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Human Capital in Digital Economy: An Empirical Analysis of Central and Eastern European Countries from the European Union

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Abstract: The hypercompetitive global economy of the 21st century is a hub of innovation, technology, talent, skills, speed, efficiency, productivity, and satisfaction. Within this context, the organizations are looking intensely for people with skills and talents that can differentiate themselves in all that noise. The human capital became slowly but surely a mean of efficiency and growth, especially through the premises of digitization, and a key issue of sustainability. The current research is meant to identify and highlight any correlations that might appear between the population's welfare of 11 Central and Eastern European Countries (CEECs) which are members of the European Union (EU), and the components of the digitization trend, including the new human cloud industry, ICT, and the connectivity to the Internet of Things. In order to achieve the needed insights, the multiple regression analysis was employed, and the latter tested the panel models with fixed effects, both from a temporal and country perspective. The results showcased a positive connection between the dependent and independent variables, confirming that the digitization of the economy and the developed human capital will ultimately lead to the increase of population's welfare. Moreover, the findings are consistent with specific insights for each of the 11 CEECs, showing that digitization and the influence of human capital is differentiated across the latter in terms of their overall effect and amplitude. The research is limited by the timeframe and countries included in the study, and it can be furthered by determining the impact of digitization on the economies of the EU28 countries grouped by level of development, and by using other significant indicators for analysis.

Keywords: human capital; digitization; ICT; welfare; CEE countries; multiple regression analysis; digital economy

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1. Introduction

Today, digital technologies are a constant component in people's lives and in their activities, with smartphones, global information networks, and virtual reality as standard presences in everyday life; thus, determining the whole society to become significantly dependent on digital technologies and on their specific infrastructures. These new technologies started to change the world in the 1950s, from the introduction (realization/creation) of the first computers (mainframe), client servers and personal computers, Web 1.0 and e-commerce, to the upgraded technologies of the 21st century, such as Web 2.0 and data storage systems (cloud), mobile data, visualizations, Big data and Analytics, Internet of Things (IoT) and, more recently, artificial intelligence [1]. Moreover, the interdisciplinarity of web science bridges together experts in computer science, software engineering, information systems management, business and economics, knowledge management systems, marketing, public relations and advertising, legislation, journalism and media, communications, psychology, anthropology, social work, design, libraries and scientific information, education. The term Web 2.0 stands for the fundamental technological improvements that allow users to publish their own content on a large scale based on social software for storing and disseminating documents, photos, videos, etc. [2].

All these technological changes involve transformative shifts within the dimension of human capital, both from the perspective of the creation and development of the technology, and the perspective attributed to the role of the user of these new technologies. Human capital has to accumulate new competences comprising of technical skills generated by human–machine interaction, and behavioral transformations that include new capabilities on interhuman relationships in virtual space, communication skills, ethical and responsibility competences.

Since the 1950s, Information and Communication Technologies (ICTs) changed the perspective and the means of living and working, having the highest impact on the trend of automation and engineering processes. Nevertheless, in a limited amount of time, technology and its applications became available to everybody and to every sector of the economy, underlining the outdated world in which we used to live, governed by outdated business practices and processes, old policies, segregation within the society, inefficient information consumption and processing, old-fashioned working dimensions and structures, etc. The big wave of cloud computing only added to the benefits determined by this structural and functional change—hyperconnectivity demonstrated that business, work, people change for the good alongside technology, and the future is today [3]. Subsequently, innovation represents the missing link within the picture, as the source for all those technological advancements within all sectors of the economy, modelling new perspectives in the knowledge transformation of this world.

With the equation complete, the main question remains how all those elements have actually shaped the human capital and its productivity, the possible connections between the wave of digitization and the working environment, the critical impact the cloud has on the human capital and its outcomes, the general expression of the market and the knowledge versus human competencies and skills, etc. The current research is based on a quantitative study on the dimension of the gig economy, namely the human capital and the human cloud industry, and the knowledge economy, including the usability of the ICT derived systems, infrastructures, and processes.

The importance of digitization has led to a focus of research either on the impact of digitization at the macroeconomic level, highlighting mixed effects (beneficial or partially beneficial) on economic and social welfare [4–7], or at the microeconomic level [8]. The effect of the digitization on the welfare of the population depends on the implemented technology type [4–6], on the level of economic development [5], on how the measurement of the income inequality is done [6], on the multiplication effect of the digitization extension and the growth of the Gross Domestic Product (GDP) per capita [6–8].

At the microeconomic level, the effect of the Internet on business performance shows the difficulty of measurement due to underuse of digital technologies, limited access to state-of-the-art technologies, different confidence levels in people using these technologies, difficulties in capturing complementary organizational investments to ensure efficient use of digital technologies [9], the need to requalify human capital in order to capitalize on the potential of technologies [10]. Considering the body of research on the topic, a limited number of studies analyze the effects of digitization in the Central and Eastern European Countries (CEECs) of the European Union (EU), and even fewer highlight the effect of digitization and human capital on welfare [11–13]; most analyze the effect of ICT on the economy by focusing on variables such as the Internet, telecommunications, ICT infrastructure, ICT equipment [14]. CEECs is an OECD (Organization for Economic Co-operation and Development) term for the group of countries comprised of Albania, Bulgaria, Croatia, the Czech Republic, Hungary, Poland, Romania, the Slovak Republic, Slovenia, and the three Baltic States: Estonia, Latvia and Lithuania. We are studying this group without Albania, which is not an EU member, because we are willing to see the gap to Western countries; we will use the acronym CEECs.

The role of human capital in the development of the EU countries has been classified as one of the most advanced in using ICT, especially in the financial sector [15,16]. Moreover, aligning the entrepreneurship education to the ICT perspectives will determine a higher probability of coping with the contemporary challenges of businesses [17].

Using an endogenous model, Sequiera [18] analyzed the link between the R&D, existing technology and human capital to highlight the positive effect on the welfare and wealth of the nation, as a consequence of the governmental effort.

The current paper analyses the impact of human capital and digitization on the well-being of the general population, in eleven CEECs of the European Union: Bulgaria—BG, Croatia—HR, Czech Republic—CZ, Estonia—EE, Hungary—HU, Latvia—LV, Lithuania—LT, Poland—PL, Romania—RO, Slovak Republic—SK and Slovenia—SL. The researchers chose these countries with the scope of understanding the extent to which digitization and the transformations it induces in human capital contribute to the increasing welfare in these countries, thereby potentially closing the gaps between the studied countries and other EU developed member states. The questions to be answered in the study are the following:

1. To what extent does the adaptation of human capital to technological change and the increase in digitization in the CEECs contribute to the well-being of the population in these countries?
2. Do differences in the degree of digitization of economies influence the size of the effect of digitization on the well-being of the population?

Panel models with fixed effects and various indices for measuring the degree of digitization of savings were used to answer these questions. The originality and novelty of this work resides in the use of composite indices to highlight the combined effect of human capital and digitization on welfare, as previous studies have only approached one of these factors [19] for human capital and digitization [20,21]. Compared to other studies that analyzed the human capital from the perspective of the education level, this study uses the Human Development Index as proxy. Given that the use of this index captures both the effect of education and health, as essential factors in increasing human capital, and also the indicator on Internet access, it determines the possibility of human capital to use digital technologies in and out of the workplace. Additionally, to highlight the degree of digitization, two different compound indices were used in the two models: ICT Development Index (IDI), developed by International Telecommunication Union (ITU), in model one, and the Networked Readiness Index (NRI), developed by Word Economic Forum, in model two, that offer the possibility of highlighting how the differences in measuring the digitization of economies could influence the well-being of population.

2. Literature Review

Digitization is the cause of profound changes not only in the economy but also in the society as a whole, determining the need for a better understanding of its transformative course. A universally accepted definition of the digital economy could not be found within the literature; nevertheless, the concept was interpreted by experts from two dimensions. The first approach is considered narrow, and has restricted the concept to reference regarding information and telecommunications technologies, e-commerce, digital delivery services, soft and information [13], or digital data generation [22]. The second approach managed to broaden the lyrics of the term up to the digital economy, including also artificial intelligence, the internet, virtual reality, cloud computing, blockchain, robotics and autonomous vehicles, parts of the economy that exploit technological changes in the market, business models and transformative daily operations, including both traditional technologies, media and telecommunication services and e-commerce, the digital banking system, digitization in agriculture, mining or manufacturing [23], or framing the term as "an economic and societal model that is driven by computer technology" [24].

What appears constantly in all attempts to define the digital economy from 1996–2017, as it results from the syntheses presented by Bukht and Heeks [25] and Vyshnevskyi [26], is the reference to information technologies and communications, the utilization of the Internet and Wide Web platforms to connect people in order to achieve different goals (productive, entertainment, culture, education, trade, banking), the technologies seen as an important factor in increasing productivity, the optimization of the economic structures, and in the end, the value-creation at the new frontiers of the business world.

Considering the human capital industry, the latter has been the subject of numerous studies since the work of Adam Smith [10], which highlights three categories of workers: the ordinary and the skilled, those working in the field of engineering, and the liberal professions, concepts that continued to be researched within the work of Mincer [27], Becker [28], Schultz [29] and others. Thus, Mincer [27] showed, among other things, the importance of the individual skills and the workers' qualifications in income distribution. Schultz [29] highlighted the quantitative and qualitative dimensions of the human capital whose most critical attribute "derives from the fact that the person and his human capital are inseparable", including "many attributes of people: physical, biological, psychological and cultural" which determines both the social value, and also the consumer services for saving or personal satisfaction [30]. Becker [28] focused on the development of a theory of investment in human capital. Therefore, he developed an individual investment model, by considering that investment in the human capital is comparable to investment in intangible resources, and underlining that those who invest more in the development of high-skills will benefit from higher income. Fleischauer Kai-Joseph [31], starting from the premise that the key element of the modern society is the education and the human capital, reviews the literature on human capital in order to better understand it, and showcases how political instruments can contribute to the overall well-being of a population, by increasing the efficiency of the education system.

In the age of the digitization, the competence and quality of the human capital are acquiring new dimensions, highlighted by a series of studies [32–36]. Among the new requirements and competencies that are necessary for the human capital in the modern era are:

- An increased level of education since technological changes require new qualifications through specialized education [32,37];
- Digital skills to select, cut, synthesize and evaluate the massive amount of information in statistical form, graphics or narrative information from Web log or blogs, Web sites and e-mails, to call for its verification from multiple sources, to formulate an opinion and to develop an action plan [35];
- A series of technical skills to search for information, to engage in dialogue, to play computer games, to be aware that the use of the Internet implies its responsible utilization within the cyberspace [34].
- Training skills to understand the perspectives or the different points of view, to learn critical skills in order to analyze and evaluate the credibility of information, to gain experience in accessing different forms of information, to be exposed to the digital environment, to understand the digital technologies and to acclimatize to this virtual environment, given the long time spent online [33].

Digital competences involve the critical and confident utilization of Information Society Technologies for work, pleasure and communication. These are based on the utilization of computer skills to find, access, store, produce and exchange information and to communicate and participate in collaborative networks via the Internet [38]. Digital competences are not enough in the digital society to ensure the utilization of the information and the new technologies for the benefit of the communities and the society. It is necessary to have a set of rules, norms, values that ensure their responsible use by each individual. A series of other studies focus on digital citizens, trying to highlight both the skills needed and the rules to be followed by them while engaging in digital activities [36,39–45].

Bennet, Wells, Rank [39] show that young people involved in the digital culture premises have a set of learning devices that differ significantly from the classical ones; thus, they prefer to receive information individually, they are more in favor of producing creative content themselves, rather than consuming it, they prefer to solve problems collaboratively rather than individually, and to share their results.

In a recent study on 129 European regions (NUTS2), Nevado Peña, López Ruiz and Alfaro Navarro [46] have demonstrated that in the digitization era, the technological developments entail the high education levels, and, as a result, the key issue of the development is investing in improving the knowledge and skills of the human capital.

Isman, Gungoren [43] consider that the wide-spread use of digital tools in the digital society generates new requirements for the skills of individuals who use these tools, namely the so-called digital citizens. They must understand the human, cultural and social aspects of new technologies, practice legal and ethical behavior, ensure the safe utilization of information, and be responsible for the use of new technologies. They also need to develop a positive, productive, collaborative and cooperation-oriented attitude towards new technologies, and to demonstrate responsibility for lifelong learning.

Noula [44] (pp. 5–6) considers that digital citizens or cybernetic citizens are terms used to identify the model of citizens who present new, digitally mediatized manifestations and changes in the social model of life. This concept is contested within the social sciences and literature, as there are different perspectives in relation to the status of the digital citizens; thus, the digital citizen is understood either as a civic responsible human, capable of using digital technologies [47], or as a person who connects the real world to cyberspace, and makes use of the Internet frequently and efficiently [48].

Ribble and Bailey [42] provide the most cited definition of digital citizens based on nine elements, namely, digital etiquette, digital access, digital legislation, digital training, digital communication, digital commerce, digital rights and responsibilities, digital health and well-being, digital security. They describe digital citizens as norms of appropriate and responsible behavior regarding the utilization of technologies, noting, however, that the digital world was installed before a series of norms were developed in order to ensure responsible behavior in the digital environment.

The training of digital citizens, meaning that people will be instilled the ability to realize the potential offered by digital technologies, implies the adequacy of education to respond to the future skills required by the labor market. Allen [49] shows that in industries that have already chosen the path of massive technological change, wage gaps in education have increased and experienced workers will obtain higher incomes compared to workers active in low-tech sectors; hence, the growing emphasis on increasing the level of education of the population.

The technological advancements require certain qualifications on behalf of the workforce. Those qualifications can be obtained mostly through on-the-job training, since the novelty of the technology implies that the necessary skills cannot be obtained outside the company, but through training within the organization. Moreover, technological changes will force workers to invest in obtaining complementary skills to their basic profession. By using the incentives provided by the organization in this regard, the human capital will be able to continue working on new technologies, with the level of education functioning as a signal of their qualifications and potential complementary qualifications. Moreover, the risk of losing a job is lower in high-tech industries for people with a university degree, and increases as the technological level of the industries decreases, and the level of education is limited to the basic one [37].

Le Baron and Mc. Donough [40] stress the importance of education dedicated to the ICT sector, concluding on what the major obstacles would be: "the attitude and beliefs of teachers and administrators; inefficiency of leadership strategies, insufficient resources for the application of ICT, local cultural insensitivity, constraints of the traditional institutional structure" [50], "poor coordination of investments in ICT between agencies and government levels; spending on new technologies is insufficient and directed without appropriate targets; educational leaders are poorly trained both in the general principles of leadership and in the specific application of leadership with ICT; teachers are poorly trained to integrate ICT technologies effectively or collaboratively; ICT specialists are not employed to train teachers about ICT; ICT investments in schools are made under a structure that is not able to capitalize on the benefits of these technologies" [40].

In 2019 [51], six out of seven EU28 citizens (approximately 87% of the Union's population) used the Internet at least once in three months, with percentages of online activity of up to 68% in Bulgaria, 96% in Hungary, 90% in Estonia, 87% in the Czech Republic, 86% in Latvia, 83% in Slovenia and Slovakia, 82% in Lithuania, 80% in Poland, 79% in Croatia, and 74% in Romania [51,52]. The data indicate an enlargement of interest for information, socialization and other activities (commercial, interaction with state and banking institutions, telework) on online platforms.

The findings of Nwankpa and Merhout [53] revealed the correlation between digital investment and IT innovation, and the conciliation influence the digital investment has between IT innovation and IT competences.

According to Romer [54], the origin of the theory of endogenous growth is related to research that has shown that GDP per capita in different countries tends to converge in the long run. Romer [55] considers economic growth as a result of the "endogenous outcome of an economic system, not the result of forces that are pushing from outside", underlining a different result from the neoclassical theory of economic growth. Moreover, he shows that the key element that differentiates the classical theory of growth from the endogenous one is the β exponent on labor in the Cobb-Douglas equation as an expression of output, concluding that its value is in the proximity of 0.25, comparable, level between 0.2–0.33 values obtained for this coefficient by Barro, Sala i-Martin [56], respectively Mankiw, Romer and Weil [19] (p. 415).

Mankiw, Romer and Weil [19] analyzed the extent to which the Solow [57] model highlights the determinants of population's well-being, considering that the non-inclusion of human capital in the model leads to incorrect conclusions. Thus, they developed the production function by adding the stock of human capital emphasizing that per capita income depends on population growth, physical capital growth and, significantly, the accumulation of human capital, the relationship between the indicators being positive. Moreover, differences in education, savings, and population growth rates may explain the differences in per capita income between countries. For the rate of accumulation of human capital, they used as a proxy indicator the percentage of working-age population that is in secondary school.

Schneider and Ziesemer [58] open the discussion of the new endogenous theory based on three issues: content of the technology, the market structure suitable for the new scale of returns generated by technology, and different specifications of production factors—less developed that the others.

Katz, Koutroumpis, Callorda [20] (p. 166) performed a study, using an endogenous growth model in which they included along with the stock of capital and labor only the digitization index built for 151 countries as proxies for technological progress in order to highlight the effects of new technologies on the economy; the results of the model confirm the positive contribution of physical capital, labor and a strong effect of the digitization index on economic output, highlighting that "a ten-point increase in Digitization Index has approximately 3% impact on GDP for the period 2004–2011".

Arendt [11] analyses the relationship between ICT and economic growth but also the impact of ICT on productivity in the EEC using the methodology proposed by Solow [57], adapted by the decomposition of physical capital into ICT and non-ICT capital, and the labor in skills and non-skills. He pointed out that in the period 1995–2014 the contribution of ICT to GDP in the EEC was ahead of that of the EU15 countries (except Romania, Poland and Slovakia), that non-ICT capital was more important for economic growth than ICT capital, different from the situation in EU15. In the period 2004–2014 the gap between the two subcomponents of capital narrowed significantly in EU15, but remained significant in CEECs, where the non-ICT capital service component outperformed ICT component service (except Hungary). The analysis showed that the best performing CEECs were Estonia and Lithuania, and the low-performing countries were Romania and Bulgaria.

Trașcă and others [12] (p. 9) also analyzed digitization in 9 of the CEECs (Romania, Czech Republic, Bulgaria, Poland, Hungary, Estonia, Latvia and Lithuania), and highlighted that "the countries in which SMEs are able to integrate components of digitalization in their business activities and acquire technological strength grow more and export more". Moreover, the researchers [12] proposed that there is a link between "low digital literacy rate and a low level of SMEs exports share of total exports" in the case of Romania, Bulgaria, Poland and Hungary.

Digital Agenda for Europe [59] assumed its targets for 2020, including that the fast band of 30 Mbps and above to be used by 100% of EU citizens, and that the 100 Mbps band to be found in about 50% of the European houses, promoting online commerce, increasing the number of Internet users, the expansion of eGovernment platforms, the doubling of public investments in research and development of the ICT sector to about EUR 11 billion, the promotion of e-commerce by achieving the digital single market, etc.

The development of a digital society at EU level involves the allocation of significant funding for the growth of R&D in the field of technologies in partnership with the private sector, and their commercialization. In this regard, the Horizon Europe Program 2021–2027, and the new investment scheme in the digital transformation of Europe provide for the allocation of EUR 2.5 billion directly for AI, and an additional EUR 700 million for investments in ensuring advanced digital skills through education and training courses [60]. A successful example of digital transformation in the public sector is analyzed by Alvarenga et al. [61] in Portugal's central administration, confirming the entire society transformation is stimulated through the digitalization process.

3. Research Data

The current research is based on a quantitative analysis of a Eurostat database comprising of 121 observations from 11 CEECs (Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovak Republic and Slovenia) during 2000–2018. The panel data model included the following indicators—GDP per capita as proxy for well-being, the investment rate as the average for gross GDP, as proxy for physical capital, labor (average of working hours by ICT personnel in country economy factored by the total working hours employed by the rest of personnel), human capital (expressed as Human Capital Index—HDI indicator, including the education effect and the health effect of human capital), Networked Readiness Index (NRI—the indicator of ease of usability of ICT) as a digitization proxy, ICT Development Index (IDI)—also as a proxy for digitization, and the percent of households with stable internet connection from the total of households (Ih).

The multiple regression models using panel data were preferred for their capacity to showcase the effect of omitted variable bias. Moreover, the panel data models are able to provide with information on specific behavior over a timeframe, such as the effect of digitization of the economy on the population's well-being. A brief analysis of the data included in the panel provides additional information for the evolution of the degree of digitization and human capital in the analyzed countries and the relationship it might have with the welfare of the population within these countries. First of all, the study analyses the evolution of human capital expressed by HDI and the increase in welfare expressed by GDP per capita (as highlighted in Figure 1).

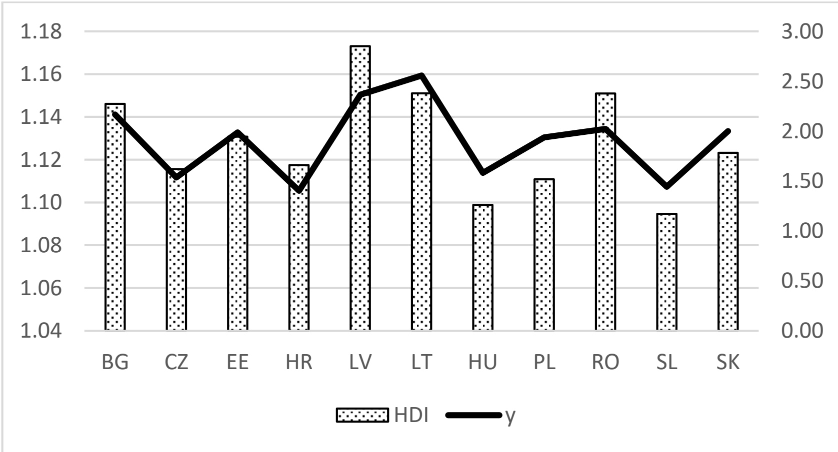

Figure 1. Growth rates of the population welfare level (Gross Domestic Product (GDP) per capita—ΔY right axis) and human capital (Δ Human Capital Index (HDI)—left axis) for the EU Central and Eastern European Countries (CEECs) in 2018 compared with 2000. Source: authors' processing based on data from UNCTAD and Eurostat. Note. HR year 2017; RO year 2002.

The data show a link between the evolutions of the two indicators that follow approximately the same trends, with variations from one country to another, as a result of the different level of development, and government policies on investment in human capital, the latter being considered an important resource in ensuring welfare. The Pearson coefficient indicates a positive and statistically significant correlation between the growth of the two indicators, the level being 0.8397 on all CEECs analyzed in the period 2000–2018.

In order to highlight the degree of digitization of the analyzed countries, this research used complex indicators that capture as much as possible the evolution of digitization, given the complexity of the phenomenon and the multiple economic and social implications. The selected indicators have undergone significant changes over time in the way they are calculated by international bodies, determined by the rapid technological changes that required the expansion of indexes, by including new components and by the scale changes, which influenced the length of the data series included in the analysis.

The data show that the digitization efforts of the countries are reflected in different sizes due to the methodological peculiarities of the two indicators used. Thus, NRI, according to Kirkman, Osorio, Sachs [62], was built given the dynamics of information and communication technology and the growing importance of ICT diffusion in economic growth processes, the first determination being for the years 2001–2002. Later, when the factors that determine the use of networks were discovered, along with their expansion, in 2003–2004, the structure changed with the inclusion of three areas: Environment, Readiness, and Use, and expanded in 2012 to four areas: Environmental, Readiness, Usage, and Impact, with 10 pillars and 53 indicators, while the evaluation was scaled from 1 to 7.

At the same time, the different efforts made by the governments of the analyzed countries, during the studied period, determined in line with the NRI index, have registered the highest increase in digitization in Poland, followed by Lithuania, Latvia and Bulgaria.

On the other hand, the indicators developed in 2002 by the International Telecommunication Union (ITU) were built around five aspects regarding: Infrastructure; Existence of the necessary means; Knowledge; The quality and The degree of use of the ICT, and included eight indicators [63]. Subsequently, those indicators underwent many changes, the most recent in 2008 when IDI was developed, as a composite index based on three stages of development of the digital society: access, use and skills. The data indicated an increase in digitization, Bulgaria moving up from 51st place to the 45th position, Romania from 60th to 46th, Lithuania from 43rd to 33rd, Estonia from 31st to 26th, while smaller changes were recorded by Slovakia (moving up three positions), Poland (two positions), Hungary and Croatia (one position). The only countries that have lost in positions have been Slovenia (from 22nd place to 28th place) and Poland (from 37th place reached on the 39th place) [63] (p. 22).

The data in Figure 2 show that the countries with the worst results have intensified their efforts towards digitization, with significant increases in Romania, followed by Bulgaria, the Czech Republic and Slovakia. These developments can be explained by the different efforts at the level of countries to ensure the necessary training to capitalize on the potential of new technologies, and to expand their implementation area at the level of services for the population. The recent COVID-19 crisis highlighted shortcomings in countries that have gone through periods of lockdown, while moving business online has saved jobs and diminished the impact on the economy and the welfare of the population. The shift depended on the existence of home connections to the Internet facilities, and on the existence of people with basic skills in accessing these technologies. The analysis of the degree of housing connection to the Internet shows that the countries with the lowest level of connectivity recorded the highest increases in the period 2004–2018 (Figure 3).

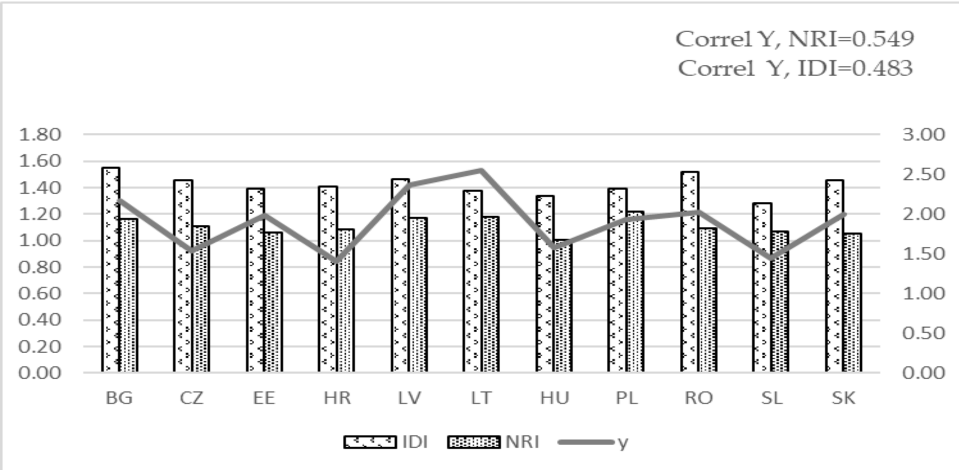

Figure 2. Growth rates of the population welfare level (GDP per capita—Y Right axis) and degree of digitalization (NRI and IDI Left axis) for the EU-CEECs in 2018 compared with 2007. Source: authors' processing based on data from Eurostat, ITU and World Economic Forum.

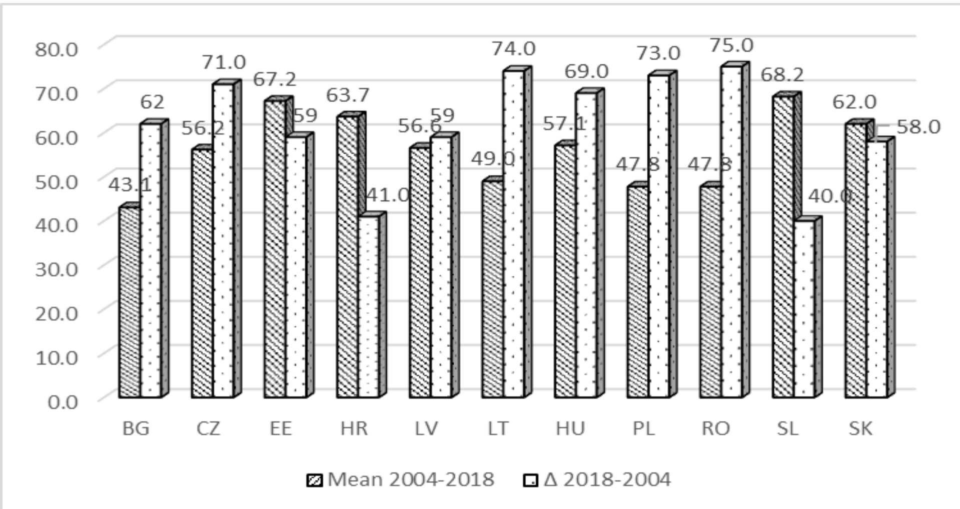

Figure 3. The growth of the degree of Internet connection of housing in the CEECs in the period 2004–2018. Source: authors' processing based on data from Eurostat.

The existence of the connectivity to the Internet is only one step toward digitization, and that should be enforced by the effort of human capital training to use these technologies. Considering the available data, it can be assessed whether the population of EU28 countries has or does not have digital skills, and at what level those skills truly are. Significantly, the share of people without digital knowledge is, in most countries, between 0–1% of the total population, but worrying is the share of people with poor digital knowledge rising on average in the EU28 to 28% at the same level as Estonia, while Bulgaria, Hungary, Poland and Romania, which usually have a level of digitization well below the European average, are above this average. It is also significant that some of these countries also have a share of people with digital knowledge above the basic level; well below the EU average of 71% are Bulgaria and Romania, while Hungary and Poland are close to the EU average, which indicates gaps in the European population, some of which capitalize too little on the benefits of new technologies. However, the greatest delays in the possession of digital knowledge are in some of the countries that joined the EU after 2004. In these countries the share of people with digital skills could not be assessed because individuals have not used the internet in the EU despite the existing connection to the Internet. 32% of the population in Bulgaria, 26% in Romania, 20% in Poland and Hungary have a constant Internet connection at home, allowing for presuming that the 2019 data stands as an indicator for the government efforts, which have been less focused on preparing the population to capitalize on new technologies. Therefore, it is proposed that in the new funding period (2021–2027) significant funds to be directed towards reducing these gaps, and toward involving the population in actions followed by the acquisition of digital skills. The needed training for the use of ICT can be achieved through the national education system, through individual effort in an informal system, or through training provided by companies seeking to capitalize their investments in new technologies.

The analysis of ICT specializations prepared by the national education system shows significant increases in the period 2013–2018, the highest being registered in Romania, given the small base of departure. It should be mentioned that in 2018, about 3.8% of higher education graduates have had a specialization in ICT; above this average, the highest shares have been registered in Estonia (6.7%) and Romania (5.8%). This education effort has led to an increase in the number of ICT specialists in 2019 to 9.38 million individuals at EU28 level, about 63.44% of whom are concentrated in the Euro Area countries (19 countries), while the share of ICT specialists of all the six CEE countries analyzed (Bulgaria, the Czech Republic, Estonia, Hungary, Poland and Romania) represented only 1.19 million people, meaning 12.7% of the total in the EU28. The education system is not the only one that offers specializations that allow the accumulation of digital skills. Thus, the share of enterprises (excluding those in the financial sector) that trained its staff to acquire digital skills in 2018 was 23% on average at the EU28 level, Slovenia, Czech Republic and Croatia registering higher values, with the highest value in Slovenia (29%). The rest of the countries registered values under the EU28 average: 18% in Slovakia, 17% in Hungary, 13% in Estonia, 11% in Latvia, 13% in Poland, and only 9% in Bulgaria and Lithuania, with the lowest level of 6% in Romania [52].

The effect of the ICT knowledge on the economic performance and growth was underlined in the literature by the results obtained by Schumpeter [64], who discussed about technology as a mean of creative destruction. Moreover, ICT has been approached within the endogenous theory of economic growth by some researchers [55,65], as well as within the space of the role it attributes to the human capital as a production variable [19]. Starting from these assumptions, this paper will follow an econometric model which includes the human capital and the new digital technologies with the purpose of showcasing the role of these two factors for the well-being of the former.

4. Methodology and Data

The impact of the technology on the economic growth was highlighted in literature by the contribution of Schumpeter [64] like creative disruptions or the case of the theory of endogenous economic growth [55,65] to which are added the development regarding the role of human capital as a factor of production [19].

4.1. Models Description

Based on these developments the current research will use an econometric model that includes both human capital and new digital technologies in order to highlight their role in increasing the welfare of the population, following the approach of Mankiw, Romer and Weil [19], which included in the function of production only human capital, and the approach of Katz, Koutroumpis, Callorda [20], who included in the production function only the Digitization Index.

In order to underline the impact of digitization and human capital on the overall well-being of the population of the CEECs during the period of 2000–2018, the paper proposes the adoption of a panel data model which employs a time series and a transversal series [66], that, according to Hiasio [67], allows the inclusion of a larger number of variables, within the general equation:

$$Y_{it} = \alpha_i + \beta_i X_{it} + \theta_i + \gamma_t + \varepsilon_t, \tag{1}$$

The variable Y_{it} is the dependent variable for each i = country and t = time; X_{it} represents the independent variables, and corresponds to the linear predictor from the OLS regression, in which β_i and α_i (i = 1 ... 11) are the unknown intercepts for each entity, which will be estimated on empirical data, θ_i represent the countries effect and γ_t the time effects and ε is the error term with normal multivariate distribution N (0, σ2εR).

The chosen indicators for underlining the technologic effect of digitization and the human capital effect on the well-being of the population in Equation (1) are the following:

- Y_{it} expressed as GDP per capita—Chain linked volumes (2010), in EUR per capita as proxy for well-being;
- For independent variable X_{it}, the indicators used were:
    - K—the gross fix capital formation as percent of GDP, as proxy for increasing in the physical capital stock, retrieved in others studies too [14], considering that ''the stock of physical capital is not substantially different from capital's share in income" [19] (p. 432),
    - L—labor expressed as average of working hours by ICT personnel employed in country economy factored by the total working hours employed by the rest of personnel; some studies are highlighted that ICT skills have an important role in digitalization and competitiveness development [68],
    - HDI—Human Development Index as a human capital proxy, which showcases the education effect and the health effect of human capital, considering that Knowles S., Owen P.D. [69], have demonstrated that the relationship between the income per capita and the health per capita is stronger than between educational human capital and income per capita,
    - Ih—the percent of households with stable internet connection from the total of households,
    - DT as a proxy for digitization.

By replacing the variable in Equation (1):

$$\mathrm{Log}Y_{it} = a\mathrm{Log}K_{it} + b\mathrm{Log}L_{it} + c\mathrm{Log}HDI_{it} + d\mathrm{Log}Ih_{it} + e\mathrm{Log}DT_{it} + \theta_i + \gamma_t + \varepsilon \tag{2}$$

where Y_{it} is the dependent variable for each country (i), and each time (t) and the rest are independent variable, in which a....e are the unknown intercepts for each entity, that will be estimated based on empirical data, while θ_i represents the countries' effect, γ_t the time effects, and ε is the error term with multivariate normal distribution N (0, σ2εR).

To highlight the importance of how to calculate the degree of digitization on the welfare of the population the research employed, within the two panel models developed, two different indices to express the degree of digitization of economies (DT), namely: ICT

Development Index (IDI) in model 1, and Networked Readiness Index (NRI) in model 2, caeteris paribus—the rest of variables remaining constant (Figure 4).

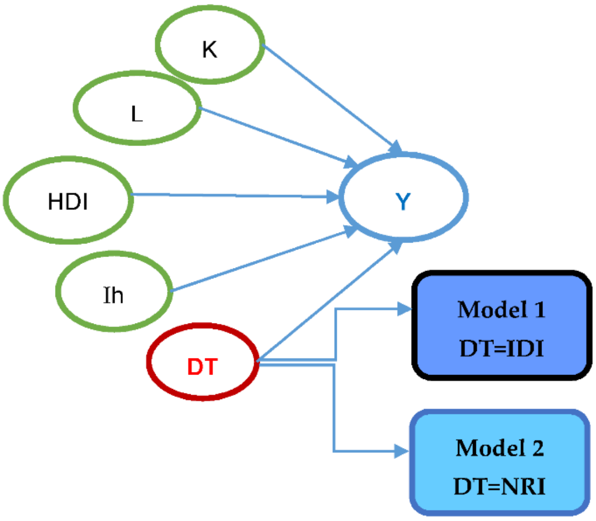

Figure 4. Logical representation of the methodology. Source: Authors representation.

By replacing in Equation (2) the variable DT with the mentioned indexes, the following proposed models were obtained.

Model 1:

$$\mathrm{LogY_{it} = aLogK_{it} + bLogL_{it} + cLogHDI_{it} + dLogIh_{it} + eLogIDI_{it}} + \theta_i + \gamma_t + \varepsilon \quad (3)$$

It uses the three-component IDI (access, use and ICT qualifications) and 14 indicators that measure these issues as a quantification of the economy's digitization in 2017. The dynamics of the field and significant changes in some areas determined the need for resizing the sub-indices that are part of IDI to capture the market environment changes, investments, lower prices for digital devices and subscriptions, the introduction of new technologies, efforts at national level to focus on a larger extent through the facilitation of a higher number of users to the high/new-tech and less through expanding the infrastructure and preparing qualifications for new technologies.

Model 2:

$$\mathrm{LogY_{it} = aLogK_{it} + bLogL_{it} + cLogHDI_{it} + dLogIh_{it} + eLogNRI_{it}} + \theta_i + \gamma_t + \varepsilon \quad (4)$$

which uses NRI consisting of four components: Environment with two pillars—political and regulatory environment and business and innovation environment; Readiness with 3 pillars—infrastructure, affordability, skills; Usage with three pillars—individual, business and government usage and Impact with two pillars—economic and social, and has 53 indicators in 2007, that show the country's capacity to exploit the opportunities offered by ICT and its impact on economy and society.

4.2. Descriptive Statistics

The data used in the model are annual data for the 2000–2018 period from the Eurostat database, UNCTAD data for Human Development Index, International Telecommunication Union for IDI [70], and World Economic Forum for NRI. The limitation of the analysis to the year 2017 was determined by the fact that after 2017 this index was not calculated by the ITU.

The chosen period 2000–2018 covers part of the pre-accession period to the EU of the first wave of countries (10 former socialist countries), among which Romania, Bulgaria and Croatia were later added. This period was chosen to capture the effect of transformations in human capital and digitization after accession to the European Union, and the implementation of measures included in the digitization programs of economies that aimed to build the digital society in the EU starting "A Digital Agenda for Europe", EC 2010, [71], "European Broadband: Investing in Digitally Driven Growth", (EC, 2013), [72], "A Digital Single Market Strategy" (COM 195, 2015), [73], "Artificial Intelligence for Europe-COM, 2018, 237", [74], among others, and concluding with "A Europe fit for the digital Age" (Webb, 2020) [75], one of the six priorities of the European Commission's program for the period 2019–2024, chaired by Ursula von der Leyen.

The results of statistical descriptions of the dependent and independent variables included in the two models, mean, median, maximum and minimum values, standard deviation, skewness and kurtosis and the J. Bera coefficient are presented in Table 1.

Table 1. Statistical description on data.

	Y	K	L	HDI	IDI	NRI	Ih
Mean	11,251.2	24.060	0.025	0.835	6.317	4.259	63.453
Median	10,800.0	23.000	0.025	0.835	6.430	4.200	66.597
Maximum	19,400.0	41.400	0.048	0.899	8.160	5.300	7.520
Minimum	4800.0	12.400	0.010	0.764	4.110	3.530	6.012
Std. Dev.	3516.327	4.779	0.005	0.029	0.792	0.382	0.428
Skewness	0.281	1.124	0.658	−0.058	−0.365	0.643	0.439
Kurtosis	2.666	4.612	5.255	2.522	2.805	3.007	2.238
Observations	119	119	119	119	119	119	119

Source: Authors' computations.

The statistical analysis of the series indicates large differences, the standard deviation reaching to vary over a wide range, depending on the unit of measurement of the used indicator, from 3516.3 to 0.005. The Skewness values show that distribution for all indicators has a right tail, except for HDI and IDI, and above the zero, especially in the case of K indicators. The Kurtosis levels of variable indicate that the variables are normal skewness and platykurtic, with flat distribution relative to normal because the values are less than 3, except for two variables (K and L) with a distribution in peaked (leptokurtic) relative to the normal level, and having the values above the normal level 3.

For the construction of the panel model, it was necessary to test the stationarity of the data by using the Unit Root test for logarithm data. Data series were made stationary by logarithm. The presence of unit roots of logarithmic data series is detected using the tests for unbalanced panels for common and heterogeneous cross-sectional independence with Levin, Lin & Chu test, Im, Pesaran and Shin W-stat test, ADF Fisher Chi_Square and PP Fisher Chi-square for same series data. The results using EViews 9.0 program are presented in Table 2.

Table 2. Unit Root test.

Methods	Level		1st Difference	
	Individual Effects	Individual Effects and Trend Effects	Individual Effects	Individual Effects and Trend Effects
Levin, Lin&Chu t	−10.244 *	−9.394 *	−16.405	−14.775
Im, Pesaran, Shin W-stat	−1.743 **	−1.445 ***	−11.022	−5.815
ADF Fisher Chi-square	210.252 *	201.789 *	426.145 *	349.418 *
PP Fisher Chi_square	817.739 *	268.872 *	1029.14 *	614.015 *
Hadry Z-stat	22.290 *	17.862 *	11.549 *	
Heteroscedastic consistent Z stat.	18.725 *	19.869 *	9.188 *	

Source: Authors' computations. Note: * Probabilities < 0.0001; ** Significant at a threshold of significance 5%; *** Significant at a threshold of significance 10%.

The result of unit root test in panel data form Table 2 confirm stationarity of panel data according to all panel root tests, including individual effects because the results reject the null hypothesis that assume a common (Levin, Lin & Chu *t* test) or individual unit root process (Im, Pesaran, Shin W-stat, ADF Fisher Chi-square, PP Fisher Chi square), according to *p* value. The Hadry Z stat accept the stationarity of panel data according to the probabilities' value.

4.3. Results Overview

The data series have been tested based on more than one model. The chosen models for testing have included the fixed effect models based on temporality and on the country specifics (Pooled PCSE type), and employed 107 observations from 11 countries from 2008–2018 period in the case of Model 1, and 120 observations from 11 countries from 2007–2017 period in the case of Model 2. The data showcase the fact that the included indicators can explain in a significant manner the dependent variable (Table 3).

Table 3. The fixed effect model for 11 CEECs.

Model 1 Cross Section Weight (PSCE)			**Model 2 Cross Section Weight (PSCE)**		
Variable	**Coefficient**	**t-Statistic**	**Variable**	**Coefficient**	**t-Statistic**
C	4.056	37.668	C	3.507	25.383
LogK	0.117	4.696	LogK	0.201	6.498
LogL	0.102	3.921	LogL	0.057	2.603
LogHDI	3.272	7.001	LogHDI	2.469	4.171
LogIDI	0.185	2.058	LogNRI	0.575	5.535
LogIh (−5)	0.052	4.307	LogIh	0.093	3.153
Fixed effects	Yes		Fixed effects	Yes	
Cross effects	Yes		Cross effects	Yes	
R^2	0.996		R^2	0.992	
Obs	120			120	

Source: authors' processing.

The results determined by applying the model on the analyzed series indicate that, as expected, the indicators expressing human capital (H), labor (L) and physical capital (K), the degree of countries digitization (IDI) and also the housing Internet connection (Ih) have a positive influence on the well-being of the population, results confirmed by other studies [76–79]. There is little evidence that the Internet has a positive effect on economic growth could be found in other studies, too [21].

The results determined by applying the second model on the analyzed series indicate that the level of coefficients obtained for physical capital are higher in the model 2 compared with model 1. The values of the coefficients for IDI are less than for NRI, and highlight the existence of the effects on the welfare depending on the definition and measurement of the composite indexes for digitalization.

Furthermore, NRI largely includes the latest generations of digital technologies compared to IDI, so, a possible explanation can be that it capitalizes the potential of new technological generations, that involves new measures to ensure the retraining of workforces to acquire skills specific to new technologies, new organization systems at the level of companies and public administrations, which generate a greater welfare effect.

Moreover, the level of the two indicators expressing the degree of digitization of economies also indicates a positive and significant relationship on the welfare of the population, in line with the generally accepted idea in the literature that digitization has a positive impact on employment [80], on poverty reduction [81], and, therefore, on the well-being of the population. The result is not surprising if we consider the strong link between the indexes that assess the degree of digitization of savings and the level of per capita income highlighted by the level of Pearson and Spearman correlations that recorded levels above 0.7 [82].

The data from the proposed models highlight the beneficial effect of the digitization process on the populations' well-being and the economic performance, as included in other studies which underline the fact that "the correlational analysis suggests that digitization has an impact on societal well-being, partially as a result of the increased access to basic services" [78].

Based on the obtained coefficients the models highlighted negative influence of the economic crisis from 2009, and also the differences deriving from the specificity of the country reflected in the in the mix of positive and negative coefficients (negative for BG, Pl, EE, LV and RO).

The models were tested with fixed effects test.

The test for fixed effects highlights the fact that the hypothesis that cross section effects are redundant is strongly rejected, statistical values and the associated *p*-value indicating this conclusion. The test for fixed effects is presented in Table 4.

Table 4. Test for fixed effects—Redundant Fixed effect test for both models, Test Cross section and period fixed effects.

Effect Test	**Model 1 (PSCE)**			**Model 2 (PSCE)**		
Statistic	**Statistic**	**d.f**	**Prob.**	**Statistic**	**d.f**	**Prob.**
Cross-section F	2.571	(10.85)	0.000	3.457	(10.74)	0.000
Cross-section Chi-square	29.076	10	0.000	37.567	10	0.000
Period F	5.767	(9.85)	0.000	3.344	(8.74)	0.000
Period Chi-square	52.428	9	0.000	30.248	8	0.000
Cross-section/Period F	5.409	(19.85)	0.000	3.330	(18.84)	0.000
Cross-section/Period Chi-square	87.178	19	0.000	58.149	18	0.000

Source: authors' processing.

The next 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 the existence of a single intercept in the model.

5. Limitations and the Future Developments

This study shows some limitations generated by the fact that the data series for digitization indicators have undergone multiple methodological changes that have greatly reduced the length of the data series possible to be used. Moreover, the differences in the definition of the digital economy, the problem of data quality, given their absence or poor quality, price problems, which affect the way deflators are calculated, the invisible aspects of the digital economy, especially in business or consumer relations [25] (p. 15), are other limits derived from the digitization composite indexes. Additionally, HDI indices do not capture the adaptability of human capital to the new digital technologies. Some of these aspects are included in IDI and NRI, but a more detailed analysis could offer more insights regarding the adaptability of human capital to new technological changes.

However, it should be noted that the model does not capture the negative effects on the labor market and welfare such as job losses and rising unemployment, reducing incomes for those who do not have the skills required by the labor market in the new technologies. Jandrić, Ranđelović [76] demonstrated that in terms of adaptability of the workforce to technological change, Romania and Bulgaria are in the low-performance cluster, while Hungary, the Czech Republic and Poland are in the medium-performance cluster, and Estonia in the cluster with high performance.

This study presents some limitations generated by the fact that it analyses the relationship between human capital and welfare only for 11 CEECs, so future studies will include a larger number of countries, and an analysis that includes their clustering according to the degree of digitization and the level of development and the distinct highlighting of the new skills needed by human capital to effectively capitalize on the potential of new technologies. Moreover, the use of GDP per capita as an indicator of well-being is considered, in recent studies, despite its wide use for comparison between countries, as insufficient to capture of economic aspects and environmental quality [83], the new research direction could be, therefore, to take into account the aspects of sustainable development, as a potential approach could consider the Index of sustainable economic welfare.

6. Discussion and Conclusions

Within the context of the knowledge economy, a valuable contemporary system is only based on extraordinary capabilities of the human society, intertwined with the modern technologies, for higher performance and efficient processing of economic activities across all sectors and industries. All the forward motions of the global economy over the centuries can be put under the presidency of information and information analysis. At work today no longer stand the same factors of influence; they have shifted into dynamic, transitioning knowledge, determining policy quality, industry performance, rupture in business models and country economies.

The 21st century, in which globalization and digital technologies tend to be important factors in achieving economic growth, is generating major changes globally, starting with the creation of new jobs, rapid access to information and services, in fact contributing to the development of the so-called digital society which also ensures the growth of the population's well-being. Under these conditions, digital technologies, communication networks, information, networking can create the premises for solving many problems facing today's society. Information and Communication Technologies (ICTs) play a key role in the digital economy, both as a sector within it, and as advanced production tools and services that produce significant changes, in terms of jobs level and also, skills level, which are required from the future workers nationally and globally, and for economic growth.

The European space has always been distinctively active in the dimensions of change, progress, sustainability and persistence. The economic growth was fundamental for the bettering of the overall output within the area, and the EU public policies have been always directed toward improvement, innovation, and defragmentation. The majority of the EU directives are meant to facilitate the development of the member states, and to create the cohesion within the area. Setting aside the cultural barriers, the economic differences, the social challenges, and one common element to all that is the global phenomenon of digitization.

Bornemann [79] demonstrated that, between 1998–2012, the digitization phenomenon has contributed by 0.6% to the economic growth in Germany [84], while Piatkowski [85] argued that, at least for eight European countries (i.e., Bulgaria, Czech Republic, Hungary, Poland, Romania, Russia, Slovenia), between 1995–2001, the ICT was an incentive for economic growth. For Bulgaria and Romania, during the same period of time, the ICT effects have been considerably smaller compared to the other EEC countries. One of the explanations for such a result could be diverted toward the FDI average within the analyzed CEECs, to which can be added the low-quality infrastructure, and poor institutional and regulatory frameworks [85].

A 10% increase in the score of the country digitization index calculated by Booz & Company's (Booz & Company's Digitization Index, New York, NY, USA) contributed 0.75 percent to GDP per capita growth [25] (p. 36).

These results are in line with the results obtained by the models applied in this paper, the influence of the degree of digitization differing depending on the indicator chosen to highlight national progress in this direction (NRI or IDI). Significantly, the influence of human capital expressed by the Human Development Index, which includes both the educational and health components, is positive and statistically significant in relation to GDP per capita in both models, according to the conclusions of De la Fuente and Doménech [86], which highlight the positive effect of investing in human factor education on the productivity.

Moreover, the coefficients for Bulgaria, Poland, Estonia, Latvia and Romania were negative and significant but small, or very small (Estonia, Polonia and Latvia-less than

0.003); the other countries were positive and significant with the exception of Hungary (a quite small coefficient in both models). It should be noted that the results correlate with the hierarchies of these countries in terms of the degree of digitization. The data and the information retrieved from the results' analysis confirmed the much lower progress achieved by Romania and Bulgaria both in terms of digitizing economies and its benefits on the welfare of the population.

Moreover, the analysis of the coefficients attached to the analyzed period shows that for the period 2010–2016 for the first model and 2009–2010 and 2013–2015 for de second model were negative, indicating that the negative effect of the financial crisis of 2007–2009 has had a deeper effect in the analyzed countries, the rest of the periods registering positive coefficients. The evolution and sustainability of the business environment are hardly influenced by the collaborative digital ecosystems build on high technology and personnel skills [87].

The heterogeneity of the CEECs in terms of the level of economic development implies an increased focus on analyses of factors that can foster the development of digitization and the reduction of national disparities through appropriate policies. The literature, rich in studies on the influence of digitization on the economy, provides less information on the well-being of the population offered by digitization in the 11 CEECs studied.

In order to highlight the impact of digitization and human capital on the welfare of the population of the CEECs analyzed, there have been two models employed. The latter were panel data sets with fixed effect and cross-section for countries and for timeframes. The results showed that there is a strong, positive, statistically significant correlation between the GDP per capita and the human capital (through the HDI indicator). Moreover, it has been established, based on the performed test and obtained results, that the number of ICT workers within a country's economy, the physical capital (K), had a positive effect. However, ease of utilization of digital technologies (NRI), the ICT development indicator (IDI), and the number of households with access to the internet (Ih) had also a positive effect, being significantly correlated to the well-being of the country's population.

The first hypothesis was confirmed since the model 1 used IDI that was developed in 2008 with 11 indicators (IDI has now has 14 indicators: five for ITC Access, three for Use of ITC, and three for ITC skills), compared with model 2 that is using the NRI published first in 2002 and revised in 2019, having 62 indicators (40 are hard/quantitative data, 12 are index/composite indicator data, and 10 are survey/qualitative data), including the readiness of the key stakeholder in ICT use (Government, Business and individual usage), and the environment subindex and impact subindex (economic and social). Based on the exploited models within this paper, the higher level of coefficient as compared to IDI underlines this complex impact, but also that if the variables reflect the human capital implication and contribution on the digitization potential, the positive effect on the welfare depend on the human capital adaptation and valuation of the ICT facilities, infrastructure, regulation, efficiency of system in changing regulation, aspects regarding the quality of education and management, etc.). In other words, a high-skilled population in ICT application generates a better regulation, environment, innovation and infrastructure, as well as other factors which contribute to the digitalization degree.

The second hypothesis was confirmed by both models' difference in digitalization influence on the well-being of the population, consistently highlighted by the second model due to the indexes content of NRI that is more complex and includes "economic, social and legal aspects", as well as all participants: individual user, government and business.

The indicators that measure the effect of digital technology, included in the NRI indicator, did not show the effectiveness of these technologies in the absence of favorable conditions. These new technologies can ensure the digitization of the economy and, thus, the increase of welfare, but the potential of the new technology can be capitalized efficiently if there is the right environment (necessary qualification of the labor force, adequate organizational systems, restructuring of public systems administrative, etc.). 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 EUR 2.5 billion directly for AI, and an additional EUR 700 million for investments in ensuring advanced digital skills through education and specialization courses [60] (p. 5).

In the future, the research can be extended with the analysis on the impact of digitization on the economies of EU28 countries grouped by level of development, and by using other significant indicators for analysis in order to capture also the negative effects of digitization.

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