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PUBLIC ADMINISTRATION DIGITALIZATION AND GOVERNMENT EFFECTIVENESS IN THE EU COUNTRIES

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ABSTRACT

Purpose: This study continues the series of previous research carried out by the authors on digital transformation in the EU countries. It aims to identify and analyse the progress made by EU administrations in terms of digitization and effective governance in the period 2019–2021.

Design/methodology/approach: Based on selected variables from Eurostat and the World Bank databases, the article provides insights into the dynamic changes that occurred in the EU in the period under consideration. The research employs Principal Component Analysis (PCA) and K-means clustering as the primary research methods to analyse the variations and correlations among 10 numerical variables selected from Eurostat and World Bank databases.

Findings and Practical Implications: The results obtained through PCA show the impact of digitalization on government effectiveness. A comprehensive analysis of government effectiveness has been conducted using PCA, which reveals that the first two principal components account for 77.05% of the initial variance. A K-means clustering with four clusters reveals that the most significant and noteworthy increase in digitalization and government effectiveness in the EU is achieved by the Nordic countries, which exhibit high levels of digitalization and government efficiency.

Originality: In this ranking, clusters 2 and 3 comprise well-developed countries with a positive relation between governmental digitalization and efficiency, while cluster 4 consists of emerging countries where the correlation between digitization and governmental efficiency is low or very low, which is primarily attributed to the limited degree of digitization within government institutions.

Keywords: *public administration, digitalization, digital transformation, government effectiveness, principal component analysis*

JEL: I28, I38

1 INTRODUCTION

Digitalization and digital transformation reduce bureaucracy and increase citizens' access to public services, offering better transparency to documents, activities, and internal processes (Strafford & Schindlinger, 2019). The main objective of digitalization and digital transformation is to contribute to a profound change in a state's public administration, economy, and society. Digitalization and digital transformation also contribute to increased performance and efficiency in the public sector.

Studies show that European countries have different speeds in their digital transformation process. The research that is the subject of this paper is based on an analysis using a set of variables that highlight the differences between the EU states grouped in representative clusters, which reflect the influence of digitization and digital transformation on governance effectiveness.

The digital transformation of public processes and services requires public investments in infrastructure and equipment, but it makes the work of officials more efficient and faster and significantly influences the quality of public services for citizens and businesses. During the digital transformation process, a wide variety of cumbersome bureaucratic administrative procedures are replaced by simple digital applications. Repetitive and bureaucratic administrative procedures carried out manually are replaced by simplified digital operations that are particularly accessible and easy.

By using computer applications that centralize electronic documents, data, and information in different databases with simultaneous access, communication is more efficient, decisions are made more easily and public services are provided more quickly. In the European states where the digitization and digital transformation process started a few decades ago, civil servants and citizens are using successfully information technologies and digital tools to communicate and solve their internal problems or those of the citizens (European Union, 2019).

Digital technologies enable innovation and keep public administrations adaptable and fit for purpose, contributing to major improvements in the govern-

ment's effectiveness by offering innovative solutions for delivering public services to citizens and the business environment (European Commission, 2020).

"Digital first" is the principle according to which some public administrations in the EU states design their policies and strategies. A unified approach at the national level regarding the reuse of public data can help the public administration to deliver better quality services for citizens and private companies. Public administration can use the existing data to support an effective decision-making process in key strategic areas of the public sector. At the same time, administrations produce the necessary data and infrastructure to facilitate the reuse of data by public and private sector organizations to increase economic competitiveness.

State administrations have the role of driving the demand for digital technologies, and promoting confidence in the use of new technologies in providing public services and government effectiveness (Bratu, 2019). New applications such as artificial intelligence and big data are integrated into different activities already (Mura and Machyniak, 2014; Harrover, 2019; Kovacova et al., 2019; Ionescu, 2019).

Digitalization and digital transformation influence the effectiveness of governments in their process of correct management of public money to meet the needs of citizens and economic agents.

Digital transformation of government activities is a real way to increase government efficiency and effectiveness. In general, efficiency is correlated with rentability and productivity, being the expression of the relationship between the results recorded and the resources introduced into the public system. In other words, efficiency consists in maximizing outputs or results by using the minimum of inputs or resources. The effectiveness of government means the capability of it to deliver expected outputs. However, there was a wide debate that sometimes has created confusion about good governance and government efficiency and effectiveness (Koivisto, 2014). The conceptual confusion can also be increased due to other expressions that have delimited different debates, such as democratic governance, multi-level governance, new governance, good governance, effective governance, administrative justice, global governance, global administrative law, new public management and similar others (Rhodes, 1996). The different theoretical, historical and contextual roots of all these expressions can be brought to the same common denominator, namely: they can all be arguments to refer to government effectiveness. In our research, we refer to government effectiveness in the EU states, reflected by several relevant indicators: government effectiveness index, digital economy, and society index and total government expenditure (European Commission, 2021). The variables selected for this research contribute to the knowledge of the effects of digitalization and digital transformation in the administrations of the EU states. The correlations identified and analysed, as well as the grouping of the EU member states into clusters according to government effectiveness, show the effectiveness of government decisions and policies in the EU states recorded in recent years. Practi-

cally, the considered variables measure not only the digital dimension of the changes but also their intensity and effectiveness reflected by the correlations between the research variables.

The governments of democratic states need information regarding the measurement and evaluation of the economy and the effectiveness of the programs or activities carried out in order to adopt decisions and measures that contribute to the improvement of government performance. If the objectives of a government were not met or were partially met, the causes that generated this situation should be identified and at the same time, recommendations should be formulated. Government effectiveness can be known following a process of monitoring, evaluation, and reporting of the way in which the objectives assumed by the government institutions at the central, regional, or local level of a country are achieved. The monitoring process must be continuous. Thus, deviations and causes can be identified, which determine concrete changes necessary to increase government effectiveness. Governmental effectiveness can be the result of the effective development of the activities and processes brought together in the fields of activity of government institutions. Therefore, it becomes necessary to evaluate the efficiency and effectiveness of the subfields, activities, and necessary processes carried out by the state governments. The scholars (Kaufmann et al., 1999, 2011; Korvisto, 2014) propose the development of specialized audits by governmental fields and activities. The evaluation of the performance of programs and activities should be done to determine the impact of government decisions. In the evaluation process of programs and activities, a wide range of data and information regarding their performance are examined. The efficiency of the monitoring, evaluation, and change processes is reflected in governmental efficiency and effectiveness, which can increase if the internal evaluation mechanisms along the way work efficiently and governments can make the necessary changes during the governance process (Rosenbloom, 2014). In this research, the correlations between the governmental effectiveness of the EU states in the digital transformation process were analysed. Our research results show the impact of digital transformation on government effectiveness in the EU states grouped into four relevant clusters.

In this research, the correlations between digitization and efficient governance in the EU states were analysed. In the research process that is the basis of this work, the correlation between the digitization of institutions in the administrations of European states and their governmental effectiveness reflected by ten specific variables selected from international databases were analysed.

Next, the paper contains a literature overview. Then, the paper continues with the presentation of the variables included in the research and methodological frame. The following sections contain Principal Component Analysis (PCA) and K-means clustering, obtaining correlations that show that digitization has positively and significantly influenced government efficiency in most EU states. The cluster analysis facilitated the grouping of the EU states according to the intensity of the correlations between the variables that reflect digitiza-

tion and those that reflect government efficiency. The data analysis revealed that a cluster of Nordic countries was placed on top, followed by a cluster of well-developed countries and two clusters of emerging states. Then, some of their most important and significant elements of impact in 2021-2022 are presented. The last part of this work contains the main conclusions and contributions to the specialized literature.

2 LITERATURE OVERVIEW

In most EU member states, there has been an extremely rapid increase of the digital transformation processes. Four strategic axes were identified for the digital transformation of public services for the citizens and the private sector (Rymarczyk, 2021). These four strategic axes are: (1) digital public administration that consists of a process of digital transformation of public administration to that of smart government; (2) digital economy through the digital transformation of economies, in general and of small and medium-sized companies; (3) digital education through the digital transformation of the educational process through the transversal inclusion of technology in all educational processes (Stoyanova et al., 2022), but especially through the implementation of policies to acquire/increase/improve digital skills at the level of the entire population; (4) digital society meaning that citizens are leaving in a new digital social frame based on a variety of accessibilities both for work and different public services like health, social assistance, public transport, relaxation, and recreation (Lindgren et al., 2019). The implementation of these strategic changes is carried out on four levels of representation: digital infrastructure (level 1); hardware and software digital tools (level 2); digital competencies and skills (level 3); digital ecosystems (level 4 – companies, public institutions and citizens). The four strategic axes and levels reflect the fact that digital transformation is a process that requires a systemic and integrated approach, which includes the economy, administration and society as a whole (Abraham et al., 2020; Berman, 2012). The reduction of digital transformations in one or another of these areas can significantly influence the efficiency of the whole process. If in the economic fields, and especially in the business field, the effects of investments in the implementation of digital transformations have already demonstrated efficiency and effectiveness, in the fields of administration and public services, the digital transformation continues at an accelerated speed. The researchers (Avram, 2020; Novak et al., 2018) show that there are correlations and gaps between the three categories of digital transformations (economic, administrative, and social) in different states, mainly due to government strategies and investment policies that differ in content (Drechsler, 2022; Demir, 2022). In these areas, the major challenge that the government assumes, is to overcome in the next 4 years several stages of the digital transformation of government and public administration, so that it acts based on the principles of smart government characterized by the administration based on data (data-centric) and able to use analytical and predictive tools such as artificial intelligence and data mining (Yigitcanlar et al., 2021; Shank et al., 2019). Government effectiveness can be influenced by the

speed with which digital transformations take place, and in turn, it can influence the speed with which digital changes occur in the economy, administration and society. This perspective is analyzed in the research that is the basis of this work. Our objective is to demonstrate that government effectiveness is significantly influenced by digital transformations in state administrations and contributes to the delivery of better public services (Demircioglu, 2017). For this, we considered a set of specific variables, including the public expenditures made by the governments of the European states, which means total costs that also include the specific costs necessary for digital changes in administration and society. Practically, the ability of the governments of the member states to effectively manage the digital transformations in the administration in order to be able to offer better administrative and social services means governmental effectiveness, which is one of our key variables.

Digital transformation involves the use of digital technologies and data to change the way of working and interaction between public administration stakeholders (Dunleavy et al., 2006). Examples of digitalization projects include automating processes or training human resources to use new technologies in the work environment. To consider that digitalization, in the sense described above, is sufficient to ensure the transition to a digital society is a strategic error (Kitchin, 2014). In the field of e-government, for example, a few states stop at digitization meaning downloading forms from the Internet or digitalization by filling in these forms online, instead of making the transition to a full digital transformation by moving services of e-government in the digital environment (Șandor et al., 2020; Munoz & Bolivar, 2018; Mura & Vlacseková, 2018).

Digital transformation is progressing in the UE member states (Micheli et al., 2018). Studies (Szostak, 2022; Taburchak et al., 2022; Craglia et al., 2018) in the field highlight the fact that Estonia is globally recognized as the most digitalized country in the world, with a rate of digitization of interactions between the state and citizens of 99% (Sabatini et al., 2022; Stępień & Światowiec-Szczepańska, 2022). Estonia is a country where the only non-digital interactions citizens have with state officials are at marriage or divorce. All this is due to a digitization process developed over the last 20 years. From a statistical point of view, 98% of Estonian citizens have an identity card based on which they can access 99% of the services the state provides, such as online voting. In other words, for the release of any document needed by citizens from the Estonian state, they use the method of online requests or even reduce to an agreement for public institutions to collaborate and access their information from each other's archives, without having to circulate any paper from side to side. The various types of data that can circulate in the network of state databases can be stored in only one of them, by one of the agencies responsible for example for personal data of citizens, land, or taxes, and can be accessed by other agencies only with the consent of the citizen and the institution holding the information. Each public institution has its own database, created according to the interactions it has had with certain citizens. Public institutions access an interface to communicate with a national network of databases (Micheli et al., 2020). In recent years, Estonia's digital system has

expanded to collaborate with other countries such as Finland, Portugal, and Croatia, especially for the interoperability of prescriptions received by citizens of any of these countries. For example, a drug prescription received by an Estonian is also valid at a pharmacy in Portugal, if the Estonian is in its territory. Contrary to expectations, interacting with digital services is not difficult at all. Each person has a digital ID card and even a mobile ID with the same functions.

Specialists (Sun et al., 2022) consider that the main risk of digitization is data security. Regarding this, the Estonian authorities have ensured the existence of a "digital embassy", outside the country, a huge archive in which the entire national network is regularly backed up. Data stored in this "digital embassy" in Luxembourg can be safely accessed even when possible problems arise with the network and databases in Estonia. The digital system in this country is accessible and efficient. Statistical data show that the digitization of the administration and de-bureaucratization saves almost 2% of the GDP (European Commission, 2021b). In addition, each citizen saves time with each necessary document that they issue online, instead of going to a counter, saving annually, at the country level, approximately 1345 years of work, collected at the level of all citizens (International Labour Organization, 2022).

Another example of successful digital applications for public administration works in France. Statistics show that in recent years the French government has announced that it has decided to adopt and use the Office package from Microsoft 365 at the national level, as well as several services with Microsoft Azure. However, they will not be delivered from the Data Centers that Microsoft has in 13 European countries - Austria, Denmark, France, Germany, Greece, Ireland, Italy, the Netherlands, Norway, Poland, Spain, Sweden and Switzerland - but from centers owned and operated by French companies.

Similarly, in Germany, to comply with the federal government's "Cloud Sovereignty" requirements, Microsoft has proposed a model whereby the ownership and management of the cloud platform rest with the companies that own and manage the data centers from which they are delivered. Analysts estimate that the German and French models can be replicated by other countries (Kohler & Weisz, 2018). Thus, the Cloud services delivered by Microsoft could become the de facto standard in the field of public administration in the EU. Most EU states have not stopped at digitalization. They continued the process of digital transformations. First, it requires a new cultural orientation that emphasizes challenging the status quo and continually testing the best solutions. Also, digital transformation is characterized by customer/beneficiary-oriented organizational changes, supported by leadership and driven by significant challenges from the environment. Digitalization and digital transformation need a legislative framework and a governance framework for digital public services, where relevant actors can collaborate and co-create solutions with other private partners, such as citizens, and the academic or business sector.

Proponents of governance for the digital age of public services refer to two characteristics that must be found in the provision of digital public services. The authors of this governance model (UNDP, 1997) do not support the idea of

the supremacy of technology in administration but use it as a means for reorganization and for encouraging the participation of citizens in the co-creation of public policies. In fact, they emphasize the need for a fundamentally different way of organizing the processes in the administration that will lead to the rethinking of services from the perspective of the needs of citizens, but also to the elimination of redundant processes from the old administrative culture. Two of the principles enunciated by them are also found in European public policy documents, namely Government as a Platform (GaaP) and the once-only principle. If once only refers to the reintegration of services, GaaP refers to the creation of a broad, national integrated framework of digital services.

Faced with such challenges, the city halls of the Member States saw the concept of a "smart city" as way to use technology for a better life for citizens in cities and municipalities (Calzada, 2017). Unfortunately, in the rush for technological progress, city halls have lost sight of the desire to improve citizens' experience with the city, and technology has become an end in itself, not a means, as it was intended (Eom et al., 2016; Howell & Higgins,1990). So, in a short time, the expensive investments in smart traffic lights, for example, were outclassed by Waze-type applications or other alternative urban mobility applications (Gutschow, 2019; Lee et al., 2019; Torugsa & Arundel, 2016). By the same token, parks with free Wi-Fi have proven difficult to maintain in a cyber-insecure area, and the examples can go on (Meijer & Thaens, 2021; Barabashev et al., 2022). Town halls in EU states collect and hold significant volumes of data. Even so, in some EU states, including Romania, these volumes are reduced in relation to what a city could obtain and use (Avram, 2020; Șandor et al., 2020). Regardless of the stage of digital transformation in the local administrations of the EU states, public investments in data infrastructure and their best possible analysis and decision-making capacity are essential (Pollitt & Bouckaert, 2011; Margetts, 2009).

According to the European Framework of Competences (DigiComp), there are 21 competencies grouped into five key categories necessary for the digitization of public administrations in the EU states.

Therefore, digitalization has a major impact both on public administration, the economy, and the well-being of citizens in general (Androniceanu A-M. et al., 2020). In a previous paper (Androniceanu et al., 2022) we studied the impact of digitalization on public administration, economic development and well-being in EU countries during 2019-2021, by Principal Component Analysis and cluster analysis. Digitalization is influencing the efficiency of public administration. The origins of effective governance and modern good governance lie in the structural adjustment and development support programs of the late 1980s. For the first time, the World Bank called crises in sub-Saharan Africa governance crises (World Bank, 1992). As it follows from the official documents of several international organizations, International Monetary Fund, United Nations Development Programme and the World Bank (1997) initially good governance was focused on solving the problems generated by the poor functioning of economic mechanisms (Privara, 2022). Later, the con-

cept also extended to political and public administration aspects (Duong et al., 2022). Therefore, the key aspects of good governance can be expressed as follows: a predictable and transparent policy and administration, an ethical and socially responsible government, a strong civil society involved in the management of public institutions, the existence of a rule of law, respect for democracy and human right, a functioning market economy (Androniceanu, 2019). A trans-disciplinary approach to the concept and practices of good governance can ensure a better understanding from a multi-disciplinary perspective. Also, such an approach can provide a better understanding of the challenges involved in identifying good governance solutions. Thus, we can have a better analysis and appreciate good governance practices (Chottray & Stoker, 2009, p. 214). Chottray and Stoker argue that the cross-disciplinary approach to good governance can be achieved through an investigative approach rather than drawing up a list of normative principles against which the system is checked. Governmental efficiency is directly dependent on the ability of public institutions to manage resources to solve social problems (Trettin et al., 2019). Policies and public services cannot be reformed and delivered efficiently without someone thinking about them, applying them, and solving them. The link between the effective functioning of governments and digitization depends on good governance and is reflected in government efficiency. Over time, EU governments have focused their resources on governance as a key factor that reflects variations in government efficiency. Thus, in the World Bank Report on Governance and Development, from 1997, governance means that the government deal with the national resources for effective development (World Bank, 1997). Later, in 2007, the definition of effective governance also included the way in which public officials and institutions provide public goods and services (World Bank, 2007). Specific indicators were developed by UNDP (1997) through which good governance and its impact on government efficiency could be evaluated. However, there is a growing demand for a wider range of indicators, with some countries even calling for newer or better good governance laws (Trapnell, 2011).

3 RESEARCH VARIABLES AND METHODOLOGICAL FRAME

In this section, the main variables together with the methodological frame are discussed. The selected variables have been chosen with respect to the purpose of the analysis, to analyse the progress towards digitization and effective governance that the administrations of the EU states have made during 2021-2022. By applying Principal Component Analysis and K-means clustering, we also examine the digital divide existing in the public administrations of EU countries. The combination of variables also used in previous research (Georgescu et al., 2023; Georgescu and Kinnunen, 2021) is important in revealing regions or countries with similar digital inequality and similar levels of government effectiveness. Also, the data were collected according to the three pillars of this research: digitalization, government effectiveness, and public administration infrastructure. The main research variables used are presented in Table 1.

Table 1. The main research variables

Variable	Variable Label	Measurement Unit	Source
OSI	Online services index	percentage	publicadministration.un.org
GEF	Government effectiveness index	[-2.5 weak; 2.5 strong]	www.maxinomics.com
EGDI	E-Government index	[0,1]	publicadministration.un.org
GOVEX	Total general government expenditure	percentage of GDP	Eurostat
ICT	Employed ICT specialists - total	percentage	Eurostat
IT	Internet use by individuals	percentage	Eurostat
CON	Connectivity	[0,100]	https://digital-strategy.ec.europa.e
INT	Integration of digital technology	[0,100]	https://digital-strategy.ec.europa.eu
DPS	Digital public services	[0,100]	https://digital-strategy.ec.europa.eu
DESI	The Digital Economy and Society Index	[0,100]	https://digital-strategy.ec.europa.eu

Source: Our selection is based on various databases

The data set composed of 10 numerical variables was gathered from various databases for 2021 and 2022. PCA is a data reduction technique used to analyze highly dimensional datasets (Kassambara, 2017; Jolliffe, 2002). By a linear transformation, the initial data are transformed into fewer variables called principal components (PCs) which retain the maximum amount of information. The steps of PCA are the following:

1. Data standardization.
2. Computing the covariance matrix of the dataset.
3. Obtaining the eigendecomposition according to the covariance matrix.
4. Ranking the eigenvalues decreasingly.
5. Selecting the first k PCs.
6. Determination of the k-dimensional feature space.

Each PC retains a certain amount of variation represented by the eigenvalues, as seen in Table 2.

Table 2. Eigenvalues and the cumulative variance

	eigenvalue	variance.percent	cumulative.variance.percent
Dim.1	6.443949348	64.43949348	64.43949
Dim.2	1.261979872	12.61979872	77.05929
Dim.3	0.764402005	7.64402005	84.70331
Dim.4	0.566058990	5.66058990	90.36390
Dim.5	0.376224450	3.76224450	94.12615
Dim.6	0.266089177	2.66089177	96.78704
Dim.7	0.170827992	1.70827992	98.49532
Dim.8	0.091834883	0.91834883	99.41367
Dim.9	0.052638937	0.52638937	99.94006
Dim.10	0.005994345	0.05994345	100.00000

Source: Authors own computation

The first column of Table 2 displays the variation represented by the eigenvalues. Eigenvalues and eigenvectors are computed from the covariance matrix to determine the PCs. The eigenvectors are the directions of axes (PCs) while the eigenvalues are the variances captured by PCs. The other columns of Table 2 represent the individual variance and the cumulative variance associated with each dimension.

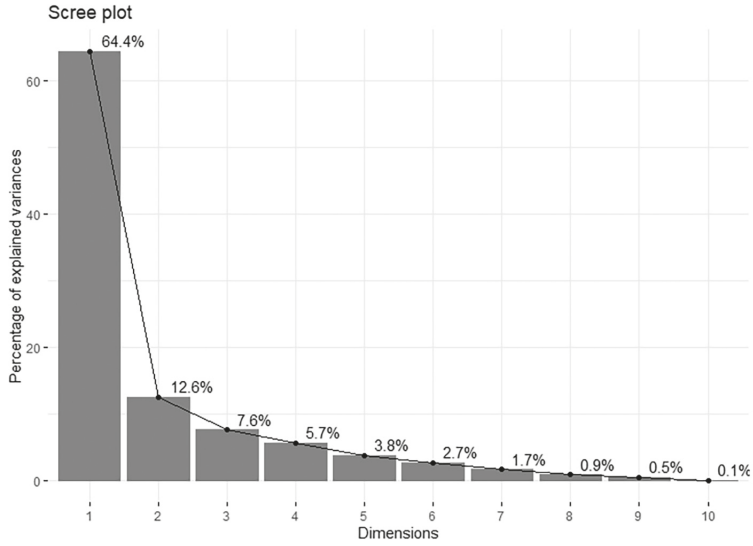
After the PCA application, the analysis continues with K-Means clustering (MacQueen, 1967) in Section 3. K-means clustering is one of the most efficient clustering techniques. The distance between the objects is the Euclidean distance and the cluster scatter is measured by variance.

4 RESEARCH RESULTS AND DISCUSSIONS

This section contains the main results of the applied methods, namely PCA and K-Means clustering. The section ends with a comparison of our results with previous similar studies. For the application of PCA, we use the scree plot and the principle of cumulative variance to determine the optimal number of PCs. Then we use K-means to cluster the 27 EU countries into 4 clusters.

The first PC captures 66.43% of the initial variability. The second PC captures 12.61% of the initial variability. The cumulative variance is shown in the third column. The first two PCs explain 77.05% of the total variance. By Borcard et al. (2018), we retain a number of PCs which account for around 75% of the total variation. Thus the first two PCs will be retained, at time same time in accordance with Kaiser's rule (Kaiser, 1960), which says that we retain the PCs with an eigenvalue greater than 1. This is also confirmed by the scree plot in Figure 1.

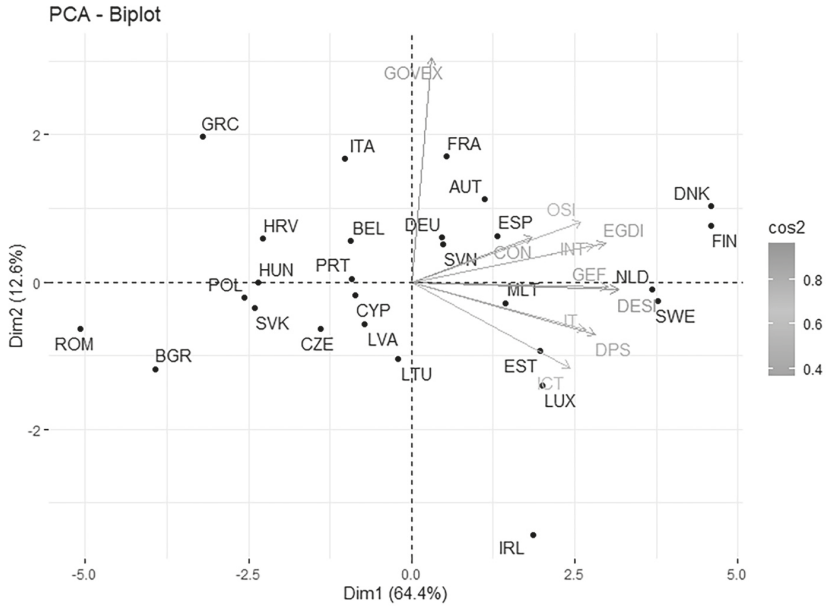
Figure 1. Scree plot explained by principal components



Source: Authors' determination

The biplot in Figure 2 displays the correlations between variables and their contributions to PCs. One can see in Figure 2 that all variables are grouped together, being positively correlated. Countries with similar features are positioned closer to each other.

Figure 2. PCA biplot with countries and variables



Source: Authors' determination

On the biplot from Figure 2, the objects are represented as points (here countries) and the vectors denote the variables (Kroonenberg, 2008). On the biplot, the variables are characterized by their correlations (Abdi and Williams, 2010). If the angle between two vectors is small, then the variables represented by vectors are strongly associated. The strong correlation between variables and PCs is shown by high cos values. High cos values indicate that the variables are located near the circumference of the correlation circle. Small cos values indicate that the variables are positioned near the circle centre. Small cos values belong to the variable CON. Middle cos values belong to ICT, IT, and OSI. High cos values belong to variables GOVEX, EGDI, INT, GEF, DESI and DPS.

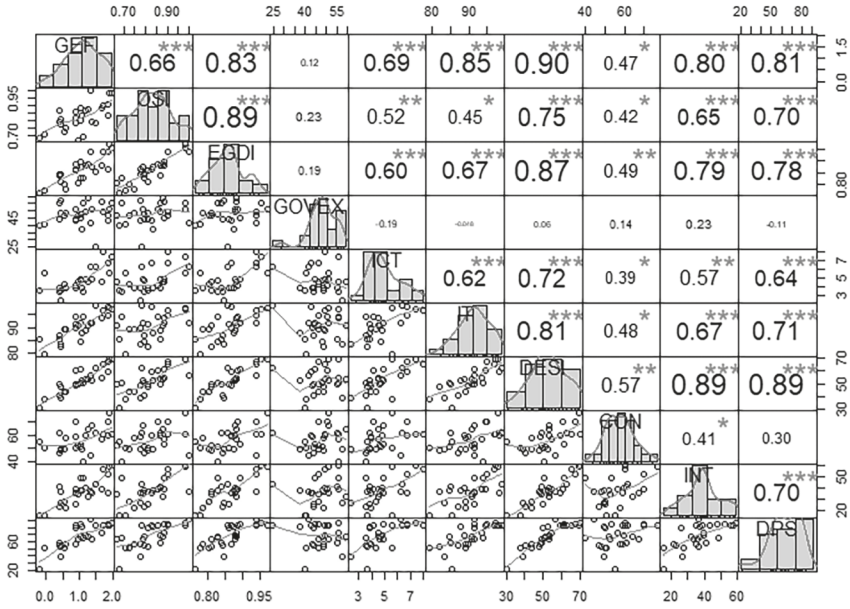
Variables situated closer to the correlation circle centre do not present so much importance for the first PCs (Kassambara, 2017).

Countries like Denmark, Finland, Sweden, and Netherlands are mainly determined by OSI, EGDI, INT, GEF, DESI, DOS and ICT. Luxembourg and Estonia are mostly characterized by ICT, DPS and IT. Malta is mostly dominated by GEF, DESI and DPD. France, Germany, Italy, and Austria are mostly dominated by GOVEX. Slovenia and Spain are mainly determined by CON, OSI, EDGI and INT. On the opposite quadrant are Romania, Bulgaria, Poland, Czech Republic, Hungary, Croatia, Slovakia, Greece, Italy. A similar representation on the factor map is obtained by Androniceanu et al. (2022), whose results confirmed that there is a digital divide between the countries situated on opposite quadrants. The countries in the right quadrant are mainly developed economies, for which digitalization, ICT and e-government index are on an increasing trend. For these countries, ICT improves the communication between government and citizens, the government services are more accessible, more transparent and more democratic. Dobrolyubova et al. (2019) confirm this assertion, that government digitalization makes more efficient public services.

On the left quadrant on the biplot in Figure 2 are positioned mainly emerging economies, between whom and the developed economies the digital divide still exists (Androniceanu et al., 2022; Mesa, 2023). During the COVID-19 pandemic, internet usage increased, making the digital gap less wide.

The governments were spurred to accelerate digital transformations. The countries lying on the left quadrant need important investments in infrastructure and experimenting with new technologies.

Figure 3. Correlation matrix



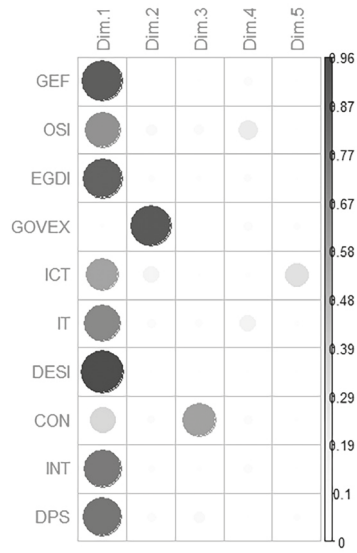
Source: Authors' determination

Figure 3 displays the histograms, density functions and smoothed regression lines together with correlation coefficients at different levels of significance (no stars mean not significant, *, ** and *** signify 10%, 5% and 1% levels of significance).

As we can also notice from the correlation matrix in Figure 3, the strongest associations are between EGDI and OSI (0.89), GEF and DESI (0.9), DESI and INT (0.89), DESI and DPS (0.89), EGDI and DESI (0.87), GEF and IT (0.85). GOVEX is weakly correlated with most variables. GOVEX are fiscal instruments by which the state intervenes in the economy. GOVEX is meant to be a living standard indicator, with a role in investments in innovation and in new technology. Its weak correlation with most of the indicators shows that public spending has a minimal influence in stimulating economic growth, unlike private spending (Pop Silaghi et al., 2014).

In Figure 4 are displayed the square cosines of variables on the first 5 PCs. The first 5 PCs are not correlated.

Figure 4. The cos2 of variables on the first 5 PCs



Source: Authors' determination

PC1 is dominated by GEF, OSI, EGDI, GOVEX, ICT, IT, DESI, CON, INT and DPS. The first direction will be named the impact of digitalization on government effectiveness. PC2 is dominated by government expenses GOVEX. It follows that the total expenditures are not affecting any other variable, which is what this PC separation suggests. This is because GOVEX is weakly correlated with the other variables, as shown by the correlation matrix. PC3 is dominated by CON.

The next step of the research was the application of the K-Means clustering algorithm. The steps of the K-means algorithm are the following:

1. Determination of the number of centroids. The initial centroids are selected randomly.
2. The objects are assigned to the nearest centroid.
3. The centroids are computed again and a new assignment of objects to clusters takes place.
4. The algorithm is repeated until the centroids become unchanged or until the objects cannot be allocated to other clusters.

According to the elbow method (Thorndike*, 1953),* the optimal number of clusters is 4. The clusters composition is the following:

Cluster 1: Estonia, Ireland, Luxembourg, Malta

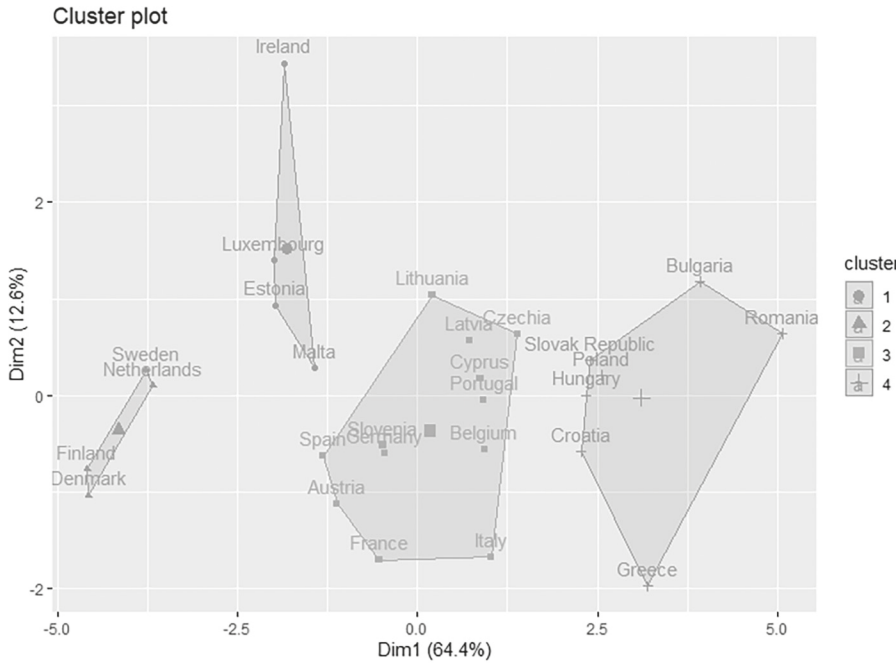
Cluster 2: Netherlands, Denmark, Sweden, Finland

Cluster 3: Belgium, Czechia, Germany, Spain, France, Italy, Cyprus, Latvia, Lithuania, Austria, Slovenia, Portugal

Cluster 4: Bulgaria, Greece, Croatia, Hungary, Poland, Romania, Slovak Republic.

In the cluster plot from Figure 5, we can see that the four clusters are well separated in the plane determined by the first two PCs.

Figure 5. Cluster Plot



Source: Authors' determination

Table 2 contains the cluster means of scaled data. The countries in cluster 2 have the highest values for all variables. The Nordic countries together with the Netherlands are the most digitalized, the implementation of IT services in public administration increases transparency and makes citizens more involved in administrative and political activities (Bernhard et. al, 2018). Citizens can benefit from e-government in three directions according to Bernhard et al. (2018): first, the living conditions such as education, health, and infrastructure, secondly the digitization of services for citizens and third, the decision-making processes made available for public scrutiny. Pérez-Morote et al. (2020) analyze an EU panel during 2010-2018 and their results confirm the hypothesis that the use of e-government services is positively correlated with the digital divide caused by income and education. Their analysis continues with a 3-cluster analysis, in which the low cluster contains most Eastern European countries together with Italy and Greece, the medium cluster is heterogeneous while the high cluster comprises the Nordic countries, France and Luxembourg. This cluster is characterized by a high level per capita, higher use of e-government, more investments in education, and a younger urban population. Ma and Zheng (2018) explore a survey of 28000 EU citizens and find that e-government performance is negatively correlated with the use of e-information and e-services.

Table 2. Cluster Means

Cluster	GEF	OSI	EGDI	GOVEX	ICT	IT	DESI	CON	INT	DPS
1	0.666	0.56	0.486	-1.216	0.907	0.874	0.731	-0.233	0.316	1.065
2	1.389	1.325	1.619	0.452	1.574	1.181	1.555	1.221	1.645	0.963
3	0.038	-0.144	-0.069	0.322	-0.413	-0.065	-0.041	0.033	0.002	0.055
4	-1.24	-0.829	-1.083	-0.116	-0.709	-1.062	-1.235	-0.627	-1.126	-1.254

Source: Authors' determination

As a result, the countries in cluster 2 also have the highest DESI index. Countries in cluster 1 are positioned second, with regard to most of the indicators. In this group of countries, Estonia is an important frontrunner in digital public services, being in the 7th place in the DESI 2021 hierarchy. Estonia is one of the most advanced digital economies, keeping online 99% of government services during the pandemic. The last position in this ranking is occupied by the countries in cluster 4, where Romania, Hungary, Slovakia, Poland and Bulgaria are positioned. Wandaogo (2022) conducted a panel data study for 139 countries during 2006-2016 and concludes that the positive effect of digitalization on public administration is higher in developed countries than in developing countries. The reverse causal effect may also happen, an effective government will induce the use of digitalization to provide online services or to improve their quality. Pakhnenko and Kuan (2023) group world countries with respect to their digital governance development. From this dataset, 69 countries have a very high level of digital governance, followed by a cluster of 46 countries with a high technological level in public administration. In this analysis, the GovTech Maturity index and its components are included. Among EU countries, Romania, Bulgaria, Slovakia, Poland, and Ireland have a GoVTech Maturity index varying between 0.5 and 0.75. The three countries at the top of GovTech Maturity index for 2022 are Estonia, France, and Lithuania. Park et al. (2022) introduce the Digital Transformation Index (DTI) to study the digital divide and its causes. The study delimits three phases of digital transformation: foundation, adoption, and acceleration. 106 world countries are included in the DTI framework and grouped into five clusters, according to the five intervals of DTI scores. In the DTI ranking, USA places first, followed by Switzerland and UK & Northern Ireland. Romania places in the second interval of DTI scores, together with 31 world countries, among which: Hungary, Bulgaria, Latvia, Poland, Slovakia and Greece. DTI's significance consists in the positive correlation between income and the digital transformation level of countries.

5 CONCLUSIONS

In this paper, we applied PCA and cluster analysis to study the panel of 27 EU member states and 10 variables collected for the period 2021-2022. PCA revealed that two PCs are retained, explaining 77.05% of the original variability. The first dimension is dominated by most of the variables included in the study, therefore it was called the impact of digitalization on public administra-

tion. The second dimension is dominated by government expenses. The combination of these indicators in the composition of the first PC measures the short-term effects of digitalization on public administration and government effectiveness. In a K-means clustering with 4 clusters, we obtain that cluster 2 which contains Nordic countries places on top, followed by cluster 1, cluster 3 of well-developed countries and cluster 4 of mainly emerging economies.

The results of this paper have certain policy implications, such as the enhancement of e-government could contribute to improved government effectiveness. Other policy implications could be oriented to reduce corruption and more transparent institutions and public services (Sadik-Zada et al., 2022; Osborn, 2006).

The research results obtained about the digital transformation in the European public administration proved the fact that it increases the quality of the governance process as a whole. It must be understood that digital solutions mean more than the transfer of decision-making processes from paper to digital format. In addition, these improve the quality of governance by minimizing the influence of corruption factors, provide equal chances and opportunities to all members of society, and much greater transparency of public services and expenditures (Głodowska et al., 2023). Digital transformation of public administration makes everyone's life much simpler, more efficient, and harmonious. In some cases, in addition to improving some processes, it fundamentally changes them (Korzynski et al., 2023). Effective e-government leads to good governance. The digital divide at the country level can be reduced by urgent technological and financial support for countries with a lower level of digital transformation or in cases when this cannot be assessed. Müller et al. (2022) discuss the potential EU-added value in different directions of social and labour policy, with the purpose to move to a convergence among EU countries.

The results of our research can be used in the extensive transformation process of European administrations until 2030. As the European Commission shows, a mechanism for the digital transformation of Europe is being launched in 2030. The European Parliament, the member states, and the Commission have jointly established objectives and targets in the four key areas namely digital skills, infrastructure including connectivity, digitalization of businesses, and online public services, in line with the Declaration on European Digital Rights and Principles. In this context, government effectiveness can become a necessary and relevant indicator.

In our future research, the current research results could be completed with an increased number of research variables and with different panel data techniques, for longer time series. Alternatively, we may tackle these issues by qualitative methods or other statistical approaches.

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