3 DIGITIZATION AND POPULATION WELFARE IN THE NEW EU MEMBER STATES

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Abstract

Today we live in times of deep socio-economic transformations under the influence of digital technologies that influence both the sectors of activity and the population. Many compare the transformations of the digital age with the former industrial revolutions generated by the steam engine or electricity, considering that they provide opportunities to improve life, change the nature and structure of organizations and markets, jobs and skills, of security and social and economic interactions (OECD, 2019). The impact of digitization on society is the object of concern of both international bodies looking for instruments to measure the effects of new digital technologies, and of specialists concerned with the effects on costs, sustainability of development, competitiveness, economic growth, etc.

The current study aims to highlight the influence of digitization on the welfare of population by using a panel model for 11 CEE countries (Romania, Bulgaria, Estonia, the Czech Republic, Croatia, Hungary, Latvia, Lithuania, Poland, Slovenia and Slovakia).

Using data for the period 2000-2019, the results highlight, as expected, the positive influence on population welfare of digitization and human capital.

Keywords: digitization, digital gaps, population welfare, panel models, Central and Eastern European countries

JEL Classification: C23, I25, I31, O57

Introduction

Nowadays, we witness one of the most dynamic and deep socio-economic transformations under the influence of digital technologies. The literature highlights the fact that the speed of development of digital infrastructure, the expansion of mobile telephony and the increasing possibilities of processing a huge volume of data completely changes the life, work and way

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of connecting people. Many compare the transformations of the digital age with the former industrial revolutions generated by the steam engine or electricity, considering that they provide opportunities to improve life, change the nature and structure of organizations and markets, jobs and skills, security and social and economic interactions (OECD, 2019).

Digitization involves changes generated by the learning machines, platforms for creative thinking development (platform thinking) and crowd-based action (McAfee & Brynjolfsson, 2017, quoted by Dufva and Dufva, 2019, p.17). We witness a fusion of technologies and an interconnection with the fields of biology, physics and digitization, a flexibility and adaptability of codes that allow for people a closer connection with machines, creating new aggregate forms of human and non-human actors (Berry, 2016). Digitization, in the opinion of Dufva and Dufva (2019, p.18) is "the action of transforming various previous physical or analogue actions into digital systems" which are based on binary structures.

Globalization and technological progress have facilitated the global economic exchanges of goods, human resources, money and ideas, with people creating real communication networks and exchanges of ideas. The 21st century is dominated by the digital technologies that ensure economic growth, create new jobs, allow for fast access to information and services; in fact, transforming the society into the so-called digital society and ensuring the growth of population welfare.

Digital technologies, such as the Internet, the World Wide Web, social media, portable devices, artificial intelligence, robots, were the engines that led to the formation and development of digital society. Communication networks, information, networking, may create the premises for solving many problems the society faces, leading to a new step in the evolution of the world, namely the digital society.

The importance of research on the relationship between Information and Communication Technologies (ICTs) and economic growth is found at the heart of researchers' interest, Vu, Hanafizadehb and Bohlin (2018, p.8) revealing that "by period, the average number of publications increased from 2.7 from 1991-2000 to 7.6 from 2001-2010 to 13.1 from 2011-2018", which also shows that this research area is of strategic significance for all the countries. ICTs play a key role in the digital society, both as a sector of the economy and as advanced tools of production and services that produce significant changes in both the jobs and in the skills required from future workers, nationally and globally. "Workers able to use information and communication technologies can help formulate solutions ... (on unemployment n.a.) both by creating new jobs in the ICT sector and by supporting the labor market to become more inclusive, innovative, flexible and accountable." (World Bank, 2013, p.6). According to experts at the Mc Kinsey Global Institute (2013, p.12), "Mobile Internet will generate an annual economic impact of over $3.7-$10.8 trillion by 2025" and, according to Elena Kvochko, quoted by World Bank experts "in the OECD countries, more than 95% of businesses have an online presence" (World Bank, 2013, p.11).

Nagy Hanna (2016) considers that ICTs might be a powerful tool for implementing a sustainable development strategy, transforming economic sectors such as education and health, businesses (2016) and cities, renovating the public delivery services, increasing the security of citizen transport, helping to reduce corruption and increase welfare.

The development of a digital society at EU level involves allocation of significant funds for the growth of research and development in the field of technologies, in partnership with the private sector, and their commercialization. In this regard, the Horizon Europe 2021-2027 Program and the new investment scheme in the digital transformation of Europe provide for the allocation of 2.5 billion Euros directly for AI and an additional EUR 700 million for investment in ensuring advanced digital skills through education and training (Chivot, 2019).

The aim of this paper is to highlight the influence of digitization on population welfare by using a panel model. The originality of the paper rests in revealing the direct impacts of digitization on welfare, showed with the help of contribution of the Information and Communications economic sector stated by the sector's value added and number of employees, as well as the indirect impacts showed with the help of other digitization indicators, such as those pertaining to connectivity: mobile phones subscriptions, households' access to Internet and Internet usage in the 11 CEE countries that are members of the European Union. It is also revealed the importance of human capital and of research efforts at national level, as key factors in stimulating the digitization process in order to ensure welfare. Considering that the human capital and its abilities (digital, for research) is the more important, Schwab and Zahidi (2020, p.5) find a stagnation in human capital in the developed countries, in parallel with a decline by 3% in meritocracy at world level and in the digital competencies scores in 2020 as compared to 2017 in 16 out of the 27 OECD countries. The expansion of ICT in an increasing number of sectors of society made that 50% of the ICT professionals work outside the ICT sector, and their deficit will continue to grow in the next period; in Japan alone is expected to reach 450 thousand persons by 2030 (ILO, 2020, p.7).

The paper is structured into three parts, including some conceptual aspects of digitization and how to approach it in different studies, the analysis of digitization in some CEE countries based on a panel model and conclusions.

1. Conceptual aspects and literature review

The term *digital* is used in the information technology as a binary number system (Dufva and Dufva, 2019 citing Ceruzzi, 2012 and Steiner, 2013) or a concept that refers to living in digital and digital culture (Negroponte, 2015). "*Digitization* is the conversion of data and analogue processes into machine reading format, i.e., 1 or 0, a format that can be read and processed by computers" (OECD, 2019a, p.7). While digitization is the use of digital data and technology and the interconnections that result in the changes in existing activities or new activities, digital transformations concern the social and economic effects of digitization that encompass society as a whole.

In the Oxford English Dictionary, digitization is defined as "the adoption or increase in the use of digital technology or computers in organizations, industries, countries, etc."

Related to digitization, the literature even defines the digital economy, characterized in the opinion of L'Hoest, (2001, p.44), by three significant factors, namely: a) the network effect that significantly contributes to economic growth by capitalizing on the so-called Metcalfe's law; b) changes in the business cycle, generated by the combination of ICT and globalization; c) more efficient business models, related to the use of new technologies that determine a more emphasized growth trend.

De Freitas W., (2020), considers that the *digital economy* captures the impact of digital technologies on production and consumption and Nosova S.S. *et al*. (2018), defines the *digital economy* as that economic activity in which the key factor of production is the digital data generation, showing that digital transformations have dramatically changed the world and had a major impact on the structures of the economy.

According to the IMF experts (2018, p.7) the *digital economy can be narrowly defined* as online platforms and the activities that take place on these platforms, while in the *broad sense the digital economy can be defined* as all activities that use digital data as part of digital economy, which in the modern economy means the whole economy.

Referring to the digital economy in a narrow sense, Zang and Chen (2019) define it only from the perspective of the ICT sector, including telecommunications, Internet, IT services, software, etc. In a broad sense, the same authors include both the previously defined ICT sector and parts of the traditional sectors that have integrated digital technologies.

The main components of the digital economy are in the view of UN specialists (2019, pp. 4-5):

- *basic or fundamental aspects* that refer to fundamental innovations (semiconductors, processors), basic technologies (computers, telecommunication devices) and available infrastructure (Internet, telecom networks);
- *information and digital technology sectors* that deliver products and services, including digital platforms, mobile applications, payment services, given that digital technologies have affected the service sector to the highest degree through innovations in this field, with spillover effect also to other sectors of the economy;
- *an increase in the digitized sectors*, such as e-commerce, e-government e-finance, e-media, but also the tourism and transport sector, so that the staff of these sectors must have digital skills, and also the population.

Many studies have digitization and its impact on society as object of research, focusing either on its measurement through indicators (Kononova, 2015; Afonasova, Panfilova, Galichkina, 2018; Herrero and Xu, 2018; Dutta & Lanvin, 2020; European Commission 2020; Cámara, Tuesta, 2017; Balcerzak, Pietrzak, 2017 and others), or on the impact of digitization on efficiency, productivity and competitiveness (Kazakova, Dunne, Bijwaard, 2020, Săvulescu, 2015, Goldfarb, Tucker, 2017), on the risk of poverty (Kwilinski, Vyshnevskyi & Dzwigol, 2020); on economic growth (Mićić, 2017); on the causes of poor acceptance of artificial intelligence (Kazakova, Dunne, Bijwaard, 2020), to highlight only a few aspects. The methodology varied from TOPSIS multicriteria analysis by applying the measure of general distance (Balcerzak, Pietrzak, 2017), to comparative analysis, correlations and the Monte Carlo method (Kwilinski, Vyshnevskyi & Dzwigol, 2020), survey (Kazakova, Dunne, Bijwaard, 2020), rank analysis (IMD, 2020), and panel data model (Biagi, Parisi, 2012, ITU, 2019).

Biagi and Parisi (2012) used a panel model with data on the Italian manufacturing companies with the aim to reveal the complementarity of ICT and human and organizational capital in processing. The data showed weak complementarity between ICT and the organizational innovations, a result that was also confirmed in the case of the German manufacturing companies, for which the data referred to investment in ICT and not ICT usage. The explanation is given by the fact that the analysis referred to the 1995-2003 period, characterized by productivity slowdown, when the solutions employed by companies to increase efficiency were changes in the structures of corporations, staff layoffs, introduction of new business forms in order to improve quality of goods and services, and to a lesser extent envisaged investment in new technologies.

Mićić (2017) analyzed the influence of digitization on gross domestic product (GDP) in the European Union countries, but also made a comparison with the Western Balkan countries, the conclusion being uncertain about the correlation between investment in ICT and the GDP growth per capita. One explanation may be, as pointed out by Dedric *et al*. (2003), that investments in ICT should not only be considered as investments purely in equipment, but also investments in telecommunications, software and services. However, the technological map of Europe shows that the countries with a high level of investment in ICT also have a high level of GDP per capita.

Piatkowski's (2004) analysis of direct contribution of ICT to the GDP growth in some EU countries shows that over the 1995-2001 period the total impact was higher than average in the EU15 countries (0.73), in the Czech Republic (0.86%), and in Hungary (1.29%) and below this average in Poland (0.70), Bulgaria (0.45%) and Romania (0.22%). Furthermore, he calculated the share of this contribution to the GDP growth in the 1995-2001 period, noticing that the largest contribution was recorded by Bulgaria (88%), followed by the Czech Republic (38%) and Hungary (35%), above the EU15 average level of 30%, while in Romania the contribution was only 28% and 14% in Poland (Piatkowski, 2004, p.21).

Săvulescu (2015), conducts an analysis of ICT in the EU countries highlighting its importance in increasing efficiency and competitiveness, despite major differences in the contribution of this sector to national GDP growth, the shares ranging in 2013 at levels below 9 % of GDP, with an average of 4.82% in the EU 28.

The ITU specialists (2019, p.3), in a study on 73 countries, grouped into OECD and no-OECD countries, revealed that and increase by 10 percent in the CAF Digital Ecosystem Development Index leads to an increase by 1.3 percent in the GDP per capita. When the data series is split into the two groups (OECD and non-OECD countries), it is found that an increase by 10 percent in the Digital Ecosystem Index (DEI) leads to an increase in the GDP by 1.4 percent in the OECD countries and by 1 percent in the non-OECD countries. Moreover, based on a fixed effects panel model it was found that and increase by 10 percent in the DEI leads to an augmentation of labor productivity by 2.6 percent and of total factor productivity by 2.3 percent.

Kazakova, Dunne, and Bijwaard (2020), examines the extent to which the EU companies use technologies based on artificial intelligence in order to increase productivity and competitiveness. Analyzing the adoption of artificial intelligence (AI) technologies in the European Union enterprises, they showed, in a study commissioned by the European Commission, on a sample of 9640 enterprises in 30 countries (of which 8.6% large enterprises, 22% medium-sized, 34.4% small and 35% micro-enterprises), that about 42% of enterprises have adopted at least one artificial intelligence technology, while 40% of enterprises have not and do not intend to adopt such technologies in the future, while 18% of enterprises intend to adopt such technologies. Moreover, about 25% of enterprises used at least two AI technologies, most of them (39%) being large enterprises and only 22% small enterprises and 21% micro-enterprises. By sectors of activity, the IT sector with about 63% is by far the largest user considering the value added obtained from these investments. The causes of the poor implementation of these new technologies indicated by the study would be: gaps in staff skills (45%) and difficulties in hiring new employees with the necessary skills (57%), to which the high costs of implementing such technologies (52%) and of adapting the operational processes (49%) are added.

Kononova (2015) highlights the existence of 14 indicators that seek to measure the digital society, each including between 8 and 113 sub-indicators, calculated by different bodies, professional organizations, and researchers. Deepening the analysis to six of them (KEI-Knowledge Economy Index, IDI-ICT Development Index, EGDI-E-Government Development Index, GII-Global Innovation Index, NRI-Networked Readiness Index, and

GCI-The Global Competitiveness Index), she highlighted a close correlation among them, varying between 0.81 (KEI-GCI) and 0.94 (NRI-GII). What this study reveals to us is the relativity of countries' ranking according to the aggregated indicators in the complex index that aims to highlight the progress made worldwide by different countries in building the digital society.

Afonasova, Panfilova, Galichkina (2018), analyze the indicators that characterize the level of digitization and the measures that stimulate the digitization process. Herrero and Xu (2018) use the New Economy Index for comparison with the Caixin Digital Economy Index for comparisons between China and the OECD countries on the progress of the digital society.

The OECD specialists (2019b, p.7) assessed the role of digitization on business dynamics in 15 countries by considering different issues of digitalization transformations, revealing that the digital-intensive sectors turned into the most dynamic of the economies and that after 2001 their dynamism has declined as compared to other sectors, major differences being recorded among the countries because of political and institutional factors. As a matter of fact, they consider that 35-40% of the digital intensive sectors' dynamics was due to technological changes and 40% was due to country-specific factors. The policies that may increase sector dynamism involve six measures, as follows: promoting education and training correlated with the supply and quality of entrepreneurs when fast changes in the business environment happen; facilitating access to finance of the new mixed companies, especially in the start-up phases; stimulating the growth potential of entrepreneurs; diminishing the legal and administrative entrance barriers for start-ups; assuming regulation of market players correctness by strengthening contract efficiency and business regulations; avoiding the excessive costs of experiments and failures, especially the inefficient insolvency procedures.

Balcerzak, Pietrzak (2017, p.11), use a TOPSIS multicriteria analysis by applying the measure of general distance (GDM) to highlight the progress made by the Visegrad countries in terms of increasing the level of digitization during the 2012-2015 period, highlighting Slovakia as ranking first, followed by the Czech Republic.

Goldfarb, Tucker (2017), resuming the analysis of the digital economy, show how the world economy is changing under the influence of such technologies, primarily highlighting cost effects: low costs of search, replication, transportation, verification, information collection on consumer habits, all these affecting organizations and companies.

Kwilinski, Vyshnevskyi, Dzwigol (2020) analyze the impact of digitization on the risk of poverty in the EU member countries for the period 2014-2018, highlighting the positive effect of digitization on reducing the risk of poverty and social exclusion. Using the method of comparative analysis, correlations and the Monte Carlo method, the authors assessed the probability of a change in the level of population at risk of poverty and social exclusion indicator depending on the level of digitization reached by each country. Analyses based on an opinion poll showed that populations in countries with a low level of digitization were much more exposed to the risk of poverty and social exclusion (25.44%), as compared to the populations in countries with a high level of digitization of activities (9.74%). A special situation was registered by Lithuania, which, although it experienced a four-position increase in the level of digitization (from the 18^{th} rank in 2014 to the 14^{th} rank in 2018) registered an increase in the risk of poverty and social exclusion by 1 percentage point.

Mentsiev *et al*. (2020, p. 2962) consider that digitization has increased business efficiency, that in 2016 Japan and Brazil registered the highest percentage of using cloud computing

(45%) and that the German companies registered the highest shares of adopting new electronic resource planning technologies (57%) and new client management technologies (45%).

All these research papers reveal concerns regarding the analysis of digitization impact either on welfare or on poverty reduction, on business efficiency or on labor productivity growth, by using a wide range of indicators. What the current paper brings as novelty is the fact that it approaches the impact of digitization on population welfare in two ways. The first one concerns the direct impact of the ICT sector, revealed by the GVA contribution, an issue also found in other studies, such as Mićić (2017), Piatkowski (2004), Săvulescu (2014), ITU (2019), etc. The second one, less investigated in the literature, refers to revealing the indirect impact, stated through the transformations occurred at the level of human capital, concerning both the digital skills and the creative abilities supported by the increasing communication capabilities and the participation in professional networks to exchanges of ideas facilitated by the new technologies and the use of the Internet tools.

The main issues raised by measuring the digital economy are: differences in the definition of the digital economy; data quality issues, given their absence or poor quality; price problems, which influence the way deflators are calculated; the invisible aspects of the digital economy, especially in the business or consumer relations. (Bukht and Heeks, 2017, p.15).

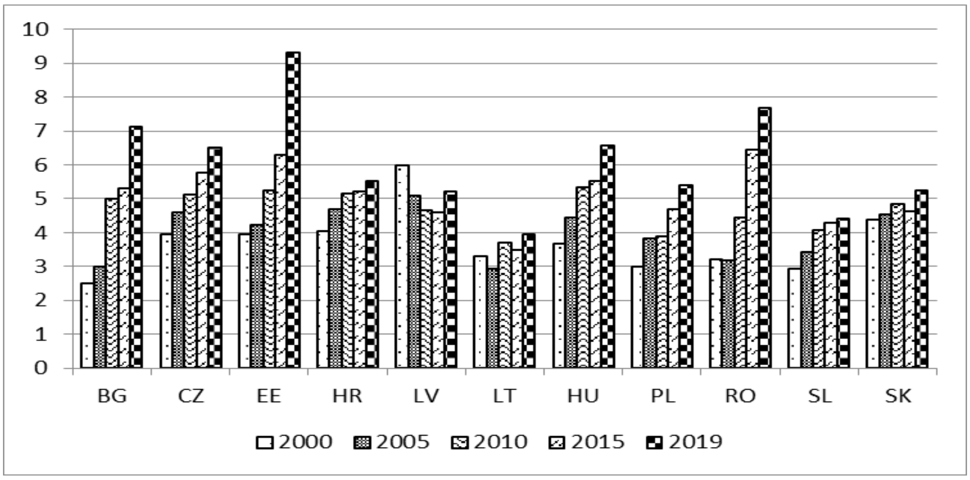
2. Analysis of degree of digitization based on a panel model

The analysis of digitization of the chosen countries based on its narrow sense definition indicates that over the 1995-2019 period the efforts of the analyzed CEE countries were significant, the share of the ICT sector in the GDP increasing significantly.

Over the 2000-2019 period, digitization of the economy continued, so that in 2019 the countries with the highest share of ICT in the total value added of the economy (GVA) in the analyzed CEE countries (Bulgaria, the Czech Republic, Estonia, Croatia, Hungary, Latvia, Lithuania, Poland, Romania, Slovenia, Slovakia) were Estonia with 9.3%, Romania with 7.69%, Bulgaria, with 7.1%, Hungary 6.56%, while Lithuania had 3.96% a share, as one may see in Figure 1.

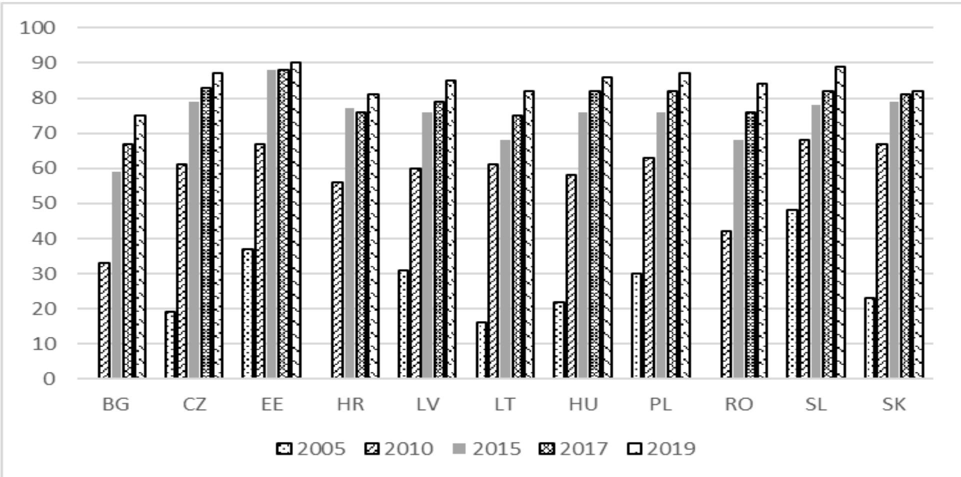
A possible cause for the evolution of share of the ICT sector in the GVA might be the different interests of entrepreneurs and governments in the development of this sector, the lack of real incentives, insufficient training of the workforce in this field and poor use of facilities offered by the new ICT technologies. However, as a result of digitization efforts, during the 2004-2019 period the share of homes connected to the Internet increased by 72 percentage points in Hungary, by 70 pp. in Latvia, Lithuania and Romania, by 68 pp. in the Czech Republic, by 65 pp. in Bulgaria, by 61 pp. in Poland, by 59 pp. in Estonia and Slovakia, by 42 pp. in Slovenia and by 40 pp. in Croatia. The progressive development of connectivity allowed for the increase in the share of homes with Internet access, so that in 2019, about 75% of all households had Internet access in Bulgaria, 81% in Croatia, 82% in Lithuania and Slovakia, 84% in Romania, 85% in Latvia, 86% in Hungary, 87% in the Czech Republic and Poland, 89% in Slovenia and 90% in Estonia (Figure 2).

Figure 1. Percentage of the ICT sector in GVA in the CEE countries



Source: Eurostat: Percentage of the value added of ICT sector in total value added of economy, authors' computations based on Eurostat data.

Figure 2. Internet access of households (% of households) in the CEE countries

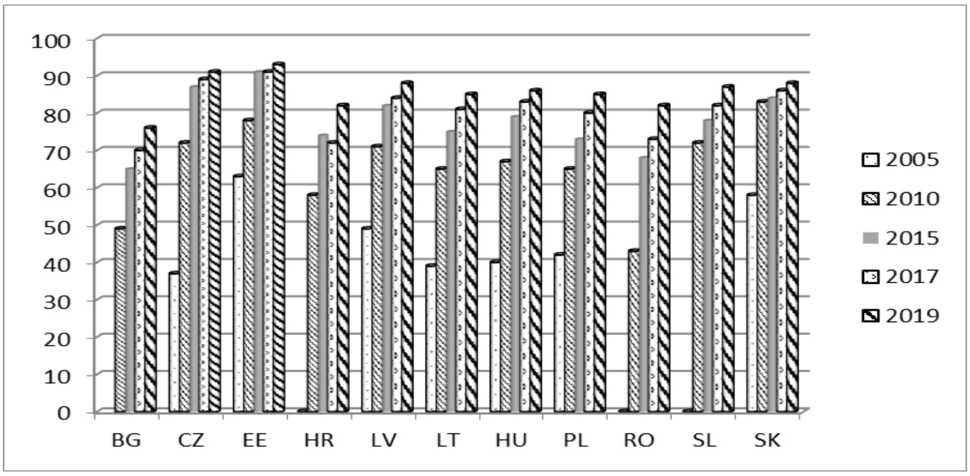


Source: Eurostat data.

The increase in the degree of connectivity led to increase in the population that used the Internet in the 2004-2019 period. Thus, data on population access to the Internet indicate low levels of connectivity in the early 2000s (below 20%, except for Estonia, which recorded 31% in 2004 and Poland, with 26% in 2004). Moreover, people who used frequently the Internet as a share in total population aged 16-74 years registered in 2019 an average level in the range of 57-83%, the highest being registered in Estonia (83%) and the lowest in Romania (57%), followed by Bulgaria with 60%. The rest of the CEE countries registered levels between 68% (Poland) and 76% (Slovakia and the Czech Republic).

Moreover, the share of people who ever have used the Internet increased to the highest level among the analyzed countries in 2019 in Estonia (93%), in the Czech Republic (91%), in Slovakia and Latvia (88%), in Slovenia (87%), followed in downward order by Hungary (86%), Poland and Lithuania (85%), Romania and Croatia (82%), the last ranked being Bulgaria (76%) (Figure 3).

Figure 3. Internet ever used by individuals in the CEE countries, % of individuals



Source: Eurostat data.

These developments indicate an increase in the degree of digitization of the analyzed economies and a change in their ranking in the hierarchy of the EU28 member states, but also in the world hierarchy. Thus, according to the Redinex Technology Subindex, in 2004 Estonia was ranked 25th out of 102 countries, while Hungary was ranked 38th, the Czech Republic was ranked 40th, Romania was ranked 53rd, Poland was ranked 72nd and Bulgaria was ranked 73rd. In 2019, the ranking has changed, Estonia being ranked 24th out of 134 countries, Slovenia being ranked 29th, the Czech Republic 26th, Lithuania 32nd, Poland 36th, Slovakia 34th, Hungary 31st, Bulgaria 43rd and Romania 46th as according to the data published by the PORTULANS Institute in 2020.

The human capital is paramount in implementing the digital technologies; on the educational level, the endowment with skills, the knowledge in applying and successfully developing such technologies depending to a large extent their success.

2.1 Data presentation

The data used in the model are annual data for the 2000-2019 period from the Eurostat database.

Given the multitude of indicators used in the international analyses to highlight the degree of digitization of countries, from among them were selected those that had a close relationship with the indicator chosen for the welfare of population, namely the GDP per capita - denoted by Y. In order to identify the explanatory variables, we took into account, on the one hand, the indicators that can highlight the degree of digitization of the analyzed economies.

The indicators, computation methods, data sources and the levels of Pearson correlation with the dependent GDP per capita variable are shown in Table 1.

Table 1

Variables used in the model and the Pearson correlation with GDP per capita

Variable used in the model	Computation method	Pearson Coeff.	Source of data
GDP per capita (Y)	Chain linked volumes (2010); euro per capita		Eurostat data [nama_10_pc]
Gross fixed capital formation (K)	As percent of GDP (%)	0.7848	Eurostat data [nama_10_gdp]
VAB of the ICT sector (Ic)	As percentage in total VAB of the economy	0.620	Eurostat data, table [rd_p_persocc])
Total employment (L)	Domestic concept, thousand hours worked	-0.302	Eurostat [nama_10_a64_e]
Employed in ICT (Li)	As percent of total employment	0.592	Eurostat [nama_10_a64_e]]
Expenditure on the R&D sector (R)	Intramural R&D expenditure (GERD) in euro per capita	0.9298	Eurostat data, table [rd_e_gerdtot]
Households' Internet access (Ih)	Percentage of households	0.553	Eurostat data [isoc_ci_in_h]

Source: Authors.

The all-data series were transformed by logarithm in order to diminish the discrepancies generated by the use of very different measure units.

2.2 Presentation of the model and results

Many studies used multiple regressions as a method, given the possibility of using time, cross-sectional and panel data series (Asteriou, 2009). In the paper, we chose as method the use of panel models, which, according to Hiasio (2003), provide a higher degree of freedom and are more suitable for cross-sectional data and time series, allowing for the inclusion of a higher number of variables (including pseudo-variables), for control of heterogeneity of variables and for verification of the delay effect. Another reason for using the panel models is their ability to control for the possible correlation, the time-invariant heterogeneity without its observation (Arellano, 2009, p.2).

In order to highlight the impact of digitization on the welfare of population, we start from a basic panel model described as in equation 1.

$$y_{i,t} = \alpha + \beta_1 X_{i,t} + \beta_2 Z_{i,t} + \beta_3 W_{i,t} + \delta_i + \varepsilon_{i,t} \quad (1)$$

where: Y is the gross domestic product per capita as an indicator of population welfare as dependent variable, expressed as 2010 chain linked volumes, euro per capita received by country i at time t, with i=1, …N, and t=1, …T. α is a constant term, X is a vector of macroeconomic variables (expressed by indicators: gross capital formation-K and labor – L). Z is a vector of direct effect of digitization expressed as share of GVA in the ICT sectors in total economy GVA (Ic) and W is a vector of indirect effects of digitization generated by creative and digital ability of human capital expressed as intramural R&D expenditure (GERD) by sectors of performance per capita (R), share of employment in ICT sectors in total employment (Li) and households' Internet access (Ih). We consider the employment in ICT sector (Li) as proxy for advanced digital abilities of human capital and households' Internet access as proxy for digital connectivity of people. Also, δ_i is the individual error component and $e_{i,t}$ is the random disturbance, $\varepsilon_{i,t} \sim$ IID(0, σ_u^2).

The results of statistical descriptions of the dependent and independent variables included in the three models, mean, median, maximum and minimum values, standard deviation, skewness and kurtosis and the J. Bera coefficient are presented in Table 2.

Table 2

Statistical description of the data

	Y	K	L	Ih	R	Li	Ic
Mean	3.995	1.356	6.665	1.710	1.884	0.341	0.656
Median	4.013	1.349	6.593	1.806	1.899	0.357	0.663
Maximum	4.316	1.566	7.520	1.954	2.677	0.696	0.969
Minimum	3.479	1.191	6.012	0.477	0.820	-0.076	0.399
Std. Dev.	0.170	0.070	0.426	0.268	0.411	0.135	0.100
Skewness	-0.570	0.160	0.440	-2.040	-0.246	-0.377	-0.047
Kurtosis	3.008	2.558	2.207	7.540	2.645	3.560	2.767
Jarque-Bera	11.793	2.723	12.852	274.801	3.336	8.094	0.577
Probability	0.003	0.256	0.002	0.000	0.189	0.017	0.749
Observations	218	220	220	177	218	220	220
Cross sections	11	11	11	11	11	11	11

Source: Authors' computations.

The statistical analysis of the series indicates that all the series take values between +0,5 and -0,5 which show a slight asymmetry, so we may say that the data are fairly symmetrical and could not affect the performance of the models (except for the Ih indicator). The Kurtosis indicator higher than 3 is leptokurtic, which means that a lot of outliers may be found in the data, especially in the case of series with the highest level (7.54), recorded for the Ih indicator. These high levels show that there is a gap between mean and items, even after we applied a simple solution such as a log transformation to fit skewed and kurtosis distribution into a Gaussian one.

In order to test for stationarity of the logarithm series, we used four tests, namely the Levin, Lin, Chu test (2002) and the Im, Pesaran and Shin test (2003), to which we have added two Fisher-type tests: the Augmented-Dickey Fuller test and the Philips Perron test (Maddala and Wu and Choi). The all-data series were tested in logarithm, and the results of the unit root stationarity test is presented in Table 3. Testing the stationarity of each series indicates that, according to the results of all unit root tests presented in Table 3, all the logarithm series are stationary in first differences.

Table 3

Unit root tests

Variables/ methods	Level with individual effects				1st Difference with individual effects			
	Levin, Lin &Chu t*	Im, Pesaran ShinW-stat**	ADF - Fisher Chi-square	PP - Fisher Chi-square	Levin, Lin &Chu t*	Im, Pesaran ShinW-stat**	ADF - Fisher Chi-square	PP - Fisher Chi-square
Y	-2.470 (0.006)	0.5074 (0.694)	16.923 (0.768)	17.765 (0.719)	-7.738 (0.000)	-4.843 (0.000)	60.545 (0.000)	51.101 (0.000)
K	-3.410 (0.0003)	-3.147 (0.0008)	45.86 (0.002)	27.42 (0.196)	-9.497 (0.000)	-7.373 (0.000)	92.567 (0.000)	115.66 (0.000)
L	-2.517 (0.0059)	-1.6115 (0.0535)	34.3413 (0.0453)	19.3607 (0.623)	-5.5669 (0.000)	-5.0897 (0.000)	66.8117 (0.000)	62.407 (0.000)
Ic	0.3170 (0.6244)	2.4809 (0.9934)	11.545 (0.9661)	19.2746 (0.6283)	-8.1349 (0.000)	-7.9319 (0.000)	100.811 (0.000)	137.769 (0.000)
Li	-0.7734 (0.2196)	4.6534 (1.000)	5.3106 (0.9999)	4.88706 (0.9999)	-9.4102 (0.000)	-8.8229 (0.000)	115.106 (0.000)	272.373 (0.000)
R	-2.3748 (0.009)	1.6238 (0.9478)	12.9948 (0.9333)	20.4699 (0.5537)	-10.788 (0.000)	-8.226 (0.000)	101.096 (0.000)	119.953 (0.000)
Ih	-24.3131 (0.000)	5.1958 (1.000)	2.8098 (1.000)	0.4473 (1.000)	-19.407 (0.000)	-12.192 (0.000)	124.457 (0.000)	91.3239 (0.000)

Source: Authors' computations. Probabilities are presented in parentheses.

In order to find out the best model, we tested both the fixed effects model and the random effects model. The Hausman test (1978) rejected the null hypothesis, which stated that the random effects model was preferred. In this context, it was considered that the use of the fixed-effect models can avoid the identification problems generated by unobservable factors at the national level (Glaeser *et al*., 2004; Gennaioli *et al*., 2013).

According to literature, in the case of the panel models it is enough to test for multicollinearity – which shows up when there is a linear relationship among all or some of the variables in the model (Frisch, 1934), resulting in difficulty to reveal the effect of explainable variable on the explained one (Maddala, 1992, pp. 269-270) and of heteroskedasticity, whose presence impacts the efficiency of the estimators. In order to avoid the multicollinearity problem, we have introduced the variables gradually, so that the final model has the highest R^2, case in which one may conclude that the model does not include collinearity.

To avoid the unwanted effects of heteroskedasticity and contemporary correlation of the cross-section series and to pursue their correction we chose a model with fixed effects for countries and for periods, of pooled-type with least squares method with cross-section SUR (PCSE) with error-correction, with 163 total pool unbalanced observations for the 2003-2019 period (Table 4).

Table 4

Pooled least squares method with cross-section SUR (PCSE) standard errors & covariance (d.f. correction)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.0073	0.00129	5.6412	0.0000
ΔK(-1)	0.0468	0.0288	1.6188	0.1079
ΔL	0.5245	0.0825	6.3604	0.0000
ΔLi(-2)	0.0371	0.0224	1.6577	0.0998
ΔIc(-1)	0.0826	0.0239	3.4616	0.0007

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ΔIh	0.0468	0.0177	2.6396	0.0093
ΔR(-1)	0.0551	0.01911	2.8805	0.0046
R-squared	0.85535			
Adjusted R-squared	0.89747			
DW	2.0544			
Schwarz criterion	-6.0409			
Fixed effects cross	Yes			
Fixed effects period	Yes			

Source: Authors' computations.

The data in the model indicate that R^2 is 0.8553 and adjusted R^2 is 0.8974. The results of the model indicate that macroeconomic variables such as labor (L), physical capital (K) and also gross value added of the ICT sector as percent of total GVA (Ic) and expenditure on the R&D sector (R) have the higher positive influence on population welfare, as we expected. Also, the digitization indicators (Li and Ih) have also a positive influence on the level of welfare, but the coefficients recorded low levels throughout the analyzed period (Table 4). The results are in accordance with the analyses of Vu, Hanafizadeh, and Boihlin (2019), who showed that the papers they had reviewed revealed positive and increasing effects of ICT on economic growth and productivity. Pilat (2004) showed the presence of complementarity between human capital and ICT usage, as well as the importance of relationship between ICT usage and the innovation ability of companies.

Weak evidence of the fact that the Internet has a positive impact on economic growth we find in the study of Stanley, Doucouliagos and Steel (2018), different from the results of other studies. Thus, Bahrini and Quaffas (2019) reveal for the Middle East and North Africa (MENA) countries that the mobile phones and Internet usage were, beside Broadband adoption, the main factors of economic growth over the 2007-2016 period. Moreover, Pradhan *et al*. (2018) have also revealed a positive impact between economic growth and the ICT infrastructure (broadband and Internet).

It should be mentioned that in the case of the Czech Republic, Estonia, Croatia, Hungary, and Slovenia the country effect is negative (the coefficients being -0.00382; -0.00073; -0.00311; -0.00432 and -0.0037, respectively) while the coefficients for the other countries were positive. Moreover, the analysis of the coefficients for the periods 2008-2009 and 2012-2014 showed that they were negative, highlighting the adverse effect of the financial crisis of 2007-2009, which was felt stronger in the analyzed countries, the rest of the periods registering positive coefficients, except for 2016 and 2019. The coefficients of the explanatory variables are stable.

The test for fixed effects is presented in Table 5.

Table 5

Redundant fixed effects tests

Test cross-section and period fixed effects			
Effects Test	Statistic	d.f.	Prob.
Cross-section F	2.6374	-10,130	0.0059
Cross-section Chi-square	30.1087	10	0.0008
Period F	14.1079	-16,130	0
Period Chi-square	164.0801	16	0
Cross-Section/Period F	10.2720	-26,130	0
Cross-Section/Period Chi-square	182.0026	26	0

Source: Authors' computations.

It is worth noticing that the hypothesis that cross-section effects are redundant is strongly rejected (the statistical values of 2.6374 and 30.1087 and the associated p value pointing towards this conclusion). Moreover, the following two values strongly reject the hypothesis that there are no effects of the time period taken into account. The latest test results evaluate the significance of all effects and reject the idea of existence of a single intercept in the model.

Furthermore, the model showed both the negative influence of the economic crisis and the existence of differences deriving from the specificity of the countries. The testing of the panel models with random effects for cross-section and period were invalidated by the Hausman test, the model with fixed effects being the one that best models the analyzed phenomenon.

Conclusion

The literature, rich in studies on the influence of human capital and digitization on economic growth, addresses to a lesser extent the effect of all these factors (human capital; digitization and research) together with the level of digitization, on the 11 CEE countries, significant factors that act in a complementary manner on the economies of the countries, contributing to the development of digital society. The analyzed studies revealed contradictory contributions, in relation to the considered periods, the indicators used and the methods applied to reveal the impacts. However, a conclusion may be drawn, namely the importance of such factors in developing the digital society, with different impacts in relation to the implemented policies and the national specific features.

The heterogeneity of the analyzed countries from the point of view of the level of economic development implies an increased attention paid to the analyses regarding the factors that may favor the development of digitization and the reduction in national gaps through appropriate policies.

The paper highlighted the importance of factors such as human capital, research efforts, digitization capacity in ensuring welfare, expressed as gross domestic product per capita. The conclusion is in line with those of ITU (2019), Vu *et al*. (2020) that confirm that the magnitude of ICT contribution to growth and productivity increased over time, and that among the main transmission channels we find: ‘learning, technology diffusion, and innovation’.

In the paper, we chose as a method the use of panel models which, according to Hiasio (2003) provide a higher degree of freedom and are more suitable for cross-sectional data and time series; the use of different models and different indicators as proxies for human capital and digitization have highlighted the achievement of positive results, as we expected.

The model highlighted the existence of a positive, statistically significant link, between the gross domestic product per capita and direct and indirect effects of digitization, and the research expenditure as euro/capita. Also, the results of the model show the importance of specific indicators which can ensure the digitization of the economy and, thus, the increase in welfare, as expected according to economic theory. (Pilat, 2004; Wu, 2011; Stanley, Doucouliagos, Steel, 2018; Pradhan *et al*., 2018; Bahrini and Quaffas, 2019). Moreover, the model highlighted both the negative influence of the economic crisis and the country-specific differences.

The limits of the model stem from the difficulty to reveal the indirect ICT effects on welfare, considering the presence also of other factors with multiple influences on population wellbeing. The model has not considered other key factors, such as social media penetration, e-commerce, e-government, e-learning, governmental policies and others.

In the future, we intend to use other alternative variables for digitization in the model, to highlight the extent to which the results were influenced by the choice of the proxy variants for these variables, and to employ cluster analysis to group the countries by level of development, and to further highlight the differences in effects by the development level.

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