management courses. She regularly publishes scientific papers and collaborates on various projects. Her main research interests are digital literacy, business process management, knowledge management, digital transformation, intelligent automation, and e-learning. The author can be contacted at dsusa@efzg.hr.

Mirjana Pejic Bach
Mirjana Pejić Bach is a full professor at the Department of Informatics, Faculty of Economics & Business in Zagreb. Mirjana is the leader and collaborator of numerous projects in which she cooperates with Croatian companies and international organizations, mainly through European Union projects and the bilateral research framework. Her research areas are the strategic application of information technology in business, data science, and simulation modeling. The author can be contacted at mpejic@net.efzg.hr.