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Digital economy in Europe: Evaluation of countries' performances*

Nela Milošević[1], *Marina Dobrota*[2], *Slađana Barjaktarović Rakočević*[3]

Abstract

The accelerated expansion of the Internet as a communication tool, the mobile internet, and the social networks and commercial platforms, commonly observed as digitalisation, have greatly affected the functioning of the economy and with it also businesses, public institutions, and individuals. The state of the digitalisation of business and industry varies between the European Union (EU) countries and regions. Each economy struggles to keep up with digitalisation in order to keep their productivity and achievement on a high level. Using the Composite I-distance Indicator (CIDI) methodology, we have created a multivariate indicator that can serve as a measurement of digital economy performances. Furthermore, we evaluate and rank 28 countries in EU (EU-28), based on their digital performances. We made an in-depth comparative analysis of countries in Europe, providing information about each economy with information on where they currently stand in terms of digital economy and what steps they need to undertake to improve and boost up their position in the domain of digitalisation.

Key words: *digital economy, ranking, CIDI, evaluation of countries, EU countries*

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1 *Teaching assistant, University of Belgrade, Faculty of Organizational Sciences, Jove Ilića 154, Belgrade, Serbia. Scientific affiliation: management accounting, finance, banking. Phone: +381 69 889 3303. E-mail: nela.milosevic@fon.bg.ac.rs (corresponding author)*

2 *Assistant professor, University of Belgrade, Faculty of Organizational Sciences, Jove Ilića 154, Belgrade, Serbia. Scientific affiliation: statistics, econometrics. Phone: +381 69 889 3386. E-mail: dobrota.marina@fon.bg.ac.rs*

3 *Associate professor, University of Belgrade, Faculty of Organizational Sciences, Jove Ilića 154, Belgrade, Serbia. Scientific affiliation: financial institutions, management accounting, financial markets. E-mail: sladjana@fon.bg.ac.rs*

1. Introduction

The digital transformation (see Schallmo and Williams, 2018a) offers a broad set of opportunities for Europe, presenting the enormous growth potential for business and society (Kamalipour and Friedrichsen, 2017). Economies across the world are greatly affected by the expansion of the World Wide Web, the mobile internet, and the social networks and commercial platforms. These are the common elements of the global term of digitalisation, which nowadays makes an increasingly significant contribution to economic growth. Digital technologies create an instrument that progressively links all parts of social and economic life, because digitalisation makes knowledge and information easy to store, access, and modify (European Commission, 2018a). Carlsson and Stankiewicz (1991) point out the importance of a particular technology or set of technologies, the networks through which people interact, and the institutional infrastructure. The importance of Information and Communications Technologies (ICT) has been recognized also by the World Economic Forum. It is included in Global Competitiveness Index (GCI) that has been issued every year (World Economic Forum, 2018). The influence of digitalisation is spread out over businesses, public institutions, and individuals, and, while it has brought many benefits, it has also generated new problems, policy issues, and challenges that policymakers are struggling to resolve. European Union (EU) businesses are taking advantage of these progressive technologies to some extent, but the digitalisation of industry diverges across areas and between EU countries and regions. There are disparities between companies of different sizes (Chen et al., 2016). Thus, there is always room for improvement. The smart use of ICT by enterprises and corporations in manufacturing and services is a crucial factor for success in competitiveness, innovation, and economic growth (Nadeem et al., 2018).

This paper investigates how the on-going digital transformation and ICT are manifesting in the economies across Europe. We have collected the publicly available data on digital economy indicators in countries of EU and used them to perform a multivariate statistical analysis on countries' performances. The data include an extensive evaluation of online platforms, EU data ownership, and digital media content. The large volumes of data are nowadays generated, which provide significant opportunities for innovation, new business models, and smart products and services (Wamba et al., 2017), and this is why it is crucial to include big data in the analysis (Huda et al., 2018). We also investigated digital skills of the public. One must bear in mind that digital skills are also a significant resource that influences the ability of EU businesses and economies to benefit from the opportunities of digitalisation (O'Donnell, 2016).

In this research, we used the Composite I-distance Indicator (CIDI) methodology (see Section 3) to evaluate and rank 28 countries in EU (EU-28), based on the collected data regarding their digital performances. Our main hypothesis is that by using the CIDI methodology, it is possible to create a specific multivariate indicator that can serve as a measurement of digital economy performances, and that is characterized by objectivity and stability.

Regarding the literature on the digitalisation, there are two main streams of research. The first is focused on the usage of digital technologies in both, macro and micro levels. The second stream deals with the digital gap – the differences in the development of digital technologies. Our analysis contributes to the second stream of the research aiming to find the unique set of criteria for comparing EU countries in terms of digitalisation level. Moreover, using the CIDI methodology, we have created a multivariate indicator that can serve as a measurement of digital economy development. In addition, the opportunity for comparison between countries leads to better understanding of characteristics of economies which benefit the most from the usage of ICT. Finally, we propose country-specific policy recommendations based on our findings which can be seen as practical implications of our study.

This paper is organised as follows. The next section gives a comprehensive literature review. Section 3 describes the methodology used in the research and Section 4 illustrates the empirical data used in the research. Section 5 represents the results of the survey, while Section 6 gives some concluding remarks.

2. Literature review

In recent years, companies have started a number of initiatives to analyse new digital technologies in order to focus on their benefits. Digital transformation involves changes of key business operations, products, and processes. It goes even further, requiring new management concepts (Matt et al., 2015). We argue that success of digital transformation depends on the development and innovativeness of different economies across Europe.

Before analysing the differences among countries in terms of digitalisation, it is important to understand the term "digital". Digitalisation is about creating value; it relies on process optimisation; and focuses on capabilities which support the whole business idea (Schallmo and Williams, 2018b). With the fast development in the field of ICT, countries, industries, and companies compete and create value in completely new ways (Hyvönen, 2018). Development of digital capabilities and resources is a consequence which is usually defined as digital transformation. Selected definitions of the term "digital transformation" could be found in Schallmo and Williams (2018a).

The term New or Digital Economy is tightly linked to digital transformation. Following the work of Johansson and his colleagues, we use the phrase digital economy in terms of "recent and still largely unrealised transformation of all sectors of the economy by the general spread of ICT" (Johansson et al., 2006: 3). Moreover, digital economy is driven by development and active usage of modern ICT. Carlsson (2004) defines the New or Digital Economy, pointing out that it is about dynamic efficiency. Moreover, the author emphasises results in new activities and products rather than higher productivity. Within the New or Digital Economy people face a new level and form of connections among all market players; ideas are widespread, and there is a high potential for creating heterogeneous and successful teams. Company's efficiency results in the long-term competitive position in the market. A new challenge is how to measure the impact of ICT in both emerging and well-developed countries. This paper is an attempt to define some of the digital economy performances.

Some EU countries are more focused on innovations and digital business environments which means that those countries actively use all benefits of digitalisation. In the last decades, research moves from innovation systems to technological innovation system. The purpose of technological innovation system is to provide connections among various parts of the system (Carlsson and Stankiewicz, 1991). Nowadays, the key idea is to use all ICT advantages for creating synergies on the national, but also international level.

Not only are the companies aware of the pressure to innovate, but they spot all opportunities to connect across the world with other companies in order to improve their products and services, as well as to distinguish their strategies from the key competitors. Until now, research has been limited in discovering and measuring the results of all these innovations and ICT developments. On the country level, researchers still measure national output in terms of Gross Domestic Product (GDP) which leaves us without a clear picture of the true effects of the technology (Degryse, 2016). Billon and colleagues (Billon et al., 2009) analysed countries' differences in terms of ICT development and found out that in well-developed countries digitalisation is explained by GDP, service sector, education, and governmental effectiveness. Moreover, authors pointed out that in developing countries population age and urban population are positively associated with the ICT adoption. Additionally, the results showed that in developing countries Internet costs are negatively associated with ICT adoption. This might be a valuable finding which should give the direction for the future activities in terms of ICT implementation in developing countries.

Moreover, the factors that explain the determinants of ICT adoption in different groups of countries have been found (Billon et al., 2009). A significant impact on digital development for all country groups has only GDP. ICT and the Internet decrease production costs, enhance the creation and spread of new ideas, support knowledge, sharing, and improve Research and Development processes (Meijers, 2014). The main conclusion is that ICT is tightly linked to higher economic growth. Therefore, we argue that countries should create strategies in order to use the high potential of the digitalisation.

Nadim suggests that digitalisation includes new platforms that facilitate direct transactions (Nadim et al., 2016), such as Airbnb and Uber, new activities such as crowdsourcing, a growing category of the freelancers and 'free' media services, supported by 'Big data'. Without ICT networking, learning, and innovation processes, the development on a country level would not be possible. Having the previous fact in mind, it is not strange that many researchers point out the importance of ICT, using it as a key factor for growth (Yousefi, 2011; Meijers, 2014). The usage of new communication technologies like the Internet, social networks, and commercial platforms improves knowledge and skills (Roller and Waverman, 2001; Czernich et al., 2011) which leads to higher satisfaction and better productivity.

The aim of Hanafizadeh and colleagues is to present a multi-stage methodology for constructing a composite index for measuring ICT infrastructure and access (Hanafizadeh et al., 2009). Without an attempt to analyse the digital divide between countries, they emphasise that the most important factors in digital transformation are ICT infrastructure and access. Some studies focus on measuring and quantifying the digital divide (Corrocher and Ordanini, 2002; Bagchi, 2005; Vicente and Lopez, 2006). The multi-dimensional character of the digital divide has led to the creation and analysis of different ICT indexes. Therefore, we argue that there is a need for comprehensive research on indicators which will create an index, good enough to show the current situation and explain the ability of EU businesses and economies to benefit from all opportunities of digitalisation.

The contribution of ICT investments, in terms of technological infrastructure, diffusion, and even usage, has been in the focal point for many researchers and practitioners. The importance of ICT is out of the question, but still, there is a gap regarding measuring ICT development across countries. There are enormous imbalances in terms of access inequalities of location, age, gender, education, and income (Heeks, 2010).

The Organization for Economic Cooperation and Development (OECD) has developed several studies, whereby different countries are compared in terms of access to ICT and the Internet (OECD, 2000, 2001). The World Bank has also issued research on the measurement of the digital division (a section of the 'World Development Indicators') that analyses different factors of digitalisation. Usually, work on this topic is more informative rather than methodological (Corrocher and Ordanini, 2002). Therefore, we firmly believe that CIDI methodology has a potential to create an added value to the measurement of the digitalisation in EU countries.

3. Methodology

CIDI is the methodology for calculating a multidimensional composite indicator. The general concept of CIDI is to calculate the weights for a set of variables that create a composite indicator; in this case, it is a set of variables that measure digitalisation of economies (see Section 4). The calculation of weights is based on the Pearson correlation coefficients between the values of the I-distance (see section 3.1) and a set of input variables. Correlations are therefore altered appropriately to depict the importance of the input variables.

3.1. I-distance

The I-distance method is a metric distance in an n-dimensional space (Jeremic et al., 2011, 2012; Dobrota et al., 2012; Dobrota et al., 2015a), initially defined by Ivanovic (Ivanovic, 1973; Ivanovic and Fanchette, 1973). The methodology was developed to rank entities according to specific variables of interest. The main issue was how to use all of the variables to calculate a single indicator, which could be transformed into a rank, but to overcome the common problem that a lot of different ranking methods possess, and that can affect the measurements and evaluation: possible biases and subjectivity. The procedure is the following (Jeremić et al., 2013; Seke et al., 2013; Dobrota et al., 2015b; Išljamović et al., 2015):

Let $X^T = (X_1, X_2, ..., X_k)$ be a set of variables chosen to describe the particular set of entities. The I-distance between two entities $e_r = (X_{1r}, X_{2r}, ..., X_{kr})$ and $e_s = (X_{1s}, X_{2s}, ..., X_{ks})$ is defined as

$$D(r,s) = \sum_{i=1}^{k} \frac{|d_i(r,s)|}{\sigma_i} \prod_{j=1}^{i-1} \left(1 - r_{ji.12...j-1}\right) \quad (1)$$

where $d_i(r; s) = x_{ir} - x_{is}$, $i \in \{1, ... k\}$, is the distance between the values of the variable X_i for e_r and e_s, e.g. the discriminate effect, σ_i is the standard deviation of X_i, and $r_{ji,\ 12\ ...\ j-1}$ is a partial correlation coefficient between X_i and X_j, $(j < i)$ (Ivanovic, 1973; Ivanovic, 1977).

The I-distance is based on calculating the distances between the entities. It is important to fix one entity up as the reference entity (Dobrota et al., 2015c). The ranking of entities in the whole set is based on the calculated distance from the reference entity (Ivanovic, 1973; Ivanovic and Fanchette, 1973).

When measuring I-distance based on a set of variables, it is preferable to have all the variables of the same direction, i.e. that they are positively correlated. This is mainly because the composite indicator, created using the I-distance, is designed to measure the specific phenomenon which is described with a whole set of different individual indicators, but all measuring the dimensions of that exact phenomenon. However, sometimes negative coefficient of partial correlation can occur when it is not possible to achieve the same direction of movement for all variables in all sets (Dobrota et al., 2015b). If they occur, negative coefficient of partial correlation could cause peculiar values in the product part of the formula (1) given above. To conquer this problem, it is suitable to use the square I-distance, given as:

$$D^2(r,s)=\sum_{i=1}^{k}\frac{d_i^2(r,s)}{\sigma_i^2}\prod_{j=1}^{i-1}\left(1-r_{ji.12\ldots j-1}^2\right) \tag{2}$$

The square I-distance is not equal to the square of the ordinary I-distance. It is also most commonly used if the number of selected variables is large, so in the ordinary I-distance it is possible to lose the influence of a number of lower-level variables. In addition, the square I-distance requires a smaller number of operations, especially because the formula (2) given above can be reduced to the formula (3) given below. Therefore, less computer time is needed for square I-distance than the regular one (Ivanovic, 1973; Ivanovic and Fanchette, 1973).

$$D^2(r,s)=\sum_{i=1}^{k}\frac{d_i^2(r,s)}{\sigma_i^2}\left(1-r_{i.12\ldots i-1}^2\right) \tag{3}$$

3.2. Composite I-distance Indicator

The purpose of the CIDI is to create such a ranking methodology which would be comparable and transparent as the broad set of biased ranking methodologies defined by experts, but which would overcome the problem of biases. The key to do so is to base a ranking methodology on an I-distance measure. Thus, we could create the methodology which was unbiased as I-distance, but significantly more transparent and robust.

To create a CIDI, it is necessary to calculate the I-distance values based on a set of input variables. After that, the Pearson correlation coefficients between the I-distance values and input variables are calculated. Correlation coefficients are used because of the particular characteristic of the I-distance method: it can present the relevance of input variables. The next step is to calculate the new weights for each of the compounding variables, which are based on the appropriate correlations. Weights are formed by weighting the empirical correlation coefficients: their values are divided by the sum of correlation coefficients (Dobrota et al., 2015c; Dobrota et al., 2016). The final sum equals 1, thus forming a novel appropriate weighting system:

$$w_i=\frac{r_i}{\sum_{j=1}^{k}r_j} \tag{4}$$

where r_i ($i = 1,\ldots k$) is a Pearson correlation coefficient between the i-th input variable and I-distance value.

3.3. Uncertainty and sensitivity analysis

To measure the stability of the given ranking system, we have performed the uncertainty and sensitivity analysis that is based on the relative contribution of the variables. The relative contribution of the variables to each entity score can provide useful information as to whether some variables dominate the overall scores (Saisana and D'Hombres, 2008; Dobrota et al., 2016). It is estimated as a proportion of a variables' score multiplied by the appropriate weight with regard to the overall entity score.

Using the Monte Carlo simulation method, the score results can be simulated a sufficient number of times, each time recording the results. After that it is possible to count the ranks for all the entities, thus measuring the amount of uncertainty of the ranking results.

4. Empirical data and analysis

The data required to perform the study of how the digitalisation and digital transformations are affecting the economies in Europe are collected from Eurostat (ec.europa.eu/eurostat). All the data are public and available on a Eurostat website. We extracted a set of 13 variables that measure the influence that digitalisation has on the economies. Among them, eight variables are related to the enterprises (which could be defined as "E – economic") and five variables that are essentially related to households or individuals (which could be labelled as "P – private").

Eight indicators that are related to the enterprises (E1 to E8), for the year 2017, are the following:

- *E1 E-commerce Purchases of Enterprises* – This indicator represents enterprises that have ever made any purchase through computer-mediated networks. It is measured in a percentage of all the enterprises, without financial sector (ten persons employed or more)*E2 E-commerce Sales of Enterprises* – The indicator represents the percentage of enterprises that are selling their products online (which covers at least 1% of their turnover). It includes all the enterprises, without financial sector (ten persons employed or more).
- *E3 Internet Advertising of Enterprises* – The percentage of enterprises that use any social media for advertising over the internet. It covers all enterprises, without financial sector (ten persons employed or more).
- *E4 Value of E-Commerce Sales of Enterprises* – The indicator that measures enterprises' total turnover from e-commerce. It is given as a percentage of total turnover and includes all the enterprises, without financial sector (ten persons employed or more).

- *E5 Computer Internet Connections used by the Employees in Enterprises* – Indicator represents the persons employed using computers with access to World Wide Web. It is measured as a percentage of total employment and covers all the enterprises, without financial sector (ten persons employed or more).
- *E6 Mobile Internet Connections used by the Employees in Enterprises* – This indicator counts persons employed in a company, which were provided with a portable device that allows a mobile connection to the internet for business use. It is measured as a percentage of total employment and covers all the enterprises, without financial sector (ten persons employed or more).
- *E7 Enterprises that have a Website* – Percentage of enterprises that own a website, enterprises without financial sector (ten persons employed or more).
- *E8 Enterprises that Employ ICT Specialists* – Indicator is given as a percentage of enterprises, without financial sector (ten persons employed or more).

Five indicators that are related to the households or individuals (P1 to P5) for the year 2017, are the following:

- *P1 Level of Internet Access in Households* – Indicator is given as a percentage of households with internet access.
- *P2 Internet Use by Individuals* – Percentage of all the individuals that have accessed the internet in last three months.
- *P3 Mobile Internet Access by Individuals* – The percentage of individuals that have used a mobile phone (or smartphone) to access the internet.
- *P4 Use of Cloud Services by Individuals* – The percentage of individuals that have used internet storage space to save documents, pictures, music, video or other files.
- *P5 Internet Purchases by Individuals* – Percentage of all the individuals that have made an online purchase in the last three months.

The results of the CIDI analysis are given in Tables 1 and 2. Table 1 lists the set of 13 variables described in Section 4 and the set of their weights calculated through the CIDI analysis. All the variables are normalised as they represent the percentage of all the observed entities (enterprises, households, or individuals). The variables, as described above, represent the input data for the CIDI indicator. We established the set of these variables firstly due to their coherence with the issue that is processed in this research. It is secondly based on the availability and the quality of the accessible data, and their high suitability for the proposed methodology. The rationale for this decision is the reason that the I-distance methodology, described in Section 3.1, has the ability to calculate the distance between the entities based on the established set of individual variables, taking into account that all the variables are not equally important for finally obtained I-distance scores. Thus, the methodology gives the priority to the variables that largely influence the I-distance scores and less priority to the variables whose influence is less significant. These differences are notable from the Table 1.

Table 1: Variables that measure digitalisation in economies and their CIDI weights

VarID	Variable	CIDI weight
E5	Computer Internet Connections used by the Employees in Enterprises	9.32%
P4	Use of Cloud Services by Individuals	8.84%
E6	Mobile Internet Connections used by the Employees in Enterprises	8.64%
P1	Level of Internet Access in Households	8.43%
P3	Mobile Internet Access by Individuals	8.16%
P2	Internet Use by Individuals	8.08%
P5	Internet Purchases by Individuals	8.06%
E1	E-commerce Purchases of Enterprises	7.82%
E7	Enterprises that have a Website	7.79%
E3	Internet Advertising of Enterprises	7.38%
E2	E-commerce Sales of Enterprises	6.98%
E8	Enterprises that Employ ICT Specialists	5.50%
E4	Value of E-Commerce Sales of Enterprises	4.99%

Source: Authors' calculations

The variables in Table 1 are given in a descending order according to weights obtained by the CIDI methodology. The most critical variable in ranking countries is *E5 Computer Internet Connections used by the Employees in Enterprises* with the largest weight of 9.32%. It is followed by *P4 Use of Cloud Services by Individuals* and *E6 Mobile Internet Connections used by the Employees in Enterprises*. The variables are later followed by four "private" by importance, and only at the end are remaining six "economic" variables.

Table 2 presents the results of evaluation and ranking for EU-28, based on their digital performances.

The results of CIDI methodology place Denmark on the top of the digital performance ranking list. Denmark has accomplished the highest score of 66.62. Top five countries according to CIDI scores are Denmark, Sweden, Netherlands, Finland, and United Kingdom. Lowest five rated countries in EU-28 are Italy, Poland, Greece, Romania, and Bulgaria, which have the lowest digital performances.

Table 2: CIDI scores and CIDI ranks for EU-28

Country	CIDI score	CIDI rank
Denmark	66.62	1
Sweden	64.63	2
Netherlands	61.68	3
Finland	59.98	4
United Kingdom	58.48	5
Ireland	56.27	6
Luxembourg	54.13	7
Germany	53.71	8
Belgium	53.43	9
Austria	53.30	10
Spain	49.00	11
Malta	48.66	12
France	48.49	13
Czech Republic	47.26	14
Estonia	45.86	15
Slovenia	45.28	16
Cyprus	44.86	17
Slovakia	43.74	18
Lithuania	42.46	19
Hungary	42.08	20
Portugal	40.03	21
Latvia	39.50	22
Croatia	39.41	23
Italy	39.07	24
Poland	37.67	25
Greece	35.86	26
Romania	31.40	27
Bulgaria	30.21	28

Source: Authors' calculations

We also tested the stability of the CIDI indicator regarding the digital performances of countries for EU-28 in 10 000 Monte Carlo simulations. The results of the uncertainty and sensitivity analysis, as explained in Section 3.3., are given in Table 3 and Figure 1.

Table 3: Uncertainty and sensitivity analysis of CIDI ranks

Country	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Denmark	10000																											
Sweden		10000																										
Netherlands			10000																									
Finland				9959	41																							
UK				41	9959																							
Luxembourg						9966	31	3																				
Germany						27	9558	342	72	1																		
Austria						4	143	8858	981	14																		
Ireland						3	268	795	7962	972																		
Belgium								2	985	9013																		
Spain											5633	4289	78															
Malta											3942	4659	1388	11														
France											425	1052	8337	185	1													
Estonia													184	7826	1900	90												
Czech Rep.													12	1936	6831	879	340	2										
Slovenia															703	5873	3424											
Cyprus													1	42	565	3156	5959	277										
Slovakia																2	277	9721										
Lithuania																			9249	751								
Hungary																			751	9249								
Latvia																					7493	2328	166	13				
Portugal																					2298	6910	791	1				
Italy																					207	723	5436	3548	86			
Croatia																					2	39	3579	6005	375			
Poland																							28	433	9534	5		
Greece																									5	9995		
Romania																											10000	
Bulgaria																												10000

Source: Authors' calculations

From Table 3, we can see that Denmark, Sweden, and the Netherlands are in all 10 000 simulations precisely on their acquired positions, not making any variations. Finland and United Kingdom (UK) have some slight deviations from their positions but only in 0.41% of cases (41 out of 10 000). Variations in ranks are increasing as we move down the ranking list. The largest variations could be found Ireland, France, Czech Republic, Cyprus, Latvia, and Croatia. For example, even though Cyprus takes 17th position, its rank varies from 13 to 18. Initially 23rd, Croatia varies from positions 21 to 25. Greece, Romania, and Bulgaria at the end, again have stabile ranks.

5. Results and discussion

Variables' weights obtained by CIDI and given in Table 1 reveal some interesting findings. The most important variables in ranking countries according to their digital performances are the computer and mobile internet connections used by the employees and the use of cloud services. First interesting and perhaps a bit unexpected finding is that the variables are followed by "private" by importance, and only at the end are "economic" variables.

Second interesting and unexpected finding is regarding the importance of the variables that can be labelled as "commercially oriented" and "non- commercially oriented". Variables *P5 Internet Purchases by Individuals*, *E1 E-commerce Purchases of Enterprises*, *E2 E-commerce Sales of Enterprises*, and *E4 Value of E-Commerce Sales of Enterprises* could to some extent be defined as "commercially oriented" variables. While *P5 Internet Purchases by Individuals* and *E1 E-commerce Purchases of Enterprises* are relatively highly rated among variables (with their respective weights 8.06% and 7.82%), other two are graded quite low. Variables *E4 Value of E-Commerce Sales of Enterprises* has even obtained the lowest weight according to CIDI, only 5%. This signals that when it comes to the positioning of the economies based on their digital performances, the variables that measure the internet use and the digitalisation access are more important than the amount of digital financial flow.

As stated above, the results of CIDI methodology place Denmark on the top of the digital performance ranking list. Denmark is a country that stands out also when it comes to the publicly available ICT Development Index (IDI), published by International Telecommunication Union (ITU) (www.itu.int), the index that measures information and communication development of countries. With IDI, Denmark takes the fourth position out of the 176 analysed countries (ITU, 2017), and the first position if we extract EU-28. Also, top five countries according to CIDI scores top IDI ranking list, in a slightly revised order, except for Finland whose position is notably lower with IDI. It is interesting to note that top five countries are not standing out when it comes to some economic indicators, for example, trade surplus/deficit or unemployment (Djogo and Stanisic, 2016). According to Djogo and Stanisic (2016), Denmark for example has the trade surplus of 5.8% of GDP and is not even in the list of first ten countries that stand out by the trade surplus. Sweden has the trade surplus of 4.9%, while Finland and UK even have a trade deficit of 0.9% and 1.9% respectively. Netherlands is the country that stands out to some extent, with the surplus of 10.3% of GDP.

Another index created by European Commission is the Digital Economy and Society Index (DESI), a composite index that summarises relevant indicators on Europe's digital performance and tracks the evolution of EU member states in digital competitiveness (European Commission, 2018b). The results of DESI index are similar as to CIDI index. UK is rated slightly higher by CIDI (5th place) than by DESI (7th place).

Alongside the official IDI and DESI index, the well-known index is the Networked Readiness Index (NRI), published in The Global Information Technology Report (GITR) (Baller et al., 2016), by the partnership of World Economic Forum and European Institute of Business Administration (INSEAD). Its latest publication dates from 2016. When comparing CIDI, DESI, and NRI, there are slightly more differences between CIDI and NRI, than between CIDI and DESI index. According to NRI index Denmark that is 1st by CIDI is in 7th place when extracting solely European countries. Sweden and Finland top NRI list as well as CIDI list while Netherlands and UK follow up.

CIDI index created in this survey differs from DESI and NRI index because it is more thorough and profound. It holds the values of digitalisation variables that we defined as "economic" (see Section 4), that are omitted from the DESI and NRI indexes.

When it comes to the lowest five rated countries by CIDI, a similar result is shown in IDI ranking (ITU, 2017) and DESI ranking (European Commission, 2018b). These countries have also shown the considerable economic disparities (Simionescu, 2016) or a more substantial risk of poverty (Iwacewicz-Orłowska, 2016) compared to other EU-28 countries. Poland, for example, is better rated by DESI (23rd place) than by CIDI (25th place).

Croatia is ranked 23rd by CIDI methodology according to countries digital performances. It is ranked 24th by DESI methodology, and it has made progress in IDI positions over the years. To understand the position of Croatia, we can extract the values of individual variables that create CIDI. For example, *E5 Computer Internet Connections used by the Employees in Enterprises* is the most significant variable when it comes to forming a CIDI. In Croatia, 44% of total employees are using computers with access to World Wide Web, while in Denmark this percentage is 73%, and in Sweden 75%, which is largest in the region. The second variable is

P4 Use of Cloud Services by Individuals. In Croatia, only 16% of individuals have used internet storage space to save documents, pictures, music, video, or other files. In Denmark, we have 69% of individuals, while the largest percentage is in the UK, 78%. Croatia stands out with the indicator *E6 Mobile Internet Connections used by the Employees in Enterprises* because there are 28% of employees, which were provided with a portable device that allows a mobile connection to the internet for business use. It is not a high percentage, but Croatia is ranked 6th by this single indicator among EU-28. Nevertheless, Croatia is struggling to keep up. For example, a company Hrvatski Telekom plans to invest more than 28 million euros in the digital transformation strategies in the next three years (www.t.ht.hr). In the business report for 2017, the company also stated that, in the mobile segment, the capacities of the 4G network were increased by 34%, and mobile internet speed was increased by 38%, reaching 350 Mbit/s (www.t.ht.hr). The objective of digital transformation is positioning of Hrvatski Telekom as the frontrunner in terms of user experience.

6. Conclusions

In this paper we performed a statistical CIDI analysis that allowed us to create a multivariate indicator that can serve as a measurement of digital economy performances. The main focus was to investigate how the digital transformation affects the economies across Europe. According to the results, we can see that Denmark tops the ranking list, followed by Sweden and Netherlands. These countries stand out by their digital performances from other EU countries. Lowest ranked countries are Romania and Bulgaria. Croatia is struggling to find its place among other EU countries but still has a long way to go, since it is in the lower half of a ranking list (23rd position). Croatian enterprises are at the cutting edge of digital openness, surpassing their regional counterparts, and they readily endorse digital technologies, especially in the area of e-commerce and cloud computing services. In spite of this, the pace of their digital transformation is being slowed down by the low-performance Internet infrastructure in the EU and the poor digital skills of human capital. The most critical variables in ranking countries according to their digital performances are the computer and mobile internet connections used by the employees and the use of cloud services. We also found that "private" variables tend to stand out by importance in comparison to the "economic" variables. The "non-commercially oriented" variables, ones that measure the internet use and the digitalisation access are more prominent than the "commercially oriented" variables that measure the financial flow of digitalisation.

Unlike some studies that focus on measuring and quantifying the digital divide and present a multi-stage methodology for constructing a composite index for measuring ICT infrastructure and access, we give the weights to each individual indicator obtained by CIDI methodology. Thus, the weights are unbiased and permeated by objectivity. Moreover, we point out that the multivariate indicator presented in this research has very low level of deviations between ranks obtained by Monte Carlo simulation. For top ranked countries deviations are even extremely low, which indicates low level of uncertainty. This shows that the multivariate indicator created by CIDI methodology is characterized by a high level of stability. These findings approve and are in favour of our initial hypothesis defined in the research.

Additionally, our study has several practical contributions. This survey may serve as a guide for future policy developments in the digital domain. We also suggest that countries may benefit from a detailed analysis of their digital performances which can help them in order to create innovative ICT strategies and future plans for digital development. Finally, we propose a potential explanation why countries should consider digital transformation as one of the biggest challenges in today's economy.

Limitations of this study encompass the fact that we have used secondary data that were publicly available, while yet maybe some other significant variables could more soundly contribute to the ranking of countries based on their digital performances. The study could be expanded to more countries other than EU in the future. This survey would particularly be interesting to those countries that strive to join EU in the future. Researchers could use data from the survey to compare results from other countries to those of EU, and to propose recommendations and expose digital opportunities, both for businesses and people. In due course, this could lead those countries to get closer to prominent representatives of EU countries in this field. For future research, it would be profoundly interesting to exclude "private" variables and to create CIDI only based on "economic" variables. It would be interesting to see what kind of changes in scores and ranks would this variation cause. Another direction of future research can include the comparison of CIDI, IDI, DESI, and NRI indexes and to determine the difference in these indexes results, weights, and above all the stability, which could provide a detailed report of the state of digitalisation in Europe.

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Digitalna ekonomija u Europi: procjena performansi zemalja

Nela Milošević[1], *Marina Dobrota*[2], *Slađana Barjaktarović Rakočević*[3]

Sažetak

Ubrzano širenje Interneta kao komunikacijskog alata, mobilnog interneta, kao i društvenih mreža i komercijalnih platformi, koji se općenito mogu svrstati u termin digitalizacija, značajno su utjecale na funkcioniranje zemalja, a time i na tvrtke, javne institucije i pojedince. Stanje digitalizacije poslovanja i industrije varira između zemalja i regija EU. Svaka ekonomija se bori da drži korak s digitalizacijom kako bi zadržala svoju produktivnost i postignuća na visokoj razini. U ovom istraživanju koristili smo CIDI metodologiju za procjenu i rangiranje 28 zemalja u Europskoj uniji (EU-28), temeljeno na njihovim digitalnim izvedbama. Napravili smo dubinsku komparativnu analizu zemalja u Europi, pružajući informacije o svakoj zemlji o tome gdje trenutno stoje u smislu digitalne ekonomije i koje je korake potrebno poduzeti za poboljšanje i jačanje svojeg položaja u globalnom svijetu digitalizacije.

Ključne riječi*: digitalna ekonomija, rangiranje, CIDI, evaluacija zemalja, EU*

JEL klasifikacija*: C30, C49, O52, P51*

[1] *Asistent, Univerzitet u Beogradu, Fakultet organizacionih nauka, Jove Ilića 154, Beograd, Srbija. Znanstveni interes: upravljačko računovodstvo, financije, bankarstvo. Tel: +381 69 889 3303. E-mail: nela.milosevic@fon.bg.ac.rs (osoba za kontakt).*

[2] *Docent, Univerzitet u Beogradu, Fakultet organizacionih nauka, Jove Ilića 154, Beograd, Srbija. Znanstveni interes: statistika, ekonometrija. Tel: +381 69 889 3386. E-mail: dobrota.marina@fon.bg.ac.rs.*

[3] *Izvanredni profesor, Univerzitet u Beogradu, Fakultet organizacionih nauka, Jove Ilića 154, Beograd, Srbija. Znanstveni interes: financijske institucije, upravljačko računovodstvo, financijska tržišta. E-mail: sladjana@fon.bg.ac.rs.*