



E-Government in European Countries, a Comparative Approach Using the Principal Components Analysis

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Abstract

The digitalization of public administration is a necessary condition for the economic and social development of each country. In this context, e-government is developing and diversifying its forms of implementation, contributing significantly to the efficiency of public administration, to increasing the degree of transparency and to reducing corruption in public institutions. The aim of the research was to know how the states of the European Union evolved from the point of view of e-government and what influence it had on the economic development of the analyzed states and on the European citizens during the analyzed period. For this we selected ten research variables from several databases: Eurostat, the World Bank and the United Nations E-Government Development Database (UNeGovDD) of the United Nations. The period for which we did the analysis is 2010–2019. Using EViews 12 we applied panel Principal Component Analysis to reduce the 10-variable panel into a lower dimension of 3 principal components to find the underlying simplified structure. The three principal components retained explain about 76.5 % of the initial information. The research results show significant differences between the states analyzed, in terms of e-government, but also in terms of the impact it has on government effectiveness, controlling corruption, e-participation of European citizens and the economic development of Member States. In countries with a high level of e-government implementation, governance is efficient, corruption is low, citizen involvement is higher and economic development is faster.

Keywords:

e-government, government effectiveness, public administration, digitalization, panel Principal Component Analysis

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1. Introduction

E-government is an essential stage of public-administration reform and involves a process of digitization of the public sector. In the modern sense, E-government includes not only the network infrastructure of executive power, but, in general, the whole infrastructure of the authorities (Pachkal 2016; Robinson 2020). E-Government is essential for eliminating or simplifying bureaucratic procedures, improving access to information, reducing public spending, combating corruption or strengthening the administrative capacity of public institutions. It has almost become an imperative change in all state administrations. E-Government can stimulate public services, while reducing red tape for all European citizens and the business community (Rodríguez et al. 2011). E-Government is also increasingly used to improve transparency in the administrative system and to connect communities through digital interaction (Androniceanu 2021). E-Government is important and necessary for public, private and citizen institutions. The analysis of the e-Government activity is necessary to know the demand for public services and the expected quality (Barabashev et al. 2019). Measuring the quality of a service provided by e-Government is of special importance, as most public administrations have the improvement of the quality of services provided to citizens as a major objective. Quality standards vary from service to service or from institution to institution. They must be developed in the context of service norms and standards in the context of the modern information society. Through e-government one can find the degree of satisfaction of citizens in relation to the costs of services provided.

E-government contributes significantly to reducing corruption in public administration. Available data show that corruption is lower in states where e-government is widely implemented. E-government can help to know the evolution of the expectations and habits of citizens and economic agents regarding public services. Also, e-government is important and necessary as it contributes to the identification of improvements to satisfy the public interest by increasing the accessibility and efficiency of services. The European Union has developed and is implementing the European Commission's Strategy on cross-border digital public services and e-government in the digital single market. Its main objective is for Member States to implement technological communication solutions between public administrations, citizens and organizations. The objective of our research is to know how e-government has evolved in the states of the European Union from the point of view of e-government and what influence it has on the economic development of the analyzed states and on European citizens.

2. E-government in the literature and in practice

E-government is the process of changing the public sector through digitalization and new information management techniques, a process whose ultimate goal is to

streamline public administration and increase the degree of citizen participation in the administrative process (Lincaru et al. 2018; Glotko et al. 2020; Burhanudddin et al. 2019; Afonasova et al. 2019; Sidorenko et al. 2019).

E-government is the provision by the state of services financed from public money in electronic form, based on the use of information and communication technology (Joseph 2017; Müller and Skau 2015; Moon 2002). From another perspective, e-government can be defined as the interaction between the Government, Parliament and other public institutions with citizens through computer applications and electronic means (Androniceanu et al. 2020; Styrin et al. 2019; Špaček 2015). The steep increase of e-government opportunities is caused by ICT development and appropriate demand for digital services (Bilan et al. 2019; Victor et al. 2019). In turn, it grew essentially in terms of the coronavirus crisis (Smeureanu and Diab 2020). The main benefits of e-government are: efficient management of resources; transparency of processes and activities; reducing corruption, and shadow economy (Shpak et al. 2021), increasing the degree of involvement of citizens and economic agents in specific administrative activities and processes; reducing bureaucracy (Revyakin 2019; Barabashev 2016) and its costs (Lincényi and Čársky 2021; Shevyakova et al. 2021). By expanding e-government and digitizing the state administration, effective means are provided to stakeholders to exercise the fundamental rights of citizens. In the process of developing e-government, citizen orientation is essential, as it represents an assumed goal for any institution that aims to meet the needs of citizens (Buchmann and Meza 2012). It also relates to the local self-government level of governance, which is closest to citizens (Tolėikiene and Juknevičienė 2019).

According to the Organization for Economic Cooperation and Development (2003), e-Government is the use of information and communication technology, in particular the Internet, as a tool for better administration (Walker et al. 2020). The main components of e-government are government-to-government (G2G), government-to-employee (G2E), government-to-citizens (G2C) and government-to-companies relations (G2B, Government-to-Business).

Thus, through a summary analysis, government-government relations (G2G) can be defined as those links established between several public institutions in order to solve problems of general interest, which give rise to the generation of complex solutions, government relations to governmental employees (G2E) involve online management between government and employees through electronic means, government-citizen relations (G2C) have as their main objective the approachability of public institutions to citizens through communication and exchange of information on both sides through the Internet, and, not least, the government-company relationship (G2B) finds its applicability in the field of public procurement and tenders, contributing to increasing transparency and reducing costs. E-Government influences many fields and has implications in the social, political or economic sphere,

radically transforming the way public institutions interact with citizens but also with other stakeholders in the public and private sectors (Bayona and Morales 2017; Bundschuh-Rieseneder 2008; Johnson 2020).

The trust and security of systems that integrate e-government applications is the principle of e-government and shows that online interaction with public administration must be as secure as the classic office visit (Mugge et al. 2020). The secure exchange of information and the transfer of data must be guaranteed by defined security standards (Andronie et al. 2021; Grayson 2020).

E-government requires a process of change, but this change is mediated by the relationship of trust between citizens and government and requires stability in this regard (Müller and Skau 2015). Thus, it is imperative that governments take action to strengthen the connection, cooperation with citizens and other stakeholders for successful e-government policies (Mircică 2020).

The main principles underlying the provision of public information and services by electronic means are:

- transparency in the provision of public information and services;
- equal, non-discriminatory access to public information and services, including for people with disabilities;
- efficiency of using public funds;
- confidentiality or, respectively, guaranteeing the protection of personal data secrecy;
- guaranteeing the availability of information and public services

There are several advanced Member States in Europe regarding e-government. They provide many examples of good practice for changing states about integrating e-government (Auffret 2010). Thus, good practices with tradition can be found in Austria, Switzerland, Denmark, the Netherlands and Estonia. Due to its emphasis on digitizing its administration, Austria is at the top of the EU rankings, along with Latvia. Together with Malta and Estonia, Austria ranks in the top 3 EU countries with an advanced level of e-government. In the group of Germanic states, Austria ranks first (Shkarlet et al. 2020). An example of great success is the establishment and expansion of electronic services on oesterreich.gv.at, on the digital application “Digitales Amt” and on the business services portal (USP). With a total rating of 96 percent, Austria is extremely well positioned, taking into account the user-centricity benchmark. Especially in the field of mobile facility there is a concern for the continuous improvement of the necessary fixed and mobile electronic applications (Russell 2020). In the future, the improvement of the application will be intensified, and a design with a good capacity for site receptivity will be pursued. The continuous increase of the transparency degree of the Austrian administration located at 82 % shows the high degree of openness and accessibility for those interested in public data and information.

Nemec et al. (2020) discuss the situation of the COVID-19 crisis in four countries, the Czech Republic, Estonia, Hungary and Slovak Republic. Among them, Estonia is the leader in governance digitalization (Drechsler 2018). Androniceanu and Marton analyzed the psychological and social impact of the COVID-19 pandemic on the population (2021).

In the field of cross-border mobility and accessibility of online services abroad, Austria has recovered a lot in recent years and ranks third in the EU. In terms of ease of use of cross-border services, the expansion of digital and multilingual service provision needs to be further promoted for companies. The key-enablers indicator for the processing of online services shows the stable high level that Austrian e-government has now reached at 89 %.

In addition, there are initiatives and programs that help advance digitalization in Austria, such as the continuous expansion of research infrastructure (Ionescu 2020; Osei-Kojo 2016). The “Digital Action Plan for Austria” was presented in June 2020, with the main objective of positioning Austria as a region of digital innovation and, among other things, creating 20,000 new jobs a year. E-commerce and “Kaufhaus Österreich” – an online platform for strengthening internal trade – are also planned. “Kaufhaus Österreich” will bring together all Austrian online stores to make them more easily accessible to customers.

Last but not least, Microsoft has announced that it wants to invest one billion euros in Austria to create its own cloud computing center. This will provide storage and software over the Internet. This extended commitment is intended to promote innovation and growth in Austria.

Another example of a top state in terms of the implementation of e-government in public administration is Denmark. In Denmark, the beginning of the information society took place in 2000, when the Commission for Digital Administration was set up, subordinated to the Ministry of Finance, and whose role was to implement a meta-marking language (XML) as a communication standard in the public sector and to develop its use (European Commission 2011a). The national electronic portal of Denmark, borger.dk, was launched in 2007, and the e-Government strategy for 2007–2010, whose main objective was to improve cohesion and cooperation within the public sector, was quickly embraced by the Government, local authorities and by the five Danish regions. Transformations have continued so that Denmark now has an efficient and sustainable integrated e-government system.

The third example of a top state in Europe according to the stage of implementation of e-government is the Netherlands. In 2003, the first version of the e-Government portal was launched in the Netherlands, the Netherlands becoming the first European country to ensure the presence of all local authorities on the Internet. Through the DigiD application, citizens, based on authentication with an ID, had access to electronic services (2005) and could access the websites of public institutions in the simplest way possible, including for people with disabilities (2006),

launching The website “Working on the Netherlands Together” was launched, by means of which citizens were encouraged to provide feedback to improve the performance of e-Government (2007), and to oblige all authorities to use open source (2007) (European Commission 2011b). The Dutch national portal, data.overheid.nl, and the DigiD Authorize system, launched in 2011, have as their main objectives more efficient governance and less bureaucracy, with some citizens being able to subscribe to possible objections to government decisions, in the event that they feel disadvantaged or treated inappropriately. The Dutch national portal provides citizens with access to government data on the environment, population or infrastructure. In their pilot study on e-government and digitalization of G2C – government services to citizens – for the Czech Republic, Hungary and Romania Špaček et al. (2020) conclude that in the three CEE countries, the level of digitalization of administrative services for citizens is rather low. Dobrolyubova (2021) offers an extensive literature review on the digital transformation in public administration, underlining the positive and negative effects of digitalization. Empirical evidence points out the positive correlation between the development of e-government and economic indicators.

An exceptional example of e-government is the Estonian administrative system. This is the only country in the world where 99 % of public services are available online. Two decades ago, the right to the Internet was declared a fundamental human right in Estonia, and since then Estonia has begun to build the information society. At that time, the general population did not have access to the Internet or even devices to use the Internet. However, changes took place quickly. E-Government is probably the most complex system Estonia has. In a few minutes, its citizens can complete their online application for almost any municipal or state service. In 2000, the State Infocommunication Foundation (RIKS) was created by a foundation managed by the Estonian Ministry of Economy and Communications. RIKS's mission is to provide coherent, high-quality, secure and cost-effective communication services to public institutions, local municipalities and other state-budgeted institutions, including communications for private purposes, through its own infrastructures and communication services provided by the free market.

In this context, Cybernetics was founded. It is a research and development company that develops and sells key systems and products for maritime surveillance and radio communications solutions. E-Government could be implemented with the help of Cybernetics, which has been and is an active partner in the development of critical systems such as Estonian X-Road, i-Vot, e-Customs and others. Today, Cybernetics offers its services in over 35 countries around the world. There are several applications whose proven efficiency is remarkable. These are: e-cabinet; i-voting and others. E-cabinet is the information system for government sessions. This is a powerful tool that the Estonian government is using to streamline its decision-making process. The system has a single database for multiple users, which keeps the relevant information organized and updated in real time, giving ministers

a clear overview of each element in question. After Estonia adopted e-Government, the paperless e-Cabinet application, the average duration of weekly cabinet meetings was reduced from 4 or 5 hours to 30–90 minutes. The government has also eliminated the need to print and deliver thousands of pages of documents each week – a significant benefit to the environment and the taxpayer. E-government has generated more trust in society, and the adoption of this governance model has saved Estonia over 800 years of work. Thanks to a smart, convenient and flexible ecosystem, Estonia has reached an unprecedented level of transparency by switching to digitization.

To measure the evolution of different countries in the field of e-government, one of the most relevant images is given by the e-government development index, periodically measured by the United Nations on the basis of three dimensions: scope and quality of online services, the situation of telecommunications infrastructure and inherent human resources. According to this assessment, all EU Member States are above the global average and, in fact, the European area is more developed than any other geographical area of the world.

EU Member States are also above the global average in terms of e-participation measured on three dimensions: the availability of unsolicited public service information; online participation of citizens in the public policy debate; participation of citizens through online forms in the elaboration of public policies or the design of certain components of public services.

Another relevant measure of progress in e-government is the Digital Economy and Society Index (DESI), which captures the picture of about 30 indicators relevant to the EU's digital performance, in terms of five dimensions: connectivity, human capital, Internet use, digital technology integration, digital public services. Although the field of e-government is distinctly captured in the dimension of digital public services, it is useful to retain data on the degree of digital literacy of the population or the extent of Internet penetration (for example); the latter can be interpreted as factors that directly influence the development of digital public services and their use/popularity. Our research focuses on a variety of factors that influence e-government in the EU countries and its impact on their economic development and not only that.

The main questions answered by this research are: (1) What is the stage of the implementation of e-government in the European states included in the research? (2) What is the impact of e-government on public administration, economic development and European citizens? (3) What is the impact of e-government on corruption? (4) How have information technology and communications influenced the pace and scale of the implementation of e-government-focused administrative reforms? To answer these questions, we selected 10 relevant variables with which we identified both the particularities and the interdependencies between the 27 states analyzed based on Principal Component Analysis (Jolliffe 2002). The period for

which the analysis was made is 2010–2019, and the databases of Eurostat, the World Bank and the United Nations E-Government Development Database (UNeGovDD) of the United Nations (2020) were used.

The novelty of our research consists in the comparative approach of the interdependencies between the 10 variables included in the research and their influence on e-government in the EU states. For this we used the Principal Component Analysis. Comparative research focusing on the correlations between factual variables and e-government, covering all EU states, is not known in the literature. That is why we appreciate that our work covers an important research space, offering interesting results for each member state, but also comparisons between them that highlight significant differences and their causes.

As a result of the panel Principal Component Analysis, three principal components were extracted, explaining about 76.5 % of the original information. The main determinants of the first PC are control of corruption, e-government, government effectiveness, political stability, ICT and Internet use. The second PC is determined by e-participation, public expenses and GDP growth rate. The third PC is dominated by mobile cellular subscriptions per 100 people.

The next section of the paper presents the research methodology and the main results. The paper ends with a few key conclusions based on the research results.

3. Research methodology

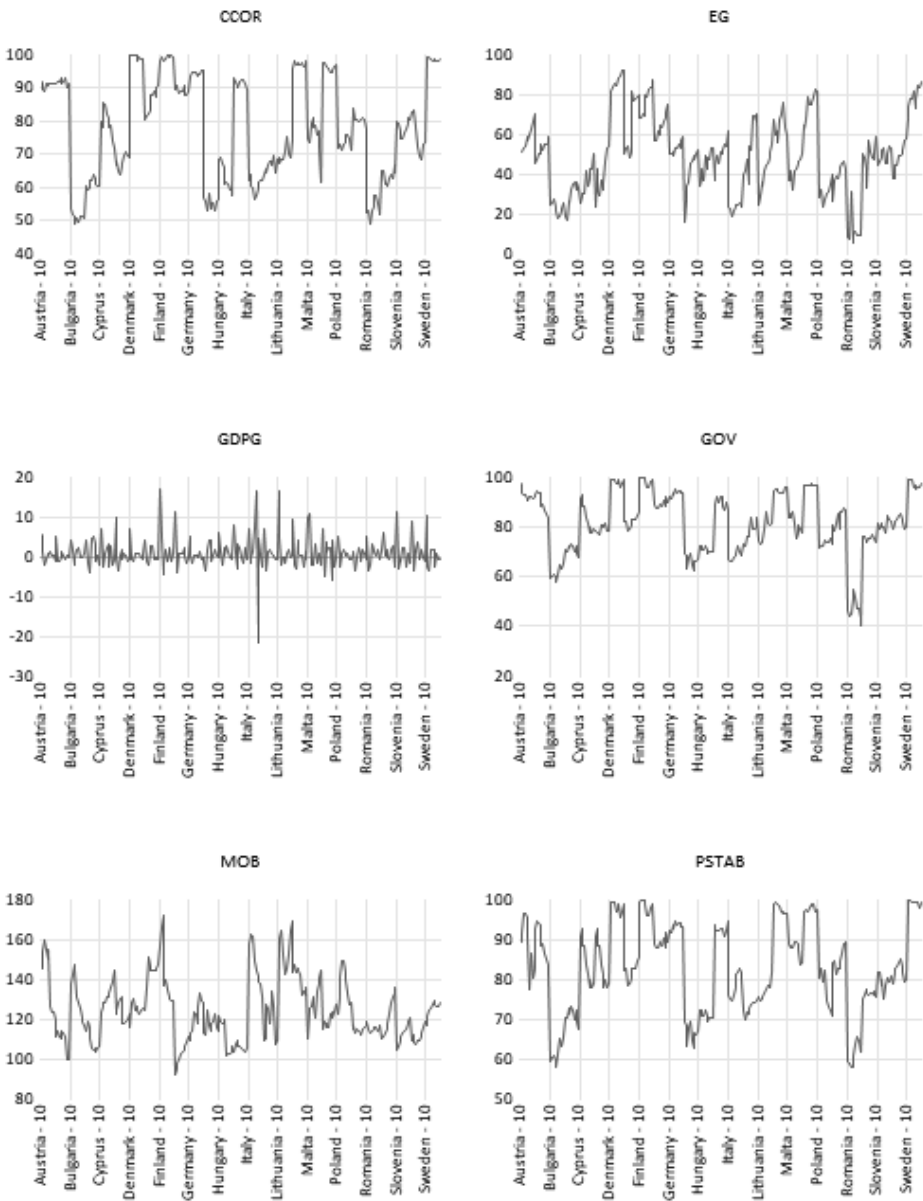
The main research variables considered in the analysis are presented in Table 1. The paper examines the interrelationships between the performance of the digitalization of public administration and economic growth in European Union. Therefore, we selected ten representative variables to reflect these aspects.

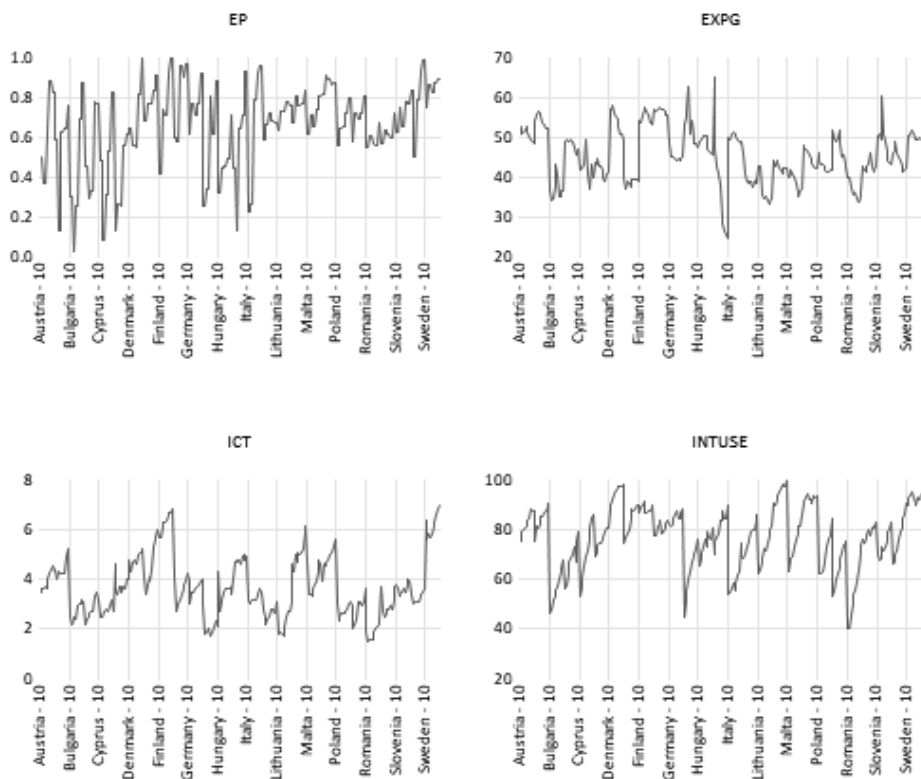
Starting from these variables, our research is based on the correlations among them in the analyzed period. The aim of our research is to study the correlations and the impact of ICT and digitalization-related indicators to public administration, GDP growth rate and public expenditure. The evolution of the ten selected variables in the period 2010–2019 is presented in Figure 1.

Table 1
The definitions of variables

Variable	Description of the variable	Abbreviation symbol of the variable	Range of possible values	Source
E-participation index	the use of online services to facilitate the interaction between government and citizens	EP	[0, 1]	https://publicadministration.un.org/
Control of corruption index	the quality of governance to combat and prevent corruption	CCOR	[-2.5, 2.5]	World Bank
Political stability and absence of violence/terrorism index	perceptions on the probability of political instability, violence and terrorism	PSTAB	[-2.5, 2.5]	World Bank
Government effectiveness index	the use by government of information technology in the public relations	GOV	[-2.5, 2.5]	World Bank
GDP growth rate	The pace how quickly the economy is growing or shrinking	GDPG	%	World Bank
Expense % GDP	cash payments for operating activities of the government in providing goods and services	EXPG	%	World Bank
E-Government index	individuals using the Internet with public authorities (% of individuals aged 16 to 74)	EG	%	knoema.com
Individuals using the Internet (% of population)	individuals who have used the Internet (from any location) in the last 3 months	INTUSE	%	World Bank
Mobile cellular subscriptions (per 100 people)	subscriptions to a public mobile telephone service that provide access to the PSTN using cellular technology	MOB		World Bank
ICT employment of total	the percentage of employment of ICT specialists out of total	ICT	%	World Bank

Figure 1
Trend of the studied variables for the 27 EU countries during 2010–2019





(Own determination, based on the World Bank databases)

As can be seen in Figure 1, GDP growth rate has the smoothest trend of all the variables.

Table 2 reports the descriptive statistics of the data used for the parameter estimation of the model. From Table 2 one can notice a high income inequality among EU countries, since the standard deviation of the GDP growth rate is very high, 3.56, compared to the mean, 0.81. The standard deviations of ICT and INTUSE are relatively high compared to their mean values, indicating that there exists a digital divide among EU countries. At the same time, one can see that EU countries have significant disparities as far as the public administration indicators, such as control of corruption, e-government and political stability, are concerned. The mobile cellular subscriptions per 100 people have a standard deviation of 15.82, moderately small to the mean of 124.45, meaning that at the EU level, the inequality is not so large. Poland, Estonia and Finland are among the top EU countries with respect to mobile broadband subscriptions per 100 inhabitants.

Table 2
Descriptive statistics

	CCOR	EG	EP	EXPG	GDPG	GOV	ICT	INTUSE	MOB	PSTAB
Mean	77.95	48.89	0.66	45.32	0.81	81.47	3.67	76.69	124.45	82.98
Median	78.61	49.00	0.69	44.85	0.35	81.52	3.50	77.94	122.53	82.66
Maximum	100.00	92.00	1.00	65.10	17.12	100.00	7.00	99.67	172.12	100.00
Minimum	48.82	5.00	0.03	24.50	-21.48	40.38	1.50	39.93	91.90	57.69
Std. Dev.	15.39	19.34	0.21	6.93	3.57	12.45	1.21	12.41	15.83	11.34
Skewness	-0.16	0.12	-0.86	-0.07	0.67	-0.69	0.61	-0.51	0.66	-0.26
Kurtosis	1.71	2.49	3.36	2.87	12.30	3.41	2.88	2.80	2.96	2.16

(Own determination)

The implementation of the Principal Component Analysis (PCA) is appropriate for our research purposes. First, the principal components are less dependent on measurement errors of the real data. Secondly, PCA reduces the data dimensionality. PCA generates uncorrelated variables called principal components. Most of the variance in the initial data can be explained by the first few principal components, therefore the loss of information is minimal and the measurement errors have no influence on the results. The application of panel PCA allows tracking progress over time (Jolliffe 2002).

4. Main results, analysis and discussions

Table 3 reports the correlation matrix to which the eigenvector decomposition was applied. The panel PCA will be built starting from the correlation matrix.

CCOR is strongly positively correlated with PSTAB (0.91), GOV (0.92), EG (0.76) and ICT (0.75). PSTAB is strongly positively correlated with GOV (0.92), EG (0.70) and ICT (0.75). This suggests that a good business climate is associated with ICT employment and a good quality of public administration. The strong connection between government effectiveness, digitalization and the quality of public administration is also captured by Dobrolyubova et al. (2019). The development of ICT technology improves the performance of public administration. On the contrary, there is a weak correlation between the governmental expenses EXPG and ICT (0.24), which could be interpreted as the public expenses not being saved as a result of e-government policies, as emphasized by Dobrolyubova et al. (2019) and the National Audit Office Report (2017). Dobrolyubova and Alexandrov (2016) argue that the correlation between digitalization indicators and governmental expenses is weak because the share of digitalization expenses in the budget expenditure is not very high. The positive high correlation (0.92) between government effectiveness GOV and control of corruption CCOR suggests than an efficient performance of

public administration contributes to a reduction of corruption, a hypothesis confirmed by Garcia-Murillo (2013). The correlation between CCOR and ICT (0.75) proves that ICT can reduce the degree of corruption. This correlation is validated by the results of Darusalam et al. (2021) and Ben Ali and Gasmi (2017).

Table 3
Correlation matrix

	CCOR	EG	EP	EXPG	GDPG	GOV	ICT	INTUSE	MOB	PSTAB
CCOR	1.00	0.77	0.34	0.33	0.00	0.92	0.76	0.75	0.04	0.91
EG	0.77	1.00	0.49	0.31	-0.08	0.80	0.76	0.87	0.02	0.71
EP	0.34	0.49	1.00	-0.05	-0.13	0.31	0.35	0.52	-0.03	0.29
EXPG	0.33	0.31	-0.05	1.00	0.08	0.35	0.24	0.13	-0.18	0.32
GDPG	0.00	-0.08	-0.13	0.08	1.00	0.01	0.01	-0.11	0.00	0.02
GOV	0.92	0.80	0.31	0.35	0.01	1.00	0.73	0.77	0.05	0.93
ICT	0.76	0.76	0.35	0.24	0.01	0.73	1.00	0.75	0.07	0.76
INTUSE	0.75	0.87	0.52	0.13	-0.11	0.77	0.75	1.00	0.02	0.72
MOB	0.04	0.02	-0.03	-0.18	0.00	0.05	0.07	0.02	1.00	0.10
PSTAB	0.91	0.71	0.29	0.32	0.02	0.93	0.76	0.72	0.10	1.00

(Own determination)

Table 4
Information on eigenvalues

Number	Eigenvalue	Proportion	Cumulative proportion
1.00	5.28	0.53	0.53
2.00	1.28	0.13	0.66
3.00	1.09	0.11	0.76
4.00	0.87	0.09	0.85
5.00	0.59	0.06	0.91
6.00	0.37	0.04	0.95
7.00	0.27	0.03	0.98
8.00	0.12	0.01	0.99
9.00	0.08	0.01	1.00

(Own determination)

Table 4 contains the eigenvalues of the PCs, their individual proportion and the cumulative proportion. The third column of Table 4 shows that the proportions of variability of the first principal component PC1 constitute 52.8% of the variance of the original data. One can retain an appropriate number of principal

components according to the rule-of-thumb that the cumulative weight should constitute at least 80 % (76 %) of the variance of the original data. In this case, the first three principal components have a cumulative variability of 76.7 %. In the second column of Table 4 we have the eigenvalues from which we will retain the first three, which are greater than 1.

Table 5
Loadings

Variable	PC 1	PC 2	PC 3	PC 4	PC 5	PC 6	PC 7	PC 8	PC 9	PC 10
CCOR	0.41	0.09	0.07	-0.06	-0.16	0.33	0.03	-0.14	0.81	-0.05
EG	0.39	-0.08	-0.09	0.04	0.12	-0.38	-0.44	-0.61	-0.11	-0.32
EP	0.21	-0.46	-0.29	0.44	0.55	0.36	0.20	-0.00	-0.03	0.04
EXPG	0.15	0.61	-0.23	-0.34	0.64	-0.05	0.03	0.16	0.02	0.02
GDPG	-0.02	0.50	0.37	0.77	0.07	-0.04	-0.08	0.02	0.01	-0.01
GOV	0.41	0.11	0.08	-0.08	-0.16	0.30	-0.20	-0.14	-0.36	0.71
ICT	0.37	-0.01	0.08	0.04	-0.09	-0.52	0.74	-0.07	-0.03	0.16
INTUSE	0.39	-0.20	-0.07	0.10	-0.07	-0.34	-0.38	0.72	0.10	0.05
MOB	0.02	-0.28	0.82	-0.25	0.42	-0.02	-0.05	0.02	0.04	0.03
PSTAB	0.40	0.11	0.15	-0.09	-0.19	0.38	0.17	0.20	-0.43	-0.60

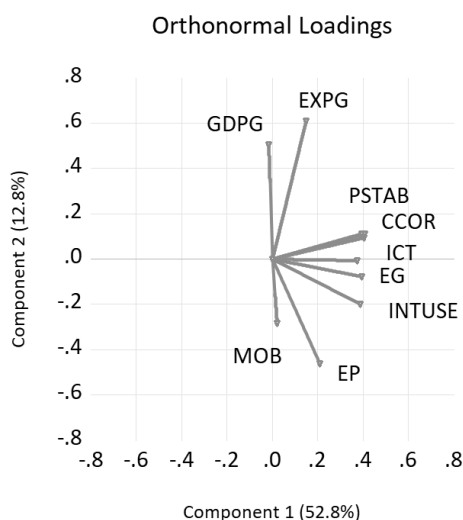
Table 5 describes the linear combination coefficients, called loadings. The first PC is positively dominated by CCOR (0.4), EG (0.39), GOV (0.4), ICT (0.37), INTUSE (0.38) and PSTAB (0.39). Therefore PC1 can be labeled as the digitalization of public administration.

The second PC is negatively dominated by EP (-0.46) and positively dominated by EXPG (0.6) and the GDP growth rate (0.5). PC2 can be labeled as the component of government spending and political stability. Adam et al. (2008) analyze 19 OECD countries for 1980–2000 and find that countries efficient in their public spending have also transparent regulatory policies and practices and a high political stability, and their public spending is oriented towards their policy goals.

The third PC is dominated by MOB (0.82), so PC3 is the mobile cellular subscription component. The government may develop online services and encourage online access for the citizens to assess government e-services. A similar conclusion is drawn in the study by Sanmukhiya (2018).

Figure 2 shows both the correlations between variables and how strongly each variable influences the first two PCs.

Figure 2
Loading plot



(Own representation)

This confirms our preliminary analysis of Table 5. The loading plot describes the relations between the variables. The relative position of the variables in the loading space should be studied to determine the correlations between them. Variables that are situated one near the other are highly correlated. Therefore, PSTAB and CCOR are high correlated, so are CCOR and ICT, ICT and EG, EG and INTUSE. If the angle between two variables is small, then the two variables are highly correlated. If the arrow direction is the same, the correlation is positive, if the arrow directions are opposite, the correlation is negative.

5. Conclusions

In this paper we applied panel Principal Component Analysis to study a ten-variable panel of the EU countries for the period 2010–2019 as a simplified structure of three principal components, which explain about 76.5% of the initial information. The main determinants of the first PC are control of corruption, e-government, government effectiveness, political stability, ICT and Internet use. The second PC is determined by e-participation, public expenses and GDP growth rate. The third PC is dominated by mobile cellular subscriptions per 100 people. The lack of cross-country or national data create a gap in the literature of quantitative models on digital transformation in public administration. Even if the panel is relatively short, we assume that this paper fills some gap in this sense. A research direction

to follow in the near future will be to build various time series models to measure the long term and short term effects on digitalization to public administration. The research confirms that a well-implemented e-Government in the EU countries is a transparent government, an efficient and effective government.

The limitation concerns the time series containing 11 years. In the near future more data will be included in order to enrich the results and conclusions.

A measure to be taken is to reduce the digital divide at the level of EU countries. Adopting integrity policies to reduce corruption should be correlated with the use of digital technologies. By including the new technologies into the initiatives that use data analytics, the early detection of potential crimes will become easier (Cetina 2020). These digital technologies may also increase the effectiveness of public administration. A digital transparent flow of information will hinder the corrupt practices and an effective e-government will bring about a lower corruption level for itself (Haafst 2017).

Our research shows the state of the EU in terms of the digitalization of public administration and the accessibility for the population of digital public services provided by public institutions. The obtained results highlight the group of advanced European states in the e-government process: Austria, Switzerland, Latvia, Malta, Germany, the Netherlands, Denmark, France, Italy. Most EU countries are located in the group with an average level of e-government implementation. There is also a group of Central and Eastern European states that still have a low level of e-government and need to invest heavily in the coming years to be able to catch up. This group includes: Romania, Bulgaria, Hungary and Slovakia. In the EU, e-government is a tool for better government in the coming decades and for increasing public values.

The EU's digital ambitions for 2030 focus on four key elements: citizens with digital skills and highly qualified professionals in the digital field – by 2030, at least 80 % of adults should have basic digital skills; secure, high-performance and sustainable digital infrastructure – by 2030, all households in the EU should have gigabyte connectivity, and all populated areas should be covered by 5G technology; digital transformation of enterprises – by 2030, three out of four companies should use cloud computing services, big data systems and artificial intelligence; digitization of public services – by 2030, all essential public services should be available online, all citizens will have access to their electronic medical records. Moreover, in order to address these trends, e-government will need to be more knowledge-based and user-, distribution- and networking-centered (Yousif et al. 2020).

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