DOI: 10.17573/cepar.2022.2.01 *1.01 Original scientific article*

The Impact of Digitalization on Public Administration, Economic Development, and Well-Being in the EU Countries

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Received: 12. 7. 2022
Revised: 12. 9. 2022
Accepted: 7. 10. 2022
Published: 28. 11. 2022

ABSTRACT

Purpose: Digitalization has been the driving change in creating jobs and increasing economic growth in recent years. However, the digitalization of countries and sectors is uneven. The paper focuses on various factors that have an impact on the economic development and well-being in EU countries. Its purpose is to show the evolution of EU countries in terms of digital transformation and how other indicators, such as e-government, human development index, labour productivity, and economic growth influenced the well-being in EU countries in 2019–2021.

Design/methodology/approach: The dataset consists of 15 numerical indicators extracted from Eurostat and World Bank databases. We apply principal component analysis and cluster analysis.

Findings and Practical Implications: The main research results show that the first dimension – named the impact of innovation on well-being – is dominated by e-government, the percentage of ICT specialists in total, internet use by individuals, the Human Development Index, the Digitalization Index, the Happiness Indicator, human capital, and the integration of digital technology. The second dimension is characterized by government expenses and productivity. Finally, the third dimension is dominated by the GDP growth rate. 77.67% of the total variance is explained by the first three principal components.

Originality: Four clusters have been identified by means of the K-Means clustering algorithm. All four clusters are well determined, with cluster 1 including the three Nordic countries ranking first, followed by cluster 3 of well-developed countries and cluster 4 containing mainly emerging economies.

Keywords: public administration, digitalization, economic growth, well-being

JEL: I12, I18

1 Introduction

On 9 March 2021, the Commission set out its vision and prospects for Europe's digital transformation by 2030. This EU's "compass for the digital dimension" revolves around four key points: skills, infrastructure, government, and business. From this perspective, in our paper, we approach the transformations that took place in the three components in the period 2019-2021 in the EU states based on a set of fifteen representative variables (Androniceanu and Georgescu, 2021). The aim of the EU's digital strategy is for this transformation to benefit citizens and businesses and simultaneously contribute to creating a climate-neutral Europe by 2050.

The crisis generated by COVID-19 has created some major problems, which have significantly accelerated the use of digital tools, which have highlighted on the one hand the opportunities and facilities that are offered through them, but on the other hand, digital inequalities have also been highlighted (Androniceanu et al., 2022; Ivanová et al.,2021; Androniceanu and Marton, 2021). In our research, they are identified and analyzed on each component. Although interest in digital transformation and implicitly in digital skills increased during the COVID-19 pandemic, it is important to be aware that the pandemic did not generate a real transformation, but rather forced a series of emergency solutions, unsustainable and should not be replicated in a post-pandemic society (Kinnunen et al., 2021). However, in our paper, we can identify the impact of the measures taken by the EU states in the analyzed period (European Commission, 2019, 2020, 2021). The digitization of public services involves rethinking the way in which public institutions design and deliver services to citizens and the business environment, more precisely, the transition from the traditional way of organization and operation towards a customer-centric institutional ecosystem (Mali, 2020). Thus, digital transformation in-

volves the integration of digital technology in all aspects of a field of activity, which fundamentally changes the way it operates and provides distinct added value for stakeholders. Unlike digitalization, which involves adapting to new technologies, digital transformation involves profound changes.

Next, the paper is structured into three main sections. The first section contains the results of an extensive analysis of the basic concepts in the specialized literature. The following section includes the presentation and explanation of the research variables' content and the research components' determination and analysis. This is followed by a large section of analysis and discussions about the mutual influences of the factors and variables studied, as they manifested themselves in the analyzed period. The last part of the paper contains the main conclusions and future directions for further research.

2 Literature review

There is a diversity of works in the literature that address digitization, digitalization, and digital transformation, in general, and in different areas of social and economic life. Digitization is the transformation of physical, analog information (such as documents, photos, reports, invoices, contracts, etc.) into a format that can be stored and accessed from a computer, phone, tablet, USB stick, smart watch and other similar devices. Digitalization is the conversion of processes from manual to automatic. In practice, digitalization has different forms, but, in essence, it consists of the creation of databases that include several files with various documents, depending on the typology, to which access can be differentiated. Digital transformation is the process by which the content, form, and mode of processing and transmission of data and documents are changing in order to save time and material resources and thus increase efficiency. In the field of administration, these three concepts are practically three stages of an extensive and complex process (Balcerzak et al., 2022). These can generate major and necessary transformations that significantly improve the content and quality of activities and services, as also the governance process, transparency, and accessibility of government institutions (Kafel et al., 2021). The research carried out by us shows the progress registered by the EU states during the pandemic, their degree of digitization, and the impact of digitization on economic and social development. Digitization, in general, and in the public sector (Lindgren et al., 2019; Špaček, Csótó and Urs, 2020; Nikolina et al., 2020), in particular, as well as digital transformation, are the subject of an impressive number of definitions in the literature (Viana, 2021; Nathan et al., 2019). Public governance in the digital age involves the adoption of three main approaches: reintegration, holism, and digitalization (Bodemann, 2018). Reintegration involves the correlation and unitary integration of public services for citizens and the business environment, the integration of outsourced technologies and services, the use of common services, and the simplification of the process of delivering public services to government clients. The holistic approach involves reorganizing services based on focusing on the needs of citizens and businesses and de-

livering unique "one-stop-shop" services that allow for the simplified integration of services in one place.

In public administration practice, the goal of digitalization is to give every citizen the same access to services, information, and knowledge (Larsson, 2021; Tangi, 2021; Sidak et al., 2021; Löfving et al., 2022). This access will be provided through digital technologies. The proliferation of digital technology has had a beneficial effect on the efficacy and efficiency, as well as the quality and cost, of operations that are carried out by governments, communities, and individuals. New doors have been opened for sociopolitical participation on the part of citizens thanks to digital technologies (Vasiliades et al., 2021; Certomà, 2022; Sharma et al., 2022). The management of the interactions that take place between the state, regions, and localities, as well as the communication that takes place between public administration authorities and citizens, increasingly makes use of these technological advancements. The foundation of good governance is openness, transparency, accountability on the side of the government, and community participation in the process of policy development and execution. Digital technologies guarantee that these procedures are accessible and simple to carry out (Kim et al., 2022).

Digitization involves the definition, development, and implementation of digital media and tools with strategic impact, combined with process automation, intelligent use of data and information, as well as new social experiences in the online environment for citizens and public institutions (Strafford and Schindlinger, 2018). Digitization is not a goal and has never been, not even as a sector of activity, geographical sector, or segment of the population. It is a means of achieving certain goals, and certain needs of a segment of the population because digitalization comes as an answer to solving these needs.

Digitizing the administration means efficiency and transparency. It means electronic archiving of documents that, once digitized, can be searched and accessed anytime, anywhere. Digitizing the administration also means simplifying procedures and efficiency - which shortens the path from a state need to acquisition and leaves much less room for politically appointed people to intervene in the process while making the whole process much easier to verify (Rosenbloom, 2014).

Digitizing the administration means efficiency in procurement and ways to set cost standards, evaluate bids, and report theft almost automatically where they occur (Neamtu and Dragos, 2014; Munoz and Bolivar, 2018). Digitizing the administration also means holding the political factor accountable to the citizens: once every acquisition and decision is easily accessible and intelligible to the citizen, the politician can be sanctioned almost instantly by the press, civil society, and especially citizens and the business community (Moller, 2020). Digitization and digital transformation are complex, transformative processes with implications in all branches of society from jobs, education, health, and social security to the transformation of public services, the economy, and relations between states. The digital economy is expected to contribute to social and economic equality. At the same time, technology

will help increase access to education, jobs, and finance, even if, in the short term, it could lead to a reduction in repetitive work.

The growth of the digital economy has both obvious advantages and disadvantages, at least in terms of developments so far: on the one hand, it promotes economic growth (Arsić, 2020), information transmission, improving efficiency, creating of new public service platforms, facilitating daily life and so on, and on the other hand, it causes information insecurity, information shortages caused by the wealth gap, difficulties in regulating information, internet fraud, infringement of intellectual property rights, intrusion into privacy and other new challenges. Digitization has considerable consequences for the labor market and work organization, such as greater income disparities and reduced access to social security systems, which can be negative if not managed properly (Mura et al., 2021). As our research shows, there is a tendency to lose jobs in developed EU countries because employees, especially in the industrial sectors, are being replaced by cars. Mainly due to robotization, large groups of workers, including managerial levels, are currently fired. The middle class of society, especially those categories that were dependent in their prosperity on employment, are severely affected, as are the generations older of people whose contact with information technology was made later in active life. At the same time, there is the possibility for emerging countries to create new jobs in the field of communications, in order to promote the necessary investments for a territorial network in the field of optical fibers. Digitization is an opportunity to stimulate the economy, especially in emerging countries. There are already positive experiences, for example in the use of mobile telephony as a commercial trading tool.

There are still opportunities for new jobs, such as those related to caring for people, where technological change is not so decisive, at least for the moment. The new trends for the future of work are technology, digitization, robotics, and artificial intelligence. Digitization provides opportunities for surveillance and monitoring of people at work, endangering their autonomy and privacy. However, it is no less true that these systems lead to better use of working time. Therefore, digitalization has a major impact both on public administration, the economy, and the well-being of citizens in general. Through sets of specific variables for the four dimensions of our research, namely: digitization, administration, economy, and the well-being of European citizens are identified, analyzed, and compared (Androniceanu A.-M. et al., 2020). Then some of their most important and significant elements of impact in 2019-2021 are presented.

Many states have made the process of digitalizing their economies one of their top strategic development priorities in light of the current economic climate. The emergence of technologies that encourage the digitalization of the economy makes it possible for the state, corporations, and society to engage productively in order to facilitate the development of a process that is increasingly expansive and fluid (Bessonova and Battalov, 2020; Pucheanu et al., 2022). Innovation, economic development, and competitiveness are in-

creasingly being driven by the digital economy. Businesses expect their competitive advantage to increase as their services are provided through virtual channels and integrated into their operations management (Reis et al., 2019). Digitalization also contributes to economic development since the process and the product can both be automated, which leads to an increase in both production and quality in different economic segments (Maiti and Kayal, 2017). Vyshnevskyi (2020) in his study regarding the main problems in EU countries associated with industry's level of digitalization, showed that the industrial production growth rates of EU member states, which are among the world's most advanced in terms of digitalization, are significantly lower than those of other countries with a lower level of digital transformation. The following is an example of a theory that could explain why countries with high degrees of digitalization are seeing a comparatively slower rate of expansion in their industrial production (Vyshnevskyi, 2020). A high level of economic development results in a high level of digitalization, but it also sets the stage for a high level of output that falls into the trap of being harder to achieve with each passing percentage due to a substantial base of comparison. The comparison of Romania and the Netherlands is a good example of this. Romania is the 27th (last) (European Commission, 2022) among all EU countries in terms of the average rate of digitization and the 19th (Eurostat, July 2022) in terms of the average growth of industry volume. The Netherlands is the third in terms of digitization (European Commission, 2022) and ranks 21 in terms of the average increase of the industrial volume index (Eurostat, July 2022). Thus, it may be stated that digitalization (digital capital) does not necessarily have a significant impact on the relative (when comparing industrial production growth rates between countries) at this time (Barabashev et al., 2022).

The improvement of people's overall quality of life is another objective of the digitalization effort. Digitalization changes people's interactions with the world outside of them as well as their internal environment, including how they view themselves, the world, and what it is like to be human (Kryzhanovskij et al., 2021). This is why the evolution of society faces new obstacles as a result of digitalization. In Clark's opinion (Clark et al., 2018), the pattern of interconnections and conduct are the two primary factors that determine the direction of the influence that social networks have on an individual's subjective well-being (Gajdoš and Hudec, 2020).

The concept of digital transformation has been around since the 1990s, although frequently under different names, such as "e-government" (Bellamy and Taylor, 1998); nonetheless, there has been a recent resurgence in the emphasis placed on digital. Many researchers around the world whose primary focus is on the field of public administration are turning their attention to the question of how to implement a digital transformation of public management and administration (Dunleavy and Margetts, 2015; Corydon, Ganesan and Lundqvist, 2016; Urs, 2018). When all systems are fully integrated, digital transformation creates a significant link between the public and the government (Agostino et al., 2021). Since their systems are fully integrated, this implies that information is shared across the many public administration

authorities (Androniceanu et al., 2021). Digital transformation also presents some difficulties (Viana, 2021). Concerns arise over the construction, boundaries, and applications of information technology, as well as disparities in users' levels of access to the digital space. In addition to this, there is a lack of structure, which leads to inefficiencies in the delivery of online services as well as the disconnect between these services.

According to Mergel et al. (2019), there are two main factors categories that could influence digital transformation: internal and external factors. Among internal factors, we can find management type and bureaucracy (as in terms of a large number of physical files). The principal categories of external factors that influence digital transformation are legislative, administrative, political, economic, social, technological, and environmental (Scupola and Mergel, 2022; Szeiner et al., 2022). Merge et al. (2019) study results showed that from the external factors, the ones with the highest percentages that influence digital transformation are: technological change – 34% (technology); businesses sector evolution – 17% (economic); dynamic of citizens needs – 14.9% (social); external pressure from the environment – 12.7% (all the changes in politics, legal, economic, social, technologic and environment).

In the last decades, a new narrative has emerged in tandem with the digital transition in technology, such as in artificial intelligence and machine learning (Curtis, 2019) with beneficiaries' experience, engagement, and co-creation playing a vital role in service development and implementation (Casula et al., 2020).

The digital transition in technology is associated with the application of digital technology in all areas, such as business, public administration, education, and society. Digital platforms stimulated different organizations and tasks. Digital technology under various aspects such as artificial intelligence and robotization leads to the improvement of productivity. Both organizations and individuals should adapt to this digital transition by developing digital abilities. The paper is addressed to businesses, public administrations, government bodies, and other communities that face the challenges of digital transformation.

The main variables used and the way in which the data were analyzed but also the main results of the research can be found in Section 3. We apply Principal Component Analysis for 15 chosen variables and 27 EU member states and we obtain that the first 3 Principal Components (PCs) retain 77.67% of the total variance. PC1 is called the impact of innovation on well-being and administration. PC2 represents government expenses and productivity. PC3 is called the dimension of GDP growth rate. The next step of the research was to apply the K-Means clustering algorithm to detect 4 well-separated clusters. Cluster 1 with three Nordic countries places first in this ranking, followed by cluster 3 of well-developed countries and cluster 4 of mainly emerging economies. The most digitalized countries are the Nordic countries, having the highest economic growth and relatively low productivity, while the least digitalized countries in cluster 4 such as Romania and Bulgaria had the lowest economic growth, but the highest productivity.

3 Research variables, results and discussions

The research focuses on a number of variables that affect economic growth and well-being in EU member states. The major goal of this study was to demonstrate how the EU states have changed in terms of digital transformation and how other ICT-related variables have affected the growth and prosperity of the chosen nations from 2019 to 2021. The Principal Component Analysis was utilized as a method, and the data set for this study was composed of 15 numerical indicators gathered from the World Bank and Eurostat databases. The main research variables used are centralized in Table 1. The selection of variables was made according to the three parameters involved in the research, namely digitization, economic development, and the standard of living of the population of the EU states. The main components identified facilitate both the discovery of the factors that influence digitalization and the impact that digitalization has on the economic development and well-being of the population.

Table 1. The main research variables

Variable Label	Research Variable	Source
EXPG	Expenses % of GDP	World Bank
EG	E-Government (Individuals using the internet for interaction with public authorities)	World Bank
ECOM	Enterprises with e-commerce	Eurostat
ICT	Employed ICT specialists -% of total	Eurostat
GDPG	GDP growth rate	World Bank
INTUSE	Internet use by individuals	Eurostat
PROD	Real labour productivity per person employed	Eurostat
HDI	Human Development Index	World Bank
WHI	Life Ladder Index	https://worldhappiness.report
RDE	Research and development expenditure, by sector of performance	Eurostat
HC	Human Capital	https://digital-strategy.ec.europa.eu
CON	Connectivity	https://digital-strategy.ec.europa.e
INT	Integration of digital technology	https://digital-strategy.ec.europa.eu
DIG	Digital public services	https://digital-strategy.ec.europa.eu
DESI	The Digital Economy and Society Index	https://digital-strategy.ec.europa.eu

Source: Authors's selection based on Eurostat and World Bank databases

The data set composed of 15 numerical indicators/variables collected from Eurostat and World Bank databases for 2019 and 2021 are relevant for our research and are briefly presented below.

Expenses % of GDP - The public's daily life and the media both demonstrate how in time, the GDP, progress, and even well-being eventually become synonymous. Indicators of living standards and comparative assessments of welfare typically employ the GDP (Frajman Ivković, 2016). Progress has become crucial in today's society in all areas. Progress can be broadly characterized as a desirable future condition when some beneficial developments are made. Progress has been defined differently over time. In other words, in addition to the objective, hard economic statistics, we also need subjective, soft indicators, or so-called alternative metrics, to assess success (e.g., various indicators of human progress, well-being, quality of life, happiness, etc., which consider how the public perceives things). Abdallah et al. (2009) argue that for more than 50 years, the illusion of economic development as a sign of progress predominated. The GDP has been used for many years in economics as a broad indication of development, and it is already widely regarded as a gauge of development, wealth, and even well-being. According to Michaelson et al. (2009), contemporary society is built on a development model in which greater economic output immediately raises people's standards of living and enhances their quality of life. Authors like Frajman Ivković (2016) claim that the previous major financial crisis serves as evidence that tracking and expanding economic output (measured by GDP) over time has shown to be an ineffective way of progress evaluation.

E-Government (Individuals using the internet for interaction with public authorities). E-government, according to Norris (2010), refers to the external IT applications for a range of tasks and activities, including government to citizen, government to business, and government to government interactions. The provision of government information and services is a common definition of e-government. 365 days a year, seven days a week, and around the clock via the Internet, transcending distance and time (Msosa et al., 2022; Moon and Norris, 2005; Moon, 2002).

Enterprises with e-commerce refer to businesses that sell to overseas markets online (EU or rest of the world), businesses that conduct online sales through their own websites or applications, and even businesses that sell online through e-commerce platforms. On Eurostat (n.d.) e-commerce is broadly described as the exchange of products or services electronically using the internet or other computer-mediated (online communication) networks between businesses, households, people, or private organizations. Although the payment and the actual delivery of the ordered goods or services may take place online or offline, the phrase refers to placing orders for them via computer networks (Altounjyet al., 2020).

Employed ICT specialists -% of the total. The study focuses on the human capital component of DESI, particularly on employed ICT professionals and the labor force's digital capabilities (percent of total employment). Herman

(2020) points out in her study that in Romania as well as the rest of the EU, demand for ICT specialists in the labor market increased between 2008 and 2018. Both in terms of the employment of ICT professionals as a percentage of the entire labor force and the rate at which this percentage is increasing, Romania lags behind the EU significantly. Despite recent good trends, the employment potential of specialized ICT skills is still underutilized given that by 2020, the EU was projected to have a growing shortage of ICT specialists (European Commission, 2017; Herman, 2020).

GDP growth rate. Di Telia et al. (2003) examined how macroeconomic factors affected happiness. The authors discover evidence that, between 1975 and 1992, national happiness in Europe was influenced by both GDP level and GDP change. The impact of GDP growth on life satisfaction is consistent with theories of adaptation, which contend that the advantages of more income diminish over time (Perovic and Golem 2010). In addition, inflation, the unemployment rate and a measure of the welfare state's generosity are included by Di Telia et al. (2003); all of these variables are found to be significant at normal levels and to exhibit the predicted signals.

Internet use by individuals. Those without access to the internet could suffer economic disadvantages as it becomes a more vital instrument in our lives. The effect of ICT investment on economic performance appears to vary. According to Roller and Waverman (2001), a critical level of telecommunications infrastructure results in rising returns on growth. Their research focuses on the role of telecommunication in economic growth. Their findings suggest that wealthy nations with adequate telecommunications infrastructure may have greater growth effects than emerging nations.

Real labour productivity per person employed. Goschin (2014) showed that in both of the researchers' built models, labor force and capital are substantial and positively influencing elements for macroeconomic growth. Real labor productivity per employed person is an important variable that reflects the quality and structure of the workforce in the second model Goschin (2014) developed. These variables have the anticipated favorable effect on GDP growth. Other researchers, like Bloom, Canning, and Sevilla (2004), affirm in their study that a healthier population may produce more through increased labor productivity as well as capital accumulation. In addition to demonstrating how inputs and technologies impact output, a fully developed model of economic growth would also demonstrate how inputs' growth rates and productivity are established. According to Caran et al. (2016), Romania's labor productivity per employee reached a very high level, significantly higher than the EU average, during the crucial years between 2002 and 2004, when increases in labor productivity of 17.0 percent and 10.3 percent had a big impact on economic growth.

Human Development Index. According to Blanchflower and Oswald (2006) one of the most well-known attempts to shift away from an exclusive focus on GDP is the Human Development Index (HDI). Despite the work put into this index, there is a strong correlation between HDI and GDP, which means that,

for purposes of international comparison, the index does not provide any additional information beyond what we would have learned from GDP rankings (Perovic and Golem 2010]. Additionally, as Blanchflower and Oswald (2006) point out, the HDI does not accurately reflect a person's psychological condition. There must be some indication of subjective well-being, or happiness.

Life Ladder Index. In terms of GDP per capita, life ladder elasticity has a positive sign and a statistical meaning; the effect is reliable and significant as a factor having an impact on the economy. So, at a 1 percent growth in GDP, the life ladder would rise (cumulatively) by an average of 0.829 percent (Ciorbagiu and Stoica, 2020). But how might the relationship be explained: a higher degree of happiness is correlated with a higher level of personal income. With such money, people have greater access to a fulfilling social life, better services for maintaining or restoring their bodily and mental health, and ultimately, greater well-being.

Research and development expenditure, by sector of performance. Researchers and policymakers who view investing in knowledge as a prerequisite for reaching a high growth rate have given specific focus to the function of research and development (R&D). The new growth paradigm emphasizes the significance of knowledge as the primary force behind economic expansion. The evolutionary approach, which views technology as the primary source of economic growth, and the endogenous growth theory, which interprets technological advancement as a byproduct of economic activity, are the two key components of the new growth theory. The world's living standards are rising as a result of investment in R&D and innovation, especially in industrialized nations where innovation is more heavily funded and new technology is adopted more swiftly (Morina, 2019). Pop Silaghi et al. (2014) investigated how R&D spending affected performance by sector. They come to the conclusion that while private R&D spending promotes economic growth, public R&D spending plays minimal influence. In order to promote innovative activity in businesses and through direct spending on education and training, the government should enact policies like tax credits and subsidies. Additionally, the government would offer incentives to businesses that presented extraordinary innovations and fresh concepts. On the other hand, Szarowská (2016) finds that government R&D spending is the primary engine of economic growth after examining the impact of R&D in 20 EU nations over the years 1995–2013.

The Digital Economy and Society Index. According to European Commission (2019) the EU countries' advancement toward a digital economy and society are using the Digital Economy and Society Index (DESI) in order to measure it. This composite index includes the following five key aspects of the digital economy and society: **connection** (connectivity), **human capital, internet use, digital technology integration,** and **digital government services.** The present research analyzed in-depth the five sub-indicators briefly presented above, which are components of DESI.

In order to reduce data dimensionality, we apply Principal Component Analysis (PCA) (Kassambara, 2017; Jolliffe, 2002) as a dimensionality reduction tech-

nique that transforms the variables of a dataset organized in columns into a set of new features called Principal Components. Organizing the information on PCs, the data dimensionality is reduced without losing much information. PCs are new uncorrelated variables constructed as linear combinations of the initial variables. In summary, PCA consists of the following steps. After data scaling, we compute the eigenvalues and the eigenvectors of the covariance matrix. Applying various criteria for retaining a certain number of PCs, we will identify the PCs in order of significance, such that the first PC accounts for the highest variance in the dataset. The second PC will capture the next highest variance, etc. In the last step, the data are oriented to the axes represented by the PCs.

In our case, we compute first the eigenvalues which quantify the amount of variation retained by each principal component (PC), as can be seen in Table 2.

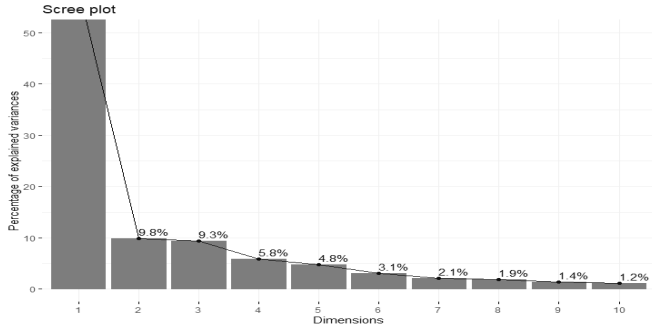
Table 2. Eigenvalues and the cumulative variance

	eigenvalue	variance.percent	cumulative.variance.percent
Dim.1	9.357073235	58.48170772	58.48171
Dim.2	1.575720900	9.84825563	68.32996
Dim.3	1.495005523	9.34378452	77.67375
Dim.4	0.932811398	5.83007124	83.50382
Dim.5	0.769851798	4.81157374	88.31539
Dim.6	0.491540331	3.07212707	91.38752
Dim.7	0.335977619	2.09986012	93.48738
Dim.8	0.300057547	1.87535967	95.36274
Dim.9	0.226449480	1.41530925	96.77805
Dim.10	0.187224098	1.17015061	97.94820
Dim.11	0.138793784	0.86746115	98.81566
Dim.12	0.074361881	0.46476176	99.28042
Dim.13	0.062507196	0.39066997	99.67109
Dim.14	0.029025716	0.18141073	99.85250
Dim.15	0.021982600	0.13739125	99.98989
Dim.16	0.001616893	0.01010558	100.00000

Source: Authors's own computation

The sum of eigenvalues gives a variance equal to 10. The second column contains the variation explained by the eigenvalues. The first eigenvalue explains 58.48% of the total variance. In the third column is shown the cumulative variation. The first 3 PCs explain together 77.67% of the total variance, applying Kaiser's rule. According to the principle of the proportion of variance explained, we will retain the first 3 PCs. The same conclusion is drawn by the scree plot presented in Figure 1.

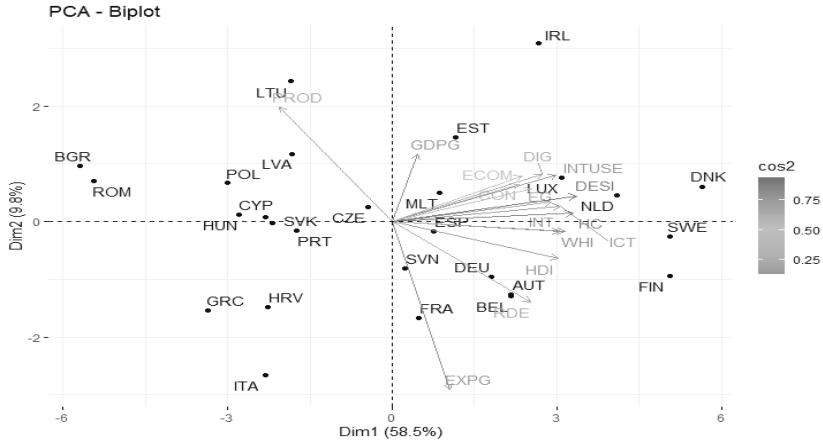
Figure 1. Scree plot explained by principal components



Source: Authors's own determination

Next, we discuss the variables according to their quality of representation on the factor map and their contributions to PCs. The particularities of variables in the EU countries are reflected in figure 2. The biplot (Greenacre, 2010) is a plot that contains information on the observations and variables simultaneously. On a biplot one can notice the relations between variables, the distances between observations according to their similarities and the inner products between observations and variables. The correlations of variables can be seen on the factor map below. Positively correlated variables are grouped together. Negatively correlated variables are positioned in the opposed quadrants.

Figure 2. PCA biplot with countries and variables



Source: Authors's own determination

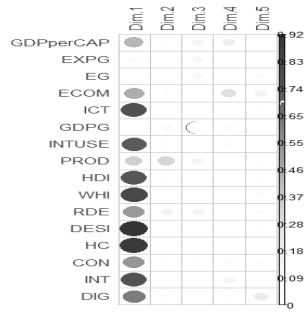
All variables are situated far away from the origin; therefore, they have a good representation on the factor map. High cos2 values indicate strong correlations between variables and PCs. Variables with high values of cos2 are situated close to the circumference of the correlation circle. Smaller values of cos2 correspond to variables closer to the center of the circle.

In Figure 2, variables with middle values of cos2 are:: PROD, ECOM, DIG, CON, and RDE. Variables with low values of cos2 are represented by GDPG. The remaining variables have high values of cos2. The biplot summarizes the determinants of the first two dimensions. Countries like Estonia, Denmark, Sweden, Finland, France, Belgium, Austria, Germany, Slovenia, Spain, Luxembourg, Malta and Netherlands have as strong determinants: GDPG, ECOM, DIG, INTUSE, DESI, INT, EXPG, HDI, WHI, CON, EG and RDE. On the opposite pole are Romania, Bulgaria, Poland, Hungary, Croatia, Greece, Czech Republic, Latvia, Slovakia, Cyprus, Portugal, and Italy. The location of countries in Figure 2 proved that the countries situated in the right quadrant are mainly developed economies that had to accelerate economic growth and fast digitalization. As a consequence, the Human Development Index and the Life Ladder Index, which are equivalent to the happiness indicator, have higher values. In developed economies, situated in the right quadrant, a quick process of digitization leads to economic growth.

On the left quadrant in Figure 2 lie mainly emerging economies, which are more export-oriented and whose benefits from digitization come more from employment than from economic development.

In Figure 3 Cos2 (square cosine) gives the quality of variable representation on the factor map. The square cosines of variables on the first 5 PCs are represented in Figure 3.

Figure 3. The cos2 of variables on the first 5 PCs



Source: Authors's own determination

The three dimensions are not correlated. The first dimension is dominated by EG, ICT, INTUSE, HDI, WHI, DESI, HC and INT. It means that the first dimesion will be called the impact of innovation on well-being and administration. The second dimension is characterized by government expenses EXPG and productivity PROD. On the biplot in Figure 2, government expenses and productivity point out in opposite directions, meaning that they are negatively correlated: when government expenses are relatively high, productivity is relatively low. Finally, the third dimension is dominated by GDP growth rate. It means that digitalization will have implications for technological progress in other areas. Policymakers should create digitization strategies for the sectors in which the impact of digitization is not seen yet. At the same time, policy-

makers should encourage consumers, industries, and public administration to use digital services on a larger scale.

The next step of the research is to apply K-Means clustering algorithm (MacQueen, 1967) to detect 4 well separated clusters. K-means algorithm is a clustering technique which groups the objects of a dataset into k similar clusters. The steps of the K-means algorithm are the following:

k points called means are randomly initialized.

Each object in the dataset is assigned to the closest mean and the mean's coordinates are updated as the averages of the objects in that cluster.

The process is repeated for a given number of iterations.

In our case, the composition of the four clusters is the following:

Cluster 1: Croatia, Italy

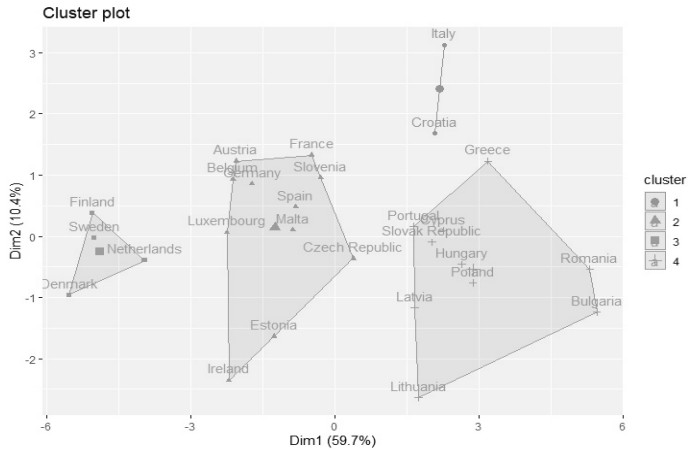
Cluster 2: Austria, Belgium, Czech Republic, Estonia, France, Germany, Ireland, Luxembourg, Malta, Slovenia, Spain

Cluster 3: Denmark, Finland, Netherlands, Sweden

Cluster 4: Bulgaria, Cyprus, Greece, Hungary, Latvia, Lithuania, Poland, Portugal, Romania, Slovak Republic

Figure 4 reveals a good separation of the four clusters in a plane whose axes are the first two principal components.

Figure 4. Cluster Plot



Source: Authors's own determination

Table 3 contains the cluster means after data scaling. The countries in cluster 3, mainly Nordic countries, have the highest governmental expenditure, e-government level, the highest number of enterprises with e-commerce, ICT specialists, and all indicators related to digitalization, but lower productivity,

and are the happiest countries at the same time. The positive impact of digital technologies on happiness is analyzed by Mochón (2018), which believes that by a global and open communication of information, breaking down barriers and creating social networks, digital life improves well-being.

Table 3. Cluster Means

Cluster	EXPG	EG	ECOM	ICT	GDPG	INTUSE	PROD	
1	0.702	-1.457	-0.356	-0.616	-2.20	-1.322	-0.837	
2	-0.058	0.239	0.325	0.344	-0.286	-0.427	-0.410	
3	0.798	1.486	1.082	1.535	0.873	1.157	-0.645	
4	-0.395	-0.566	-0.719	-0.869	0.406	-0.668	0.877	

Cluster	HDI	WHI	RDE	HC	CON	INT	DIG	DESI
1	-0.56	-0.803	-0.434	-0.783	-0.827	0.156	-0.666	-0.6
2	-0.543	0.387	0.304	0.32	0.23	0.27	0.432	0.377
3	1.172	1.5	1.278	1.667	1.392	1.58	0.971	1.562
4	-0.955	-0.865	-0.759	-0.862	-0.644	-0.96	-0.731	-0.919

Source: Authors's own determination

As a result, the countries in cluster 3 also have the highest DESI index. Cluster 2 which contains the most developed economies ranks second in terms of the number of enterprises with e-commerce, e-government digitalization, the number of ICT specialists, digital public services, happiness indicators, and the DESI index. Cluster 1 ranks third with respect to the majority of indicators and the DESI index. The last position in this ranking is occupied by the countries in cluster 4, where Romania and Bulgaria are placed. According to Figure 4 and Table 3 and taking into account the above remark that government expenses and productivity are negatively correlated, one can notice the relatively low productivity in clusters 1, 2, and 3, and relatively high productivity in cluster 4; and the relatively low economic growth in clusters 1 and 2, and relatively high economic growth specifically in cluster 3, but also in cluster 4. This implies that the most digitalized Nordic countries included in cluster 3 had the highest economic growth, but low productivity, while the least digitalized countries of cluster 4 (including e.g., Romania and Bulgaria) had the lowest economic growth, but the highest productivity.

4 Conclusions

In this paper, we applied Principal Component Analysis to study the panel of 27 EU member states and 15 variables as a simplified structure of three principal components, which explain together 77.67% of the original variance. The first dimension is dominated by e-government, the percent of ICT specialists in total, internet use by individuals, Human Development Index, Digitalization

Index, Happiness Indicator, Human Capital and integration of digital technology (Georgescu et al., 2020). It means that the first direction will be called the impact of innovation on well-being and administration. The second dimension is dominated by government expenses and productivity, which are negatively correlated. Finally, the third dimension is dominated by GDP growth rate. The combination of these indicators influencing the first PC measures the short-term effects of digitalization on public administration.

Another part of the research is dedicated to a clustering of the EU countries in 4 clusters by means of K-Means clustering algorithm. All four clusters are well determined, with a ranking in which cluster 1 which contains three Nordic countries places on top, followed by cluster 3 of well-developed countries, and cluster 4 of mainly emerging economies. The most digitalized countries are the Nordic countries, placed in cluster 3, having the highest economic growth and relatively low productivity, while the least digitalized countries in cluster 4 such as Romania and Bulgaria had the lowest economic growth, but the highest productivity.

The short research period does not allow identifying long-run effects and it can be viewed as a limitation of the study. While the effectiveness of digitalization specifically on economic growth and productivity can be hard to show in such a short research period, 2019-2021, the correlation between digitalization and well-being can be easily seen. In future research, we propose to extend the analysis period and increase the number of research variables

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