The influence of the ICT on the control of corruption in public administrations of the EU member states: a comparative analysis based on panel data

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Abstract: *Developments in Information and Communication Technology (ICT) have led to major changes in public administration in all democratic states. The fact that information can be made public and accessible from anywhere, at any time, requires a new approach to the process of computerization of public administration. The objective of the research was to know the influence of ITC integration in the EU state administrations on corruption control in the period 2010 - 2019. We selected four relevant variables, which we integrated in a panel analysis including the 27 EU member states. Using STATA we made an econometric model on panel data and obtained interesting results from a scientific point of view. The results show that the integration of ICTs in the EU public administrations has significantly contribution to reducing corruption These results demonstrate the need to accelerate the digitization of administrations and create an integrated model of government cloud in the European administrative space. In addition, the results of the research highlight the differences between EU states in terms of the impact of ICTs on government efficiency and economic development.*

Keywords: public administration, ITC, panel analysis, corruption

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Introduction

The management of information systems in public administration is becoming a very topical and increasingly complex issue. The communication process between the different structures of public administration within the states, but also between them can be improved by redirecting the existing information flows (Nica et al., 2021) and by redesigning the applications currently in use in the public sector (Kovacova and Lăzăroiu, 2021) and by creating other applications (Novak et al., 2021) that efficiently use available information resources.The quality of the IT system in the public administrations of the states influences to the highest degree the quality of the decision-making system in the public institutions (e.g. Bednárová et al., 2021). In order to support the process of improving the management of public institutions and reducing corruption in the public sector in a country, new information programs and procedures are needed, adapted to the expectations of citizens (Ardielli, 2020; Maris, 2020) and the business environment (Belas et al., 2020; Androniceanu A-M. et al., 2020a; Marišová et al., 2013; Godany et al., 2021; Fabuš et al., 2021).

At the beginning of the process of integrating ITC in the administration, in most states, the efforts towards computerization of the public administration were more fragmentary, determined by the limited financial possibilities, the level of professional training of staff and decision makers in local public administration and the degree of awareness of the need to refurbish the activities of the local public administration (Lindgren et al, 2019). In some European countries, this process began a few decades ago and a complex approach to the computerization of public institutions was needed, in parallel with the training and specialization of human resources (Ciobanu and Androniceanu, 2018; Androniceanu et al., 2020). The computerization of administrative systems is based on the creation of an information system that replaces the traditional procedures of processing information (Popescu et al., 2020a) with new information technology products (Nica and Stehel, 2021), designed and developed in accordance with the functions of public administration.

Most public institutions in the EU have already automated some of their operations (Popescu et al., 2021), aiming to become more open and transparent in their relations with the public. However, the computerization of the public administration is a complex and long process, which requires a staged approach. E-government at the level of public institutions, through modern IT applications, is proof that the administration has evolved in all aspects (Ardielli, 2020; Androniceanu A-M. et al., 2020b; Laužikas et al., 2021). From an IT point of view, it can be said that the most important advances have been in infrastructure investments, expanding the Internet connection and implementing integrated information systems (Lăzăroiu et al., 2021) through an efficient collaboration with companies specialized in information applications adapted to the needs of the administration. By running IT applications, public institutions have the opportunity

to provide taxpayers with superior quality services. Integrated information systems contribute to increasing the accessibility of administrative services, connecting officials to a single database, which allows a simplified, fast and efficient flow of administrative processes (Lahkani, et al., 2020; Muangmee et al., 2021). By using a unitary IT model, the administration institutions benefit from the standardization of the usual administrative rules and procedures. The central objective of computerization of the administration continues to be the wide and non-discriminatory access of citizens to quality public services. As an immediately visible effect for taxpayers, computerization will lead to a reduction in tariffs for services provided to the population, by reducing operating and personnel costs, increasing the accessibility and transparency of public services and reducing corruption in the administration. E-government is essential for eliminating / simplifying bureaucratic procedures, for improving access to information, for reducing state budget expenditures, for preventing and reducing corruption, and for strengthening the administrative capacity of public institutions.

1. Literature review on e-government in Europe

At European level, the implementation of eGovernment and services has started in line with its own national strategies, since 1994-1997 (e.g. the Netherlands, Denmark, Finland, Sweden, Germany or Luxembourg). In other Community countries (Portugal, Italy, Austria, Greece, France and the United Kingdom), this was done through open debate platforms, focused on related programs and action plans. Although the application of these services differs from country to country, the objectives of e-Government are common and aim at applicability, utility, efficiency, transparency, innovation, sustainability, participation and security for the state (Ključnikov et al., 2019; Burcea & Abăluță, 2007), citizens and the business environment (Szeiner et al. 2020; Mura, 2020). In this sense, eGovernment contributes to the need in fairness and equity in public administration issues important for society, particularly, tax compliance (Mas'ud et al., 2019), distributive justice at all levels of administration (Mishchuk et al., 2019). The introduction at the level of public institutions of electronic document management services, customized to their own needs, in conjunction with electronic signature and time stamping services, have contributed to reducing the costs and time associated with the document circuit, ensuring also opposability, security and flow traceability.

The introduction of inter- and intra-institutional flows guarantees the exclusive access of authorized persons to those data and information. Electronic signature and time-stamping services can be shared by document management solutions and electronic invoicing. Cloud computing is a very well represented element in the European Digital Agenda and can bring back a fast pace of development of electronic services. ICT infrastructure has increased over the last 20 years to meet the demand for public services. This approach has led to an

increasingly expensive infrastructure that limits the ability of governments to modernize and capitalize on the latest advances in ICT, becoming a factor of systemic "immobility" (Poliak et al., 2020; Russell, 2020). Cloud-computing is a radical change in institutions that use ICT resources. Instead of storing applications and data on individual servers and computers, everything is hosted in the "cloud" - a collection of computers and servers accessed through the government intranet that should include secure Internet connection components (Cuillier & Piotrowski, 2009).

Cloud computing technologies have fostered an active market for software solutions (Popescu et al., 2020b), many of which are based on open standards. This has changed the ICT landscape from one of the dedicated systems, interconnected (more or less) through the network, to one that includes widely used and interoperable solutions (Darusalam et al., 2021; Green, 2020). In turn, these changes produce other changes in the behavior of organizations, which now have the opportunity to use general-purpose solutions that are appropriate to their needs, at a much lower cost (specifically, validated solutions can now be replicated quickly in similar institutions, with very low costs) (Vartanova et al., 2021; Shevyakova et al. 2021; Zieziula, Niewiadomska, 2021). These possibilities are available now due to the steep penetration of ICT in all spheres of economic relations, especially in business surrounding (Bilan et al., 2019), development of managerial knowledge-based systems based on artificial intelligence use (Bencsik, 2021; Androniceanu, A-M. et al., 2020c; Misuraca, G. & van Noordt, C., 2020; Androniceanu A-M. et al., 2021). Rather than replacing humans, artificial intelligence will have a greater impact if it is used to reduce administrative hassles and enhance human experience. These artificial intelligence technologies, when used properly, can help offer citizen services more efficiently while potentially lowering costs and enhancing user happiness. These artificial intelligence applications could allow for a more direct communication between citizens and the government (Mehr, 2017). Resources such as computing power, storage space and services are used only when needed and only generate costs when they are exploited, ensuring greater efficiency. By adopting cloud computing, the government may be able to provide services more easily and share consumer services and products (Khan, et al., 2021). This will allow it to move from dedicated, high-cost applications and solutions to standard, low-cost interchangeable services. Therefore, porting eGovernment solutions to a cloud infrastructure can lead to important benefits, such as: - reusing (replicating) validated solutions within other institutions; - low costs; - continuity in the development of information systems; - increased flexibility; - unitary infrastructure management; - the maintenance and upgrade of information systems is done at low costs; - emphasis on optimizations and efficiency (Andersen, 2009).

The implementation and provision of cloud governance (Johnson, 2020) and e-government services in the EU takes place in the context of the adoption by the European Commission (2013) on 27 September 2012 of a Strategy for the use

of potential cloud computing in Europe (SCCE), a prerequisite for creating a homogeneous digital space, designed to enable the creation of a digital single market (Marino & Pariso, 2021).

Estimates at the level of the European institutions have revealed that the benefits of the cloud come from both the large-scale savings involved (savings of at least 10-20% of the costs of public / private entities that have adopted this technology - especially those in the field of ICT -), as well as through a significant increase in productivity in all sectors of activity, in parallel with the growth of jobs. In addition to the defining components and features of cloud services involving distinct levels of hardware, middleware (platform) and application software, the Strategy for harnessing the potential of cloud computing in Europe pays particular attention to standardizing these technologies (Lăzăroiu and Harrison, 2021), as they allow developers to address a wide range of organizations, while giving users the opportunity to choose (Kinnunen at al., 2021). The issue of standards in the cloud is a European challenge because they will influence the work of key players in the ICT industry, public sector users and small and medium-sized enterprises. In this context, the European Commission is constantly concerned with the harmonization of existing documents on standards, in order to regulate the issue of standardization in the cloud.

Thus, among the objectives of SCCE is the establishment of the necessary technical standards in the field and ensuring their interoperability and compliance. The competent European institutions have selected experts to contribute to the finalization of common standards, within the European Partnership for Cloud Computing (PECC) with the Member States and the industry. PECC includes 7 states and 12 companies. The PECC aims to avoid fragmentation and ensure that the use of the public cloud is interoperable and secure, secure, environmentally friendly and in line with European standards, both in the field of protection of personal data and information, and security (level at which view of cooperation with the private sector). The PECC also aims to create a Digital Single Market for cloud computing in Europe.

In November 2013, the PECC launched the Cloud for Europe - C4E project, with 3 main objectives: (1) Identifying barriers to using the cloud in the public sector; (2) Defining ways to deal with identified obstacles; (3) Procurement of research and development services in the profile industry to identify viable solutions for cloud services. C4E is made up of a consortium of 24 partners (public sector, industry, standardization organizations from 12 European countries. Identifying EU-wide certification schemes for reliable cloud computing providers is an ongoing concern of EU countries). Consideration is being given to developing "key" clauses (secure and fair) for cloud contracts, including service level agreements (SLAs), which should become the standard for concluding contracts between service providers and users in the field. a detailed map of the required standards, approach of the COM, finalized by ETSI (European Telecommunications Standards Institute), map included in the Final Report on the

coordination of cloud standards (November 2013), a document designed to provide solutions related to security, interoperability, portability and reversibility data (Nica, 2021) with which the main actors operate in the cloud. Another objective of the COM is to grow trust in cloud services, by developing specifications for ICT procurement to ensure compliance and performance.

The research-development-innovation component becomes critical in establishing the timing and quality of the development of eGovernment solutions. The introduction of the government cloud anticipates strategic changes and provides the necessary tool to facilitate the major change that regionalization represents because it allows, easily, the modification of infrastructures and applications in one place to adapt to the rigors of regionalization without relocating them and without setting up new hardware / software infrastructures, as in the case of the decentralized approach. In the case of the cloud, it is sufficient to reorganize the data by regions, with minimal adaptation of related applications and security and data access rules, without affecting the availability of services to the population in the medium or long term (Burhanudddin et al., 2019).

The cloud management body, together with the participating institutions, should establish the basic entities - people, addresses, telephones, e-mail addresses, IP addresses, financial transactions, etc. Depending on the competencies, the institutions will assume the specific entities, for which design and use standards will be defined, as well as the related data structures, which will be used widely at national level. Thus, the national catalog of basic entities and related data structures will be established. For the implementation of the "government cloud" it is proposed to develop a level 3 or 4 data center, which involves a similar level backup center, with 99.96% availability. To ensure connections with the institutions, a redundant high-speed, governmental infrastructure (government intranet) will be used. Data separation is done logically, within centralized databases. Currently, there is a paradigm shift regarding the replication of data in the Integrated Information System in the sense of establishing new government cloud structures, in which the institutions of the government system and administration participate. The development of information hubs at regional level in all EU countries needs to be accelerated. An information hub is a system through which a central or regional institution can request information from the database of another regional or local institution. From a topological point of view, the solution is optimal because it eliminates the need for direct connection, 1 to 1, of all public institutions, opting in favor of a central point that functions as an information broker, taking over the request of a public institution and returning it the result after querying the source system responsible for managing that information, thus minimizing the effects of changes in data structures.

The regional hubs in the EU states are implemented in the government Cloud and are interconnected with the Integrated Information System, completing it. From the point of view of the traded information, the hubs eliminate the centrifugal effect induced by regionalization and are the ones that ensure the

cooperation with the e-government system. Moreover, this topology corresponds to the principles of regionalization, in which each regional Hub is governed by the rules of that region. Habs also ensure the "synchronization" of administration databases, eliminating "historical" inconsistencies (due to the island development of eGovernment from 2003-2013). Inter-institutional cooperation to streamline the demands of citizens and companies is a basic principle of electronic public services. Thus, when a citizen or a company launches an application in electronic format to a competent authority, it will no longer have to attach documents or information from other institutions, because the competent authority will be able to obtain this information automatically through the Hub network. -hate. Due to this functionality, the Hubs can be implemented in conjunction with the Point of Single Contact, a system defined by a European directive as a point for receiving requests in electronic format addressed to the administration.

E-government is the use by the public sector of information and communication technologies in order to improve the provision of information and services by encouraging citizen participation in decision-making and accountability of the government in a transparent and efficient manner and reducing corruption in a state (Remeikienė et al., 2020; Lincényi & Čársky, 2021).

Since 2012, when the ICC methodology used by Transpaerncy International allows the comparison of scores, 26 countries have significantly improved their score in the Index, referring here to Ecuador (39), Greece (50), Guyana (41), Myanmar (28) and South Korea (61). At the same time, 22 countries significantly reduced their points, including Bosnia and Herzegovina (35), Guatemala (25), Lebanon (25), Malawi (30), Malta (53) and Poland (56). Nearly half of the countries evaluated have stagnated in the ICC rankings for more than a decade, indicating a stalemate in government efforts to address the root causes of corruption (Ben Ali & Gasmi, 2017; Sabie, 2012).

More than two-thirds of the states have scores below 50 points. Corruption is a major threat to the lives and lifestyles of citizens, especially when it overlaps with a public health emergency (Jain, 2001). Clean (uncorrupted) public sectors are correlated with higher investments in the health system. Uruguay, for example, has the highest CPI (71) in Latin America, invests heavily in the medical system and has a well-developed epidemiological surveillance system, which has helped it to respond to COVID 19 and other infectious diseases, such as yellow fever and Zika.

Corruption is also persistent in the procurement of medical supplies. Countries with high levels of corruption have tended to disregard the rule of law and democratic institutions during the COVID-19 pandemic. This category includes the Philippines (34), where the response to the COVID 19 pandemic has been characterized by serious violations of human rights and freedom of the press.

Continuing the downward trend, the United States achieved in 2020 the lowest score of 2012, with 67 points. In addition to alleged conflicts of interest and abuse of office at the highest level, in 2020 the poor oversight of the $ 1 trillion

COVID-19 aid package has caused serious concern and marked a deviation from democratic rules on which promotes responsible government.

The year 2019 highlighted integrity challenges even in the case of countries with high scores in the ICC, which proves that no country is free of corruption (Lučić et al., 2016). Previous research conducted by Transparency International (2020) under the Global Health program has shown that the phenomenon of corruption deprives the global health sector of $ 500 billion each year. In this paper we investigate the influence of ICT on public expenses, standards of citizen's life and corruption. The research question answered by our analysis is: how much does the integrated ITC in public administration contribute to reducing corruption and economic development in EU countries?

2. Research methodology

In the section of the research methodology we present in detail the steps of the Pooled Mean Group-Autoregressive Distributed Lag (PMG-ARDL) panel model. To examine the long-run and short-run relationships between the independent and dependent variables, the PMG-ARDL model was chosen.

The stationarity of all variables was tested to determine their order of integration. These stationarity tests ensure that the variables are not I(2) so as to avoid spurious regression. The direct application of OLS -based models without checking the stationarity would also lead to spurious regression (Engle and Granger, 1987).

In the section of results and discussion we present the main findings together with their interpretations. The paper ends with conclusions.

Table 1. The definitions of variables

Variable	Description of the variables	Abbreviation	Range of possible values	Source
Control of corruption	the quality of governance to combat and prevent corruption	CCOR	[0,100]	World Bank
GDP per capita	gross domestic product converted to international dollars using purchasing power parity rates	GDPCAP	PPP Current USD$	World Bank
Expense %GDP	cash payments for operating activities of the government in providing goods and services	EXPG	%	World Bank
ICT employment of total	the percentage of employment of ICT specialists out of	ICT	%	World Bank

We formulate two research hypotheses which will be tested by the ARDL panel data model.

Hypothesis 1: In the states where the government invests in the ICT sphere, then corruption is lower compared to other states, therefore the control of corruption is higher.

Hypothesis 2: The bidirectional causality between GDP per capita and corruption is negative, meaning that a higher level of corruption, therefore a lower control of corruption, leads to a lower level of GDP per capita and conversely.

In order to verify these hypotheses, we will apply a panel ARDL.

In this paper, we will apply the Pooled Mean Group-Autoregressive Distributed Lag (PMG-ARDL) for the 27 EU members for 2010-2019. The traditional panel data techniques are fixed and random effects models, where the intercepts vary across cross-sections, but the other coefficients and error variance coincide across cross-sections. (Chen and Su, 2014).

Pesaran and Smith (1995) concluded that the fixed/random effects estimators are inconsistent under the hypotheses of slope coefficients heterogeneity and error variance. Pesaran and Smith (1995) proposed the MG estimator which assumes the estimation of separate regression for each country and allows the coefficients to be heterogeneous on short and long term. PMG-ARDL was created by Pesaran et al. (1999) in order to estimate a regression equation in case of a mixture of orders of integration I(0) and I(1). PMG is characterized by heterogeneous short-run coefficients across cross-sections (here countries) and homogeneous long-run coefficients across cross-sections.

The coefficient of the error correction term (ECT) describing the long-run causality should be negative and larger than -2. ECT signifies the speed of adjustment from short run disequilibrium to long run equilibrium. To test the differences between PMG and MG techniques, we apply the long-run Hausman test (Hausman, 1978).

First, we apply the Im-Pesaran-Shin unit root test (Im et al., 2003) to check the order of integration of the four-time series, as can be seen in Table 2.

2.1 Descriptive statistics

Table 2 contains descriptive statistics.

Table 2. Descriptive statistics

Variable		Mean	Std. Dev.	Min	Max
CCOR	overall	77.95	15.39	48.81	100
	between		15.46	50.83	99.13
	within		2.41	64.41	86.26
GDPperCAP	overall	38817.17	17399.65	14879.27	120962.2
			16724.74	18818.46	103050

Variable		Mean	Std. Dev.	Min	Max
	between				
			5691.16	19794.95	63680.76
	within				
EXPG	overall	45.31	6.92	24.5	65.1
	between		6.22	36.21	56.6
	within		3.25	33.10	73.7
ICT	overall	3.37	1.21	1.5	7
	between		1.16	1.87	6.33
	within		0.39	2.44	5.04

(*Source:* Author's own determination using STATA)

From table 2 can be noticed a high income inequality among EU countries (Georgescu et al., 2020), since the standard deviation of GDP per capita is very high. The standard deviation of ICT overall, between and within is relatively high compared to the mean of 3.37, indicating that there exists a digital divide among EU countries. Next, we apply the IPS unit root test to check the stationarity of the variables. It is necessary to conduct the panel unit toot tests to make sure that the integration order of the variables does not exceed 1.

2.2 Research results and discussions

Table 3 reports that CCOR, GDP per CAP and ICT are I(1), while EXPG is I(0) at 5% significance level. We have a combination of I(0) and I(1) orders of integration, while the dependent variable CCOR is integrated of order one. Therefore, the most adequate estimating technique is PMG-ARDL.

Table 3. Panel unit root test results

Variable	IPS		
	Level P-value	First difference P-value	Order of integration
CCOR	0.0517	0.0000	I(1)
GDPperCAP	1.0000	0.0146	I(1)
EXPG	0.0020	0.0000	I(0)
ICT	0.9000	0.0000	I(1)

(*Source*: Author's own determination using STATA

The dependent variable is the control of corruption CCOR. The independent variables are GDP per capita, government expenses and ICT employment of total. We conduct PMG and MG techniques and in order to choose the best model, we apply the long- run Hausman test. The null hypothesis of the long-run Hausman test is that the PMG estimator is the most efficient versus the alternative hypothesis that the MG estimator is the most efficient. Since the p-value of the long-run Hausman test is 0.98>0.05 (Table 4), we cannot reject the null

hypothesis and we adopt the PMG estimator. It follows that only the results of the PMG estimator are discussed. The PMG estimator can be considered the most efficient instrument because at the EU level, the long term ICT-control of corruption nexus should be targeted homogeneously, while on short term, each country should be analyzed independently, heterogeneously. In other words, on short term, each country should adopt its own strategy to fight corruption, while on long term, at the EU level, by EU policies, reducing corruption should be a common target (Boufateh and Saadaoui, 2020). Table 4 contains the estimations of the long-run elasticities, the short-run coefficients and the speed of adjustment to the long-run equilibrium.

The coefficient of the error correction term -0.59 is negative, greater than -2 and statistically significant at 1% level. It means that the speed of adjustment towards the long run equilibrium is about 59% over each year. From the error correction term one can infer joint causality of the variables, that is, all variables jointly have a long run effect on the dependent variable CCOR. The long term elasticity of GDP per capita relative to CCOR is almost zero and significant at 1% level. The long term elasticity of ICT relative to CCOR is positive and significant at 1% level. The coefficient associated with governmental expenses proves insignificant.

Regarding the short term component (Table 4), the results proved that the coefficients are not significant, implying that on short term, control of corruption is not influenced by neither of the independent variables.

A change in GDP per capita of 1% would lead to an insignificant increase of about 0.000043% in CCOR in the long run. In figure 2 we can see that during 2010-2019 there is a linear positive relation between GDP per capita and control of corruption. This hypothesis is confirmed by Lučić et al. (2016), who use a sample of 40 world countries for the period 1995-2011 and noticed that a change in GDP is deferred six to 10 years after changes in the levels of corruption and vice versa.

A change in ICT of 1% would lead to an increase of about 0.87% in CCOR in the long run. This could be interpreted that ICT could be a tool to combat corruption, findings also supported by the works of Darusalam et al. 2021, Ben Ali and Gasmi, 2017, Sasi and Ben Ali, 2017.

Table 4. The PMG and MG estimators

Variables	PMG		MG	
	Long Run	Short Run	Long Run	Short Run
Error Correction Term (ECT)		-0.59		-2.56
		(0.00)		(0.07)
ΔGDPperCAP		-8.66e-06		0.015
		(0.97)		(0.26)
ΔEXPG		-0.02		4.3
		(0.87)		(0.33)
ΔICT		0.59		4.85

Variables	PMG		MG	
	Long Run	**Short Run**	**Long Run**	**Short Run**
		(0.37)		(0.51)
GDPperCAP$_{t-1}$	0.000043		-0.000064	
	(0.06)		(0.87)	
EXPG$_{t-1}$	0.047		-0.44	
	(0.27)		(0.11)	
ICT$_{t-1}$	0.87		-1.81	
	(0.02)		(0.75)	
Constant		43.89		285.48
		(0.00)		(0.18)
Hausman test	0.04			
	(0.98)			

(*Source*: Author's own determination using STATA)

A two-way scatter plot can be used to show the relationship between ICT and CCOR. As we would expect, there is a positive relationship between ICT and CCOR, as can be seen in Figure 1.

Figure 1. The relationship between ICT and CCOR
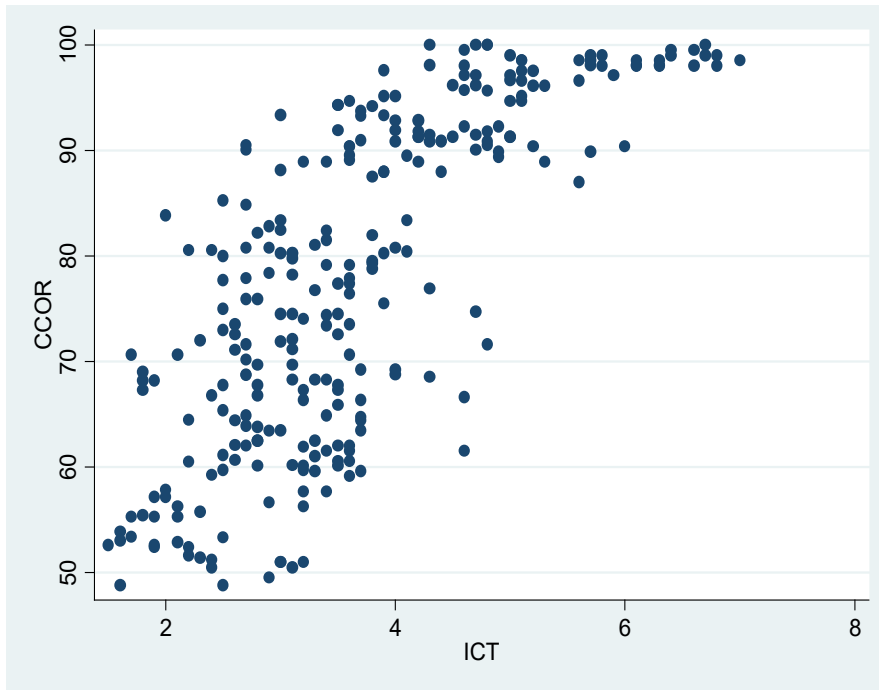
(*Source:* Author's own determination using STATA)

A two way scatter plot can be used to show the relationship between GDPperCAP and CCOR. As we would expect, there is a positive relationship between GDPperCAP and CCOR, as can be seen in figure 2.

Figure 2. The relationship between GDP per CAPITA and CCOR
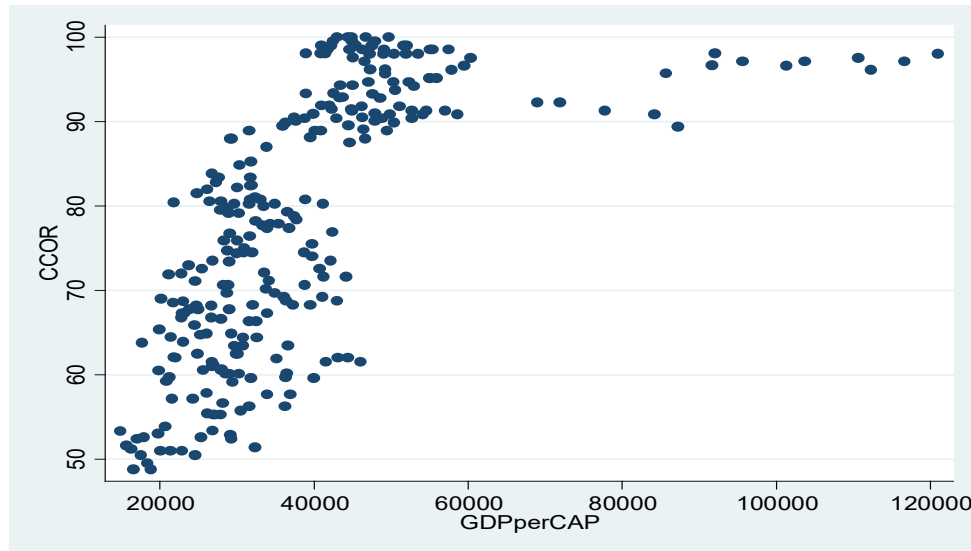
(*Source*: Author's own determination using STATA)

3. Conclusions

This paper presents a panel data ARDL model in which the determinants of corruption are GDP per capita and ICT. The study proposed PMG and MG techniques in order to determine the long and short run relationships between the variables. Applying the long run Hausman test, it followed that the PMG estimator is the most efficient. On short term, we obtained that the coefficients are not significant, implying that control of corruption is not influenced by neither of the independent variables. On long term, the speed of adjustment towards the long run equilibrium is about 59% over each year. From the error correction term one can infer joint causality of the variables, that is, all variables jointly have a long run effect on the dependent variable CCOR.

If we take the explanatory variables separately, the long term elasticity of GDP per capita relative to CCOR is positive, tending to zero and significant at 1% level. Overall, according to Figure 2, the relation between CCOR and GDPperCAP is positive. The long term elasticity of ICT relative to CCOR is positive and significant at 1% level. The coefficient associated with governmental expenses proves insignificant.

In order to reduce corruption and to be able to respond better in similar situations in the future, it is necessary to strengthen supervisory institutions to

ensure that resources reach those most in need. Anti-corruption authorities and supervisory institutions must have sufficient funds, resources and independence to carry out their duties. An open and transparent public procurement system is needed to combat illegalities, identify conflicts of interest and ensure fair prices (Mackey & Cuomo, 2020).

Democratic institutions must defend democracy and provide the necessary civic space to create the conditions under which governments can be held accountable. Publishing relevant data and guaranteeing access to public information must become a continuous practice (Lewis et al., 2020; Lima & Delen, 2020). The widespread integration of ICT and the development of IT applications for administration in the government cloud are both a priority and a necessity in most Member States.

Research shows that although there are differences in the pace and degree of absorption of ICT in the administration, most states, even those advanced in the computerization process, have problems of transparency and corruption in the public sector, which must be managed with professionalism and innovative intelligence.

Authors Contributions

The authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

Conflict of Interest Statement

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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References

Andersen, T. B. (2009). E-Government as an anti-corruption strategy. *Information Economics and Policy*, *21*(3), 201-210. https://doi.org/10.1016/J.INFOECOPOL. 2008.11.003 3.

Androniceanu, A.-M., Căplescu, R. D., Tvaronavičienė, M., & Dobrin, C. (2021). The interdependencies between economic growth, energy consumption and pollution in Europe. *Energies*, *14*(9), 2577. https://doi.org/10.3390/en14092577

Androniceanu, A.-M., Georgescu, I., Tvaronavičiene, M. & Androniceanu, A. (2020a). Canonical Correlation Analysis and a new composite index on digitalization and labor force in the context of the industrial revolution 4.0. *Sustainability*, *12*(17), 6812; https://doi.org/10.3390/su12176812

Androniceanu, A.-M., Kinnunen, J., Georgescu, I. & Androniceanu, A. (2020b). A multidimensional approach to competitiveness, innovation and well-being in the EU using canonical correlation analysis. *Journal of Competitiveness*, *12*(4), 5-21. https://doi.org/10.7441/joc.2020.04.01

Androniceanu, A.-M., Georgescu, I., Dobrin, C. & Dragulanescu, I. V. (2020c). Multifactorial components analysis of the renewable energy sector in the OECD countries and managerial implications. *Polish Journal of Management Studies*, *22*(2), 36-49. DOI: 10.17512/pjms.2020.22.2.03

Androniceanu A., Sabie O. M. & Pegulescu A. (2020). An integrated approach of the human resources motivation and the quality of health services. *Theoretical and Empirical Research in Urban Management*, *15*(1), February, 42-53.

Ang, Y. Y. (2014). Authoritarian restraints on online activism revisited: why "I-paid-a-bribe" Worked in India but Failed in China. *Comparative Politics*, *47*(1), 21-40. https://doi.org/10.5129/001041514813623100

Ardielli, E. (2020). Evaluation of eParticipation service´s availability on Czech municipal websites. *International Journal of Entrepreneurial Knowledge*, *8*(1), 19-33. https://doi.org/10.37335/ijek.v8i2.99

Belas, J., Amoah, J., Petráková, Z., Kliuchnikava, Y. & Bilan, Y. (2020). Selected factors of SMEs management in the service sector. *Journal of Tourism and Services*, *21*(11), 129-146. https://doi.org/10.29036/jots.v11i21.215

Bednárová, L., Michalková, S. & Vandžura, S. (2021). Public procurement in the conditions of the Slovak Republic concerning the participants in the procurement, *International Journal of Entrepreneurial Knowledge*, *9*(1), 67-80. https://doi.org/10.37335/ijek.v9i1.124

Ben Ali, M. S. B. and Gasmi, A. (2017). Does ICT diffusion matter for corruption? An economic development perspective. *Telematics and Informatics*, *34*(8), 1445–1453, https://doi.org/10.1016/j.tele.2017.06.008

Bencsik, A. (2021). The sixth generation of knowledge management – the headway of artificial intelligence. *Journal of International Studies, 14*(2), 84-101. doi: 10.14254/2071-8330.2021/14-2/6

Bilan, Y., Mishchuk, H., Samoliuk, N. & Grishnova, O. (2019). ICT and economic growth: links and possibilities of engaging. *Intellectual Economics*, *13*(1). DOI: https://doi.org/10.13165/IE-19-13-1-07

Burcea, Ş. G. and Abăluță (Sabie), O. M. (2007). Best practices regarding e-services delivering for citizens and business environment. *Theoretical and Empirical Researches in Urban Management*, 2(5), 24-34.

Burhanudddin, Badruddin, S. and Yapid, B.M. (2019) Determinants of citizen's intention to use online e-government services: A validation of umega model. *Polish Journal of Management Studies*, *20* (1), pp.119-128. DOI:10.17512/pjms.2019.20.1.10

Chen, Y. H. and Hsu, P.P. (2014). The divergence of long- and short-run effects of manager's shareholding on bank efficiencies in Taiwan. *Journal of Applied Finance & Banking*, *4*(6), 47-57. Available at http://www.scienpress.com/Upload/JAFB/Vol%204_6_4.pdf

Ciobanu, A. and Androniceanu, A. (2018). Integrated human resources activities - the solution for performance improvement in Romanian public sector institutions, *Management Research and Practice*, 10(3), September, 60-79.

Cuillier, D., & Piotrowski, S. J. (2009). Internet information-seeking and its relation to support for access to government records. *Government Information Quarterly*, *26*(3), 441-449.

Darusalam, D., Sohag, K., Omar, N., & Daid, J. (2021) The influence of ICT on the control of corruption: a study using panel data from ASEAN countries. *International Journal of Public Administration in the Digital Age*, *8*(1), pp. 16-31, DOI: 10.4018/IJPADA.20210101.oa2, Available at:https://www.igi-global.com/pdf.aspx?tid=274017&ptid=254384&ctid=4&oa=true&isxn =97817998 62888

Engle R.F. and Granger, G.W.J. (1987). Co-integration and error-correction: representation, estimation and testing. *Econometrica, 55*(2), 252-276. DOI: 10.2307/1913236

European Commission. Study on corruption in the healthcare sector. 2013 [cited 2015 Sep 9]. Available from: http://ec.europa.eu/dgs/home-affairs/what-is-new/ news/news/docs/20131219_study_on_corruption_in_the_healthcare_sector_en.pdf [Google Scholar]

Fabuš, M., Dudáš, T. &Cihelková, E. 2021. Business environment analysis based on the Doing Business: case study Slovakia. *Insights into Regional Development, 3*(3), 56-65. https://doi.org/10.9770/IRD.2021.3.3(3)

Georgescu I., Kinnunen, J., Androniceanu, A. & Androniceanu, A.-M. (2020). A computational approach to economic inequality, happiness and human development. *Informatica Economica*, *24*(4), December, 16-27.

Godany, Z., Machova, R., Mura, L. & Zsigmond, T. (2021). Entrepreneurship motivation in the 21st Century in terms of pull and push factors. *TEM JOURNAL-Technology Education Management Informatics*, *10*(1), 334-342. https://doi.org/10.18421/TEM101-42

Green, M. (2020). Smart urbanism: autonomous vehicle decision-making algorithms and big data-driven transportation networks. *Contemporary Readings in Law and Social Justice 12*(1), 65–71. doi:10.22381/CRLSJ12120209

Hausman, J. A. (1978). Specification tests in econometrics. *Econometrica*, 46, 1251-1271.

Im, K.S., Pesaran, M.H. & Shin, Y. (2003). Testing for unit roots in heterogeneous panels. *Journal of Econometrics* 115, 53–74. doi: 10.1016/S0304-4076(03)00092-7

Jain, A. K. (2001). Corruption: A review. *Journal of Economic Surveys*, *15*(1), 71-121. https://doi.org/10.1111/1467-6419.00133

Johnston, M. (1996). The search for definitions: The vitality of politics and the issue of corruption. *International Social Science Journal*, *48*(149), 321-335. https://doi.org/10.1111/1468-2451.00035

Johnson, A. (2020). The smart automation of urban governance: sustainable mobilities and data-driven decision support systems. *Contemporary Readings in Law and Social Justice*, *12*(1), 51–57. doi:10.22381/CRLSJ12120207

Khan, M. A., Yasir, M. & Khan, M. A. (2021). Factors affecting customer loyalty in the services sector. *Journal of Tourism and Services*, *22*(12), 184-197. https://doi.org/10.29036/jots.v12i22.257

Kinnunen, J., Georgescu, I., Hosseini, Z. & Androniceanu, A.-M. (2021). Dynamic indexing and clustering of government strategies to mitigate Covid-19. *Entrepreneurial Business and Economics Review, 9*(2), 7-20. https://doi.org/10.15678/EBER.2021.090201

Ključnikov, A., Mura, L. & Sklenár, D. (2019). Information security management in SMEs: factors of success. *Entrepreneurship and Sustainability Issues 6*(4), 2081-2094. https://doi.org/10.9770/jesi.2019.6.4(37)

Kovacova, M. and Lăzăroiu, G. (2021). Sustainable organizational performance, cyber-physical production networks, and deep learning-assisted smart process planning in industry 4.0-based manufacturing systems. *Economics, Management, and Financial Markets*, *16*(3), 41–54. http://doi.org/10.22381/emfm16320212.

Lahkani, M. J., Wang, S., Urbański, M. & Egorova, M (2020). Sustainable B2B E-commerce and blockchain-based supply chain finance. *Sustainability*, *12*(10), art. no. 3968.

Laužikas, M., Miliūtė, A., Morozovaitė, V. & Karpičius, D. (2021). Effectiveness and efficiency criteria for strategic application of mechatronics in business processes, *Insights into Regional Development*, *3*(3), 79-105. https://doi.org/10.9770/IRD. 2021.3.3(5)

Lăzăroiu, G., Kliestik, T. & Novak, A. (2021). Internet of things smart devices, industrial artificial intelligence, and real-time sensor networks in sustainable cyber-physical production systems. *Journal of Self-Governance and Management Economics, 9*(1), 20–30. http://doi.org/10.22381/jsme9120212.

Lăzăroiu, G. and Harrison, A. (2021). Internet of things sensing infrastructures and data-driven planning technologies in smart sustainable city governance and management. *Geopolitics, History, and International Relations*, *13*(2), 23-36. doi: 10.22381/ GHIR13220212.

Lewis, J., Grecu, I. & Grecu, G. (2020). Integrating the autonomous vehicle infrastructure into urban spaces; the social dynamics of data-driven mobilities. *Contemporary Readings in Law and Social Justice 12*(1), 72-78. doi:10.22381/CRLSJ 121202010

Lima, M. S. M. and Delen, D. (2020). Predicting and explaining corruption across countries: A machine learning approach. *Government Information Quarterly*, *37*(1), 101407. https://doi.org/10.1016/j.giq.2019.101407

Lincényi, M. and Čársky, J. (2021). Research of citizens' behavior in a political campaign in searching for and monitoring political advertising in the Slovak Republic. *Insights into Regional Development*, *3*(1), 29-40. https://doi.org/10.9770/IRD.2021.3.1(2)

Lindgren, I., Madsen, C. Ø., Hofmann, S. & Melin, U. (2019). Close encounters of the digital kind: A research agenda for the digitalization of public services. *Government Information Quarterly*, *36*(3), 427-436. https://doi.org/10.1016/j.giq.2019.03.002

Lučić, D., Radišić M. & Dobromirov D. (2016). Causality between corruption and the level of GDP, *Economic Research-Ekonomska Istraživanja*, *29*(1), 360-379. DOI: 10.1080/1331677X. 2016.1169701

Mackey, T.K. and Cuomo, R.E. (2020). An interdisciplinary review of digital technologies to facilitate anti-corruption, transparency and accountability in medicines procurement. *Global Health Action, 13*(1). https://doi.org/10.1080/16549716. 2019.1695241

Marino, A. and Pariso, P. (2021). Digital government platforms: issues and actions in Europe during pandemic time. *Entrepreneurship and Sustainability Issues*, *9*(1), 462-485. http://doi.org/10.9770/jesi.2021.9.1(29)

Maris, M. (2020). Municipal changes in Slovakia. The evidence from spatial data. *European Journal of Geography*, *11*(1), 058-072

Marišová, E., Ilková, Z., Schwarcz, P., Malatinec, T. & Lázárová, E. (2013). Assessment of the state administration effectiveness in the field of small business control in Slovakia. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, *61*(7), 2483-2489

Mas'ud, A., Manaf, N. A. A. & Saad, N. (2019). Trust and power as predictors to tax compliance: Global evidence. *Economics and Sociology, 12*(2), 192-204. doi:10.14254/2071-789X.2019/12-2/11

Mehr, H. (2017). *Artificial intelligence for citizen services and government*. Harvard Kennedy School, Ash Center for Democratic Governance and Innovation. Available at https://ash.harvard.edu/files/ash/files/artificial_intelligence_for_citizen_services.pdf

Mishchuk, H., Samoliuk, N. & Bilan, Y. (2019). Measuring social justice in the light of effectiveness of public distributive policy. *Administratie si Management Public*, 32, 63-76. DOI: 10.24818/amp/2019.32-05

Misuraca, G. and van Noordt, C. (2020). Overview of the use and impact of AI in public services in the EU, EUR 30255 EN, *Publications Office of the European Union*, Luxembourg. Doi:10.2760/039619, JRC120399

Muangmee, C., Kot, S., Meekaewkunchorn, N., Kassakorn, N. & Khalid, B. (2021). Factors determining the behavioral intention of using food delivery apps during covid-19 pandemics. *Journal of Theoretical and Applied Electronic Commerce Research*, *16*(5), pp. 1297-1310. DOI:10.3390/jtaer16050073

Mura, L. (2020). Marketing management of family businesses: results of empirical study. *International Journal of Entrepreneurial Knowledge*, 8(2), 56-66. doi: 10.37335/ijek.v8i2.118

Nica, E. (2021). Urban big data analytics and sustainable governance networks in integrated smart city planning and management. *Geopolitics, History, and International Relations*, *13*(2), 93-106. doi: 10.22381/GHIR13220217.

Nica, E. and Stehel, V. (2021). Internet of things sensing networks, artificial intelligence-based decision-making algorithms, and real-time process monitoring in sustainable industry 4.0. *Journal of Self-Governance and Management Economics*, *9*(3), 35-47. http://doi.org/10.22381/jsme9320213.

Nica, E., Stan, C. I., Luțan (Petre), A. G. & Oașa (Geambazi), R.-Ș. (2021). Internet of things-based real-time production logistics, sustainable industrial value creation, and artificial intelligence-driven big data analytics in cyber-physical smart manufacturing systems. *Economics, Management, and Financial Markets*, *16*(1), 52-62. http://doi.org/10.22381/emfm16120215.

Novak, A., Bennett, D. & Kliestik, T. (2021). Product Decision-Making Information Systems, Real-Time Sensor Networks, and Artificial Intelligence-driven Big Data Analytics in Sustainable Industry 4.0. *Economics, Management, and Financial Markets*, *16*(2), 62–72. http://doi.org/10.22381/emfm16220213.

Pesaran, M. H. & Smith, R. (1995). Estimating long-run relationships from dynamic heterogeneous panels. *Journal of Econometrics, 68*(1), 79-113. Doi: 10.1016/0304-4076(94)01644-F

Pesaran, M. H., Shin, Y. & Smith, R. P. (1999). Pooled mean group estimation of dynamic heterogeneous panels. *Journal of the American Statistical Association*, *94*(446), 621-634. doi: 10.2307/2670182

Poliak, M., Baker, A., Konecny, V. & Nica, E. (2020). Regulatory and governance mechanisms for self-driving cars: social equity benefits and machine learning-based ethical judgments. *Contemporary Readings in Law and Social Justice*, *12*(1), 58-64. doi:10.22381/CRLSJ12120208

Popescu, G. H., Zvarikova, K., Machova, V. & Mihai, E.-A. (2020). Industrial big data, automated production systems, and internet of things sensing networks in cyber-

physical system-based manufacturing. *Journal of Self-Governance and Management Economics*, 8(3), 30-36. http://doi.org/10.22381/JSME8320204

Popescu, G. H., Valaskova, K. & Majerova, J. (2020). Real-time sensor networks, advanced robotics, and product decision-making information systems in data-driven sustainable smart manufacturing. *Economics, Management, and Financial Markets*, 15(4), 29-38. http://doi.org/10.22381/EMFM15420203

Popescu, G. H., Petreanu, S., Alexandru, B. & Corpodean, H. (2021). Internet of things-based real-time production logistics, cyber-physical process monitoring systems, and industrial artificial intelligence in sustainable smart manufacturing. *Journal of Self-Governance and Management Economics*, 9(2), 52-62. http://doi.org/10.22381/jsme9220215.

Remeikienė, R., Gasparėnienė, L., Chadyšas, V. & Raistenskis, E. (2020). Links between corruption and quality of life in European Union. *Entrepreneurship and Sustainability Issues*, 7(4), 2664-2675. http://doi.org/10.9770/jesi.2020.7.4(7)

Russell, H. (2020). Sustainable urban governance networks: data-driven planning technologies and smart city software systems. *Geopolitics, History, and International Relations*, 12(2), 9-15. doi:10.22381/GHIR12220201

Sabie, O. M. (2012). Corruption in water sector. *Administratie si Managemene Public*, 19, 85-96. Available at https://www.ramp.ase.ro/_data/files/articole/2012/19-06.pdf

Sassi, S. and Ben Ali, M. S. (2017). Corruption in Africa: What role does ICT diffusion play. *Telecommunications Policy*, 41(7-8), 662-669. DOI:10.1016/j.telpol.2017.05.002

Shevyakova, A. Munsh, E., Arystan, M. & Petrenko, Y. (2021). Competence development for Industry 4.0: Qualification requirements and solutions: *Insights into Regional Development*, 3(1), 124-135. http://doi.org/10.9770/IRD.2021.3.1(7)

Szeiner, Z., Mura, L., Horbulák, Z., Roberson, M. & Poor, J. (2020). Management consulting trends in Slovakia in the light of global and regional tendencies. *Journal of Eastern European and Central Asian Research (JEECAR)*, 7(2), 191-204. https://doi.org/10.15549/jeecar.v7i2.390

Transparency International. Transparency in health sector procurement. (2020). Available at https://www.transparency.org/files/content/pages/TI_G20_position_paper_-_health_sector_ procurement_transparency.pdf. [Google Scholar]

Vartanova, O., Kolomytseva, O., Bilyk, V., Budnikevich, I., Vasylchenko, L. & Burtseva, T. (2021). Enterprise competitive positioning based on knowledge resources identification. *Entrepreneurship and Sustainability Issues,* 9(1), 529-541. http://doi.org/10.9770/jesi.2021.9.1(33)

Zieziula, J. and Niewiadomska, M. 2021. Location factors of e-commerce distribution centers in Zachodniopomorskie Vivodeship based on the example of a selected company. *Entrepreneurship and Sustainability Issues*, 9(1), 37-51. http://doi.org/10.9770/jesi.2021.9.1(3)