Decreasing Corruption and Increasing Competitiveness through E-Government

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Abstract

This paper investigates the contribution of e-government and the implementation of digital practices in the daily administrative procedures of the state/government to the prevention of corruption and the consolidation of transparency in the transactions between citizens and authorities. It focuses in particular on the period 2007-2021, covering the years 2020 and 2021, when the implementation of digital practices skyrocketed in response to the Covid-19 pandemic. The analysis employs a series of variables that represent the development of e-government and the digitization of public procedures and uses a series of econometric models to detect their impact on (the perceived) corruption, the rule of law and competitiveness in different member-countries of the European Union. These variables express the perceptions of citizens of different European Union countries with respect to digitized public services. The data come from the public databases of the World Bank, the Organization for Economic Cooperation and Development, the United Nations and Eurostat and cover the period 2007-2021. The study provides evidence that e-government and the use of public internet to interact with the public authorities exert significant positive impact on competitiveness at all model specifications; the use of public internet to interact with the public authorities posts significant positive influence on (the fight against) corruption at all models; and the information and communication technology access for business has significant positive effect on the rule of law in the model specifications that use foreign direct investment inflows or outflows as control variables. In contrast the positive impact of e-government on (the fight against) corruption is not statistically significant, whereas its impact on the rule of law was found to be statistically significant and negative. These findings can be of value to the policy makers across the European Union countries as they can at least secure the digitization of the transactions of the citizens with the state, as well as the digital transition of the enterprises as a means to decrease corruption, increase competitiveness and improve the rule of law.

1. Introduction

Since the mid-1990s, governments worldwide have implemented many initiatives to harness the internet's enormous potential to improve governance. Like personal computers, the Internet has emerged as an essential tool for the day-to-day functioning of governments. The Member States of the United Nations (UN), through General Assembly Resolution 66/288 entitled "The Future We Want" (United Nations, 2012), have reaffirmed that democracy, good governance, the rule of law at national and international level, as well as an enabling environment are essential for sustainable development including economic and social development, environmental protection and the eradication of poverty and hunger. Member States also emphasise that Information and Communication Technologies (ICT) facilitate the flow of information between governments and citizens and have recognised the power of communication technologies, including interconnection technologies and innovative applications to promote knowledge sharing, technical cooperation and sustainable development planning capacity.

Digitalisation in the public sector is necessary to align with international standards and reduce corruption (Afonasova et al., 2019). According to Androniceanu & Georgescu (2021), although there are differences between European states in terms of e-government implementation and the impact of ICTs on government efficiency and economic development, the integration of ICTs in the EU public administration has significant contribution to reducing corruption. In European countries where a high level of e-government is implemented, governance is efficient; corruption is low and economic growth is faster.

The study of corruption has been a long-standing concern for scholars. The number of scientific articles published on the subject is constantly increasing, and many international organisations have expressed their intention to help in the fight against corruption. The international recognition reinforces this growing interest that development requires, among other things, good governance, which, in addition to sound policies, targeted incentives and assisted actions, requires a healthy environment in which to grow. Corruption is a severe hostile factor to such an environment's development (Jain, 2001). Corruption is a phenomenon that occurs and develops in societies and public sectors where digitalisation is low, bureaucracy is high, and transparency in organisations is weak.

There is a close and direct link between digitization and corruption prevention. Digitization provides the tools to improve transparency, and efficiency, improve service delivery and reduce corruption. Numerous comparative studies

have demonstrated the correlation between these variables, showing that the digitization of processes is the critical driver for reducing corruption. According to Transparency International's report 2021 (Transparency International, 2022) corruption enables human rights abuses, triggering a staggering increase in such brutal incidents. As freedoms are undermined, democracy is weakened, and authoritarianism is entrenched, increasing corruption levels. The global Covid-19 pandemic has been used in many countries as an excuse to restrict fundamental and set aside basic checks and balances. Despite the ever-increasing global effort to end abuses, even many countries high in international rankings still allow corrupt practices. There is an urgent need to accelerate the fight against corruption in order to stop the violation of human rights and the curtailment of democratic institutions. Consequently, addressing the effect of e-government on corruption is more relevant than ever, expecting that e-government reduces corruption (and thus increases the Corruption Perceptions Index, CPI of a country).

Corruption is though associated with the rule of law and the competitiveness of a country. All of them are key for the economic development of a nation and the prosperity and welfare of its citizens. More specifically, corruption has been found to work against the rule of law (Mirzazadeh, 2021) and has been realized to post a significant effect on the competitiveness of a country (Ulman, 2013). It therefore makes sense to assess the influence of e-government on the rule of law and competitiveness, anticipating that e-government improves both the rule of law and the competitiveness of a country.

This paper contributes to the existing literature by identifying the impact of e-government on corruption prevention, as well as on the rule of law and competitiveness. It further offers a fresh approach by studying the effect of the digitization of enterprises and of citizen transactions with the state on corruption prevention on the rule of law and competitiveness.

The article is organized as follows: Section 2 addresses the literature review. Section 3 presents the methodology employed and the data used. The empirical analysis is deployed in Section 4, with sub-Section 4.1 focusing on the result interpretation. In Section 5 the conclusions are drawn and some policy implications are drafted.

2. Literature Review

E-Government is defined as the use of the internet and the web to provide public information and services to citizens (United Nations, 2002). An alternative definition is given by the United States Department of Agriculture (2002) as the use by the government of applications based on the internet and other information technologies, combined with related processes to 1) Enhance access to and dissemination of public information and services to citizens, businesses and other government agencies; 2) Improve the functioning of government, particularly in terms of effectiveness, efficiency and quality.

Another definition, given by The World Bank (2015) refers to e-government as the use by government authorities of information technologies that have the capacity to interface with citizens, businesses and other public actors. These technologies will provide a range of opportunities: better delivery of services to citizens, improved connectivity with enterprises, empowerment of citizens through access to information, and more efficient public administration. The resulting benefits are less corruption, increased transparency, more satisfaction, economic growth and cost reduction. Finally, according to the European Union/European Parliament, e-government is the use of Information and Communication Technologies by public administration bodies, combined with organisational changes and new skills, which aims to improve services and democratic processes (Gronlund & Horan, 2005; Davis, 2015).

The Member States of the United Nations (United Nations, 2012) through General Assembly Resolution 66/288 entitled "The Future We Want" have reaffirmed that democracy, good governance and the rule of law at national and international level, as well as an enabling environment, are essential for sustainable development including economic and social development, environmental protection and the eradication of poverty and hunger. Member States also emphasise that Information and Communication Technologies facilitate the flow of information between governments and citizens and have recognised the power of communication technologies, including interconnection technologies and innovative applications to promote knowledge sharing, technical cooperation and sustainable development planning capacity.

According to Lincaru et al. (2018), e-government is the process of changing the public sector through digitalisation and the use of new information technologies in public administration, with the ultimate goal of streamlining public administration and increasing the degree of citizen participation in these processes. E-government is manifested as a dominant part of the relationship between the state and society (Androniceanu et al., 2020). Increasing the number of available digital public services implies reduced public administration costs, less bureaucracy for businesses and citizens, and a reduction in corruption (Ślusarczyk & Ul Haque, 2019).

The study of corruption has been a long-standing concern for scholars. The number of scientific articles published on the subject is constantly increasing, and many international organizations have expressed their intention to help in the fight against corruption. The international recognition reinforces this growing interest that development requires, among other things, good governance, which, in addition to sound policies, targeted incentives and assisted actions, requires a healthy environment in which to grow. Corruption is a serious hostile factor to such an environment's development (Jain, 2001).

According to a standard "economic" definition of Shleifer & Vishny (1993), corruption is defined as the alienation of government property by government officials for their own benefit. Corruption entails also the use of specific means

by which private actors seek to advance their interests through government officials or politicians, where the means are determined by the recipient (Munger, 2018). Finally, a generally accepted definition of corruption is the abuse of power for personal gain. Corruption can thus be seen as the misuse of a position in the public administration or its connections to gain profit for oneself or a third party (Bennett et al., 2020).

Although corruption is a phenomenon that is difficult to identify and measure, the consequences of corruption are prevalent, and its adverse effects affect all sectors of society at an economic, political and cultural level. The consequences of the phenomenon can be referred to as primary or immediate but also secondary or posterior. Some acts of corruption primarily cause a redistribution of income, while other forms of corruption directly cause a misallocation of resources (Jain, 2001). Secondarily, corruption as an act of privatization of public power leads to reduced quality of structures, disintegration of the welfare state concept and breakdown of social relations (Kaufmann, 2005). A recent study estimates that the annual cost of corruption in public procurement in the EU Member States amounts to €5.33 billion (Androniceanu et al., 2022).

In the recent decades, various anti-corruption measures have been designed and implemented in states, which are categorised according to the direction of their implementation: Administrative reshuffle, self-regulation of the legislative framework, and social empowerment. The administrative transformation aims to upgrade bureaucratic procedures because it considers the rigidity and inefficiency of the bureaucratic apparatus to be a significant factor in causing corruption. The tightening of the legal framework strengthens the judicial system because a robust judicial framework increases the consequences as well as the penalties for engaging in corruption. Social empowerment emphasises the importance of citizen participation in the decision-making process. The active involvement of citizens in public affairs can structure a society that is a deterrent to corruption in the long run (Park & Kim, 2020). It has been shown that corruption is a phenomenon that occurs and develops in societies and public sectors where digitization is low, bureaucracy is high, transparency in organisations is weak and internal and external communication in management is problematic. Adam & Fazekas (2021) have pointed out that the impact of corruption can be reduced by promoting transparency and citizen participation through ICT.

According to Transparency International's report for the year 2021 (Transparency International, 2022), corruption enables human rights violations, triggering a staggering increase in such brutal incidents. As freedoms are undermined, democracy is weakened, and authoritarianism is entrenched, increasing levels of dissent. The COVID-19 global pandemic has been used in many countries as an excuse to restrict fundamental and set aside basic checks and balances. Despite the ever-increasing global effort to end abuses, even many countries high in international rankings still allow corrupt practices. There is an urgent

need to accelerate the fight against corruption if we want to stop the violation of human rights and the curtailment of democratic institution.

Going to the relation between e-government and corruption, we realize that over the last two decades, many governments worldwide have adopted e-government as an anti-corruption tool. Many researchers have investigated, either through qualitative research based on case studies or quantitative indicators, the impact of e-government in reducing corruption by controlling for the influence of various political, social, economic and technological factors.

The need to implement e-government starts from the essential factor of good governance. Given that Governance is primarily the way in which governments exercise power to manage the social and economic resources of states, good governance encompasses a wide range of actions with the use of Information and Communication Technologies as a critical success factor. By adopting Information and Communication Technologies, governments today can provide a vast array of services, from issuing certificates and professional licenses to issuing data, health services and education with fast, efficient, cost-effective, transparent and corruption-free processes. Good practices worldwide constantly demonstrate that the optimal use of ICTs directly affects the above and accelerates economic growth.

Transparency and the right of access to public information are considered essential factors in enhancing citizen participation, establishing trust in the state, preventing corruption and providing information to citizens (Lupu & Lazăr, 2015) in both EU and non-EU countries at two time instants: 2004 and 2012. Information and Communication Technologies can reduce corruption because they enhance good governance, trigger initiatives to reform services, and weaken the creation of an environment for the growth of corruption. They also provide the possibility of monitoring the steps of administrative processing procedures and, therefore, the control of public officials' behaviour by citizens. In this way, the increased supervision of administrative actions positively affects measures to prevent corruption. Although the authors conclude that e-government reduces corruption, they do so at only two time instants. Linhartová (2017) also finds that the use of ICT and e-government reduces corruption over a set of 117 countries for the period 2003-2014. Our paper extends to a more recent time period, 2007-2021.

Based on the principal-agent-client model, Klitgaard (2000) defines corruption as the asymmetric provision of information. According to this model, the authorities appoint public officials as agents to provide public services and information to citizen clients. Given that the agents possess more information-knowledge management than the other two, the problem of asymmetric information provision always arises. If the agents exploit their position management to satisfy their own interests the asymmetric information management leads to corruption. In this model, there are two sources of potential corruption. Also, with Jain's model (Jain, 2001), as discussed above, three factors are re-

quired for corruption to exist-discretionary power-economic interconnected-ness-loose system of punishment, which, when coexisting, are impossible to avoid corruption. However, the development of e-government can help to reduce these negative factors that create corruption, and thus e-government can be an effective tool for preventing corruption (Zhao et al., 2021). The authors reach this conclusion based on a set of 57 countries over the period of 2003-2014. It seems that e-government has a weak positive impact on corruption; it is the cultural factors that matter more. Our paper studies a more recent period and is more in line with the findings of Zhao et al. (2021) as we find that e-government has positive but not statistical impact on corruption prevention.

In the same wavelength Castro & Lopes (2022) find that e-government can be used to fight corruption over a set of 175 countries during 2003-2019; however, the e-Government Development Index has to be higher than 0.39 in order for the level of corruption to drop. Our paper studies a more recent period up to 2021 and does not necessarily contradict the findings of Castro & Lopes (2022) by not confirming the significance of e-governance as a corruption reduction determinant, as the authors find the e-Governance Development Index has to exceed 0.39.

Similarly, Ali et al. (2021) find that e-government can be used to fight corruption over a set of South Asian countries (Pakistan, India, Bangladesh and Sri Lanka) for the period 2003-2018. Our paper covers a more recent period and studies EU countries.

With the continuous development of e-government, as it is addressed in other dimensions such as e-information, e-transactions, and e-participation, the use of ICT can reduce corruption in all these dimensions. For example, e-information can lessen the provision of asymmetric information. Electronic transactions can lead to a reduction in discretionary power in the management of financial matters. E-participation can also lead to a more enabled society by also reducing discretionary power and providing complete knowledge of political decisions, hence transparency and enhancing democracy (Manoharan, 2013). This study is based on US counties; in contrast our paper extends to the EU countries.

We were not able to find any papers on the relation between e-government and the rule of law. We found very limited research on the relation between e-governance and competitiveness. More specifically Abu-Shanab (2016) realizes that e-government has a significant impact on competitiveness, based on the countries included in the UN e-government readiness index report in 2014. Our paper finds similar results over an extended period (2007-2021).

We were able to identify only a second paper by Thanh & Kim (2016) on the impact of e-government on competitiveness at local level in Vietnam. The authors study 63 local governments in Vietnam to see that e-government can be beneficial for competitiveness in this specific country. In contrast our paper is not limited to one country but extends to the EU countries.

In summary, the literature review clearly unveils the contribution of our pa-

per; when it comes to the relation between e-government and corruption it extends to a more recent period over the EU countries compared to the papers that study the EU countries (Lupu & Lazăr, 2015). It introduces for the first time the analysis of the impact of e-government on the rule of law. Moreover, it advances the very limited research on the effect of e-government on competitiveness, as the available literature is limited either to one year (Abu-Shanab, 2016) or to one country (Thanh & Kim, 2016). Finally, it assesses the influence of the digitization of the citizen transactions with the state as well as of enterprises on corruption, the rule of law and competitiveness.

3. Methodology & Data

The purpose of this study is to examine how e-government affects corruption and competitiveness. To achieve this, the study employs three fixed-effects linear regression models. The models use the (*control of*) *corruption*, the (*rule of*) *law*, and the (*global*) *competitiveness* (index) as dependent variables, as defined in Table 1. The use of the (*rule of*) *law*, rather than corruption, is justified as both are governance indicators recognized globally by The World Bank. It is worth noting that the rule of law and control of corruption are closely interrelated. This relationship is reflected in Table 3, which indicates a significant positive correlation of 0.953 between the two variables.

Each of the models has four variants with regards to the independent variables, which also serve as a robustness check. The main independent variable is the *e-government* (*development index*), which captures the capacity of the (governmental) institutions to deliver e-government services. A variant is produced, when, as an alternative, the *human capital index* (*hci*) is employed, which reflects the ability of the citizens to use e-government services. Two more variants are delivered, when the *foreign direct investment* (*fdi*) *inflows* or *foreign direct investment* (*fdi*) *outflows* are inserted as independent variables.

The remaining variables are *the percentage of individuals using the internet for interaction with public authorities*, the *information and communication technologies* (*ICT*) *access for business*, the *gross domestic product* (*gdp*) *per capita* and *the government expenses as a percent of gdp*. Table 1 provides a comprehensive overview of the dataset, which spans from 2007 to 2020. It includes a concise definition of each variable, the notation utilized in the models, and the data sources used for this study.

Table 2 displays the summary statistics for the variables. Notably, the *corruption* and *law control* variables have a significant standard deviation from their means, representing around 78.2% and 53.5% of their respective means. In contrast, the *global competitiveness* index has a smaller standard deviation from its mean, accounting for roughly 10.5% of its mean value.

Table 3 presents the correlation matrix for the dataset features. The (control of) corruption and (rule of) law have the highest correlation of 0.953. This can be explained by their shared attributes as governance indicators that measure

Table 1. Variable Definition, Notation and Source.

Variables	Variable Definition	Model Notation	Source
Dependent Variables			
Control of corruption	The quality of governance to combat and prevent corruption	corruption	World Bank (2022)
Rule of Law	The extent to which countries adhere to the rule of law in practice	law	World Bank (2022)
Competitiveness Index	The ability of a region to export more in value-added terms than it imports	competitiveness	World Bank (2022)
Independent Variables			
E-Government Development Index	The readiness and capacity of national institutions to use ICTs to deliver public services	egovernment	United Nations (2022)
Human Capital Index	The citizens' ability to use e-government services	hci	United Nations (2022)
Percentage of Individuals using the internet for interaction with public authorities	Individuals using the internet for interaction with public authorities	pubinternet	Eurostat (2022)
ICT access for business	Businesses with a website or home page (%)	ictbusiness	OECD (2022)
GDP per Capita	Gross domestic product per capita converted to international dollars using purchasing power parity rates	gdp	World Bank (2022)
Expense % GDP	Cash payments for operating activities of the government in providing goods and services	expense	World Bank (2022)
FDI net inflows (BoP, current US$)	Foreign direct investment net inflows	Infdi	World Bank (2022)
FDI net outflows (BoP, current US$)	Foreign direct investment net outflows	outfdi	World Bank (2022)

Source: Table created by the authors with input taken from Eurostat (2022), United Nations (2022), OECD (2022) and The World Bank (2022).

perceptions (World Bank (2022). The former reflects public power use for personal gain and the influence of elites and private interests on the state. The latter measures societal confidence in and adherence to rules, such as contract enforcement, property rights, law enforcement, the courts, and the likelihood of crime and violence. Both variables are strongly correlated with the (global) competitiveness index, with correlations of 0.913 and 0.880, respectively. Furthermore, the e-government (development index) exhibits correlations of 0.665, 0.624, and 0.778 with the three independent variables, validating the research question of this paper about the relationship between e-government, corruption, and competitiveness. In contrast, the human capital index has a much lower

Table 2. Summary statistics.

Variable	Obs	Mean	Std.Dev.	Min	Max
corruption	392	1.012	0.791	−0.332	2.446
law	392	1.130	0.604	−0.130	2.130
competitiveness	308	4.728	0.498	3.860	5.662
egovernment	306	0.758	0.0983	0.542	0.976
hci	306	0.801	0.175	0.293	0.974
pubinternet	387	48.87	20.13	5	92
ictbusiness	313	74.99	11.48	42.14	96.28
gdp	420	34318	22758	5885	135683
expense	382	39.43	6.891	22.37	92.38
lninfdi	345	22.89	1.728	17.33	27.32
lnoutfdi	316	22.68	2.175	16.42	27.11

Source: Table created by the authors with estimates based on data retrieved from The World Bank (2022), the United Nations (2022), Eurostat (2022), and OECD (2022).

Table 3. Correlation matrix.

	corruption	law	competitiveness	egoverment	hci	pubinternet	ictbusiness	gdp	expense	lninfdi	lnoutfdi
corruption	1										
law	0.953	1									
competitiveness	0.913	0.880	1								
egovernment	0.665	0.624	0.778	1							
hci	0.122	0.110	0.173	0.503	1						
pubinternet	0.747	0.731	0.725	0.728	0.307	1					
ictbusiness	0.684	0.679	0.716	0.566	0.297	0.661	1				
gdp	0.779	0.735	0.700	0.489	0.0685	0.555	0.484	1			
expense	−0.0877	−0.0233	−0.200	−0.0432	−0.140	−0.0220	−0.384	−0.0660	1		
lninfdi	0.458	0.422	0.536	0.373	0.0314	0.179	0.147	0.428	−0.0816	1	
lnoutfdi	0.605	0.588	0.652	0.438	0.0414	0.305	0.253	0.542	−0.0191	0.834	1

Source: Table created by the authors with estimates based on data retrieved from The World Bank (2022), the United Nations (2022), Eurostat (2022), and OECD (2022).

correlation with all three dependent variables, at 0.122, 0.110, and 0.173, respectively.

Fixed-effects linear regression is a statistical method used in econometrics to examine the relationship between two or more variables. It is a powerful tool that is commonly used to analyze panel data, which is data collected over time from the same individuals, in this case, countries. This paperuses fixed-effects linear regression to estimate the impact of a set of independent variables (Table 1) on three distinct dependent variables (Control of corruption, Rule of Law and Competitiveness Index). The dependent variables are measured over time for a

group of countries, while the independent variables may vary over time or across individuals.

To conduct fixed-effects linear regression, we first transform the data so that we can estimate the model parameters using ordinary least squares (OLS). This involves converting the variables into deviations from their mean values or time-invariant components that vary across countries. The fixed-effects model is constructed by including country-specific dummies in the regression equation, which accounts for the unobserved heterogeneity across the sample. This approach allows us to control for time-invariant factors that may influence the dependent variables, such as country characteristics, and focus on the effect of the independent variables of interest.

The main advantage of fixed-effects linear regression is that it eliminates the bias caused by unobserved heterogeneity and allows us to estimate the causal effect of the independent variables on the dependent variables. In addition, it provides a way to control for the endogeneity of the independent variables by exploiting within-unit variation. This method is particularly useful when we want to estimate the impact of a policy intervention or treatment on the dependent variables, while controlling for time-invariant factors that may influence the outcome. However, the fixed-effects approach has limitations, such as the inability to estimate the effect of time-invariant variables or to generalize the results to the population as a whole.

Before applying the fixed-effects model, we performed a series of diagnostic tests to ensure that the model was appropriate for the data and to identify any potential issues that may affect the validity of the results. The diagnostic tests included the Hausman test, Breusch-Pagan test, Durbin-Watson test, Breusch-Godfrey test, and Cook's distance. We found that all models were appropriate for the data, and no issues were identified that could affect the validity of the results. Therefore, we proceeded with the application of the fixed-effects model.

The empirical analysis in Section 4 aims to determine the effect of e-government on corruption and/or competitiveness. Through this analysis, we try to investigate whether e-government has an impact on these factors.

4. Empirical Analysis

The first (model) variant of the empirical analysisexamines the factors that affect corruption, law and competitiveness as dependent variables (dv). It employs e-government as independent variable and does not incorporate fdi inflows or outflows. It is given by

$$
\begin{aligned}
\mathrm{dv}_{i,t} = a &+ \beta_1 \mathrm{egovernment}_{i,t} + \beta_2 \mathrm{pubinternet}_{i,t} + \beta_3 \mathrm{ictbusiness}_{i,t} \\
&+ \beta_4 \ln \mathrm{gdp}_{i,t} + \beta_5 \mathrm{expense}_{i,t} + \varepsilon_{i,t}.
\end{aligned}
\tag{1}
$$

Table 4 unveils the factors that impact corruption, rule of law and competitiveness. It is worth noting that when using fixed effects modeling, missing values can be a challenge as they can reduce the effective sample size and bias

Table 4. Model estimations w/e-government and w/o FDI inflows or outflows.

Variables	(1) Corruption	(2) Law	(3) Competitiveness
egovernment	0.204	−0.572**	0.442**
	(0.189)	(0.269)	(0.169)
pubinternet	0.003**	0.000	0.003**
	(0.001)	(0.001)	(0.001)
ictbusiness	−0.005*	0.004	0.002
	(0.003)	(0.003)	(0.003)
lngdp	0.258*	0.257*	0.222***
	(0.133)	(0.149)	(0.058)
expense	0.005	0.007**	−0.006***
	(0.003)	(0.003)	(0.002)
Constant	−1.628	−1.580	2.140***
	(1.569)	(1.541)	(0.607)
Observations	242	242	198
R-squared	0.160	0.138	0.468
Hausman Test	81.96***	17.92***	12.60**
Number of Country Code	23	23	23

Notes: Robust standard errors in parentheses. ***p < 0.01, **p < 0.05, *p < 0.1. Source: Table created by the authors with estimates based on data retrieved from The World Bank (2022), the United Nations (2022), Eurostat (2022), and OECD (2022).

parameter estimates. One way to handle missing values is to use methods such as listwise deletion, where any observations with missing values are removed entirely from the analysis. However, this can lead to biased results if the missing data is not missing completely at random. An alternative method is imputation, which involves filling in the missing values with estimated values based on the observed data. This can improve the accuracy of parameter estimates, but the imputation method needs to be carefully chosen to avoid introducing bias or distorting the results. Another option is to use maximum likelihood estimation or Bayesian methods that can handle missing values naturally by incorporating them into the likelihood function. In this study, the first method has been selected given that the missing points are randomly distributed.

The regression results show that e-government has statistically significant negative impact on law and positive on competitiveness. It has positive but not statistically significant impact on corruption.

Going to the remaining variables, pubinternet has statistically significant positive impact on (control of) corruption and competitiveness –both at the 5% level but no statistically significant influence on law.

Furthermore, ictbusiness exhibits a negative and marginally significant impact

on corruption at the 10% level.

Proceeding with macroeconomic variables, one can see that gdp per capita posts statistically positive impact on all three variables (at the 10%, 10% and 1% level respectively).

Expenses, exhibit a statistically significant positive effect on law (at the 5% level) and negative effect on competitivenesss (at the 1% level).

The second (model) variant of the empirical analysisexamines the factors that affect corruption, law and competitiveness as dependent variables (dv), but uses hci as independent variable and does not incorporate fdi inflows or outflows. It is derived by

$$\mathrm{dv}_{i,t} = a + \beta_1 \mathrm{hci}_{i,t} + \beta_2 \mathrm{pubinternet}_{i,t} + \beta_3 \mathrm{ictbusiness}_{i,t} \\ + \beta_4 \ln \mathrm{gdp}_{i,t} + \beta_5 \mathrm{expense}_{i,t} + \varepsilon_{i,t} \tag{2}$$

The regression outputs, as presented in Table 5, indicate that hci is not statistically significant for any of the dependent variables (corruption, law and competitiveness).

This time, pubinternetexhibits statistically significant positive impact on (control of) corruption and competitiveness as well but both at the 1% level.

Table 5. Model estimations with hci and without fdi inflows or outflows.

Variables	(1) Corruption	(2) Law	(3) Competitiveness
hci	−0.033	−0.029	−0.018
	(0.050)	(0.039)	(0.049)
pubinternet	0.004***	−0.001	0.003***
	(0.001)	(0.002)	(0.001)
ictbusiness	−0.003	0.002	0.006*
	(0.003)	(0.004)	(0.003)
lngdp	0.273*	0.207	0.238***
	(0.134)	(0.164)	(0.056)
expense	0.005	0.006*	−0.006***
	(0.003)	(0.003)	(0.002)
Constant	−1.806	−1.156	2.018***
	(1.587)	(1.766)	(0.640)
Observations	242	242	198
R-squared	0.156	0.077	0.439
Hausman Test	62.55***	15.97***	15.85**
Number of Country Code	23	23	23

Notes: Robust standard errors in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. Source: Table created by the authors with estimates based on data retrieved from The World Bank (2022), the United Nations (2022), Eurostat (2022), and OECD (2022).

In addition, ictbusiness exerts a positive and marginally significant impact only on competitiveness at the 10% level.

In this (model) variant, gdp per capita shows a statistically positive impact corruption (at the 10% level) and on competitiveness (at the 1% level).

Expenses exhibit a statistically significant negative influence on competitiveness only at the 1% level.

The third (model) variant of the empirical analysisexamines the factors that affect corruption, law and competitiveness as dependent variables (dv). It employs e-government as independent variable and it further includes fdi inflows among the independent variables. It is given by

$$\text{dv}_{i,t} = a + \beta_1 \text{egovernment}_{i,t} + \beta_2 \text{pubinternet}_{i,t} + \beta_3 \text{ictbusiness}_{i,t}$$
$$+ \beta_4 \ln \text{gdp}_{i,t} + \beta_5 \text{expense}_{i,t} + \beta_6 \ln \text{infdi}_{i,t} + \varepsilon_{i,t}. \quad (3)$$

The regression results, as presented in Table 6, are similar to the first (model) variant, as e-government posts statistically significant negative influence on law and positive on competitiveness. It exhibits positive but not statistically significant effect on corruption.

Table 6. Model estimations with e-government and fdi inflows.

Variables	(1) Corruption	(2) Law	(3) Competitiveness
egovernment	0.091	−0.695**	0.446**
	(0.210)	(0.282)	(0.172)
pubinternet	0.004**	0.000	0.003**
	(0.001)	(0.001)	(0.001)
ictbusiness	−0.004	0.008**	0.001
	(0.003)	(0.003)	(0.003)
lngdp	0.302**	0.291**	0.225***
	(0.134)	(0.138)	(0.063)
expense	0.003	0.006*	−0.007***
	(0.003)	(0.003)	(0.002)
lninfdi	0.002	−0.007	−0.009
	(0.008)	(0.007)	(0.005)
Constant	−2.160	−1.933	2.333***
	(1.570)	(1.393)	(0.663)
Observations	204	204	171
R-squared	0.194	0.195	0.536
Hausman Test	54.18***	9.60*	12.90**
Number of Country Code	23	23	23

Notes: Robust standard errors in parentheses. ***p < 0.01, **p < 0.05, *p < 0.1. Source: Table created by the authors with estimates based on data retrieved from The World Bank (2022), the United Nations (2022), Eurostat (2022), and OECD (2022).

As in the first (model) variant, pubinternet posts statistically significant positive impact on (control of) corruption and competitiveness (both) at the 5% level.

Additionally, ictbusiness has a positive and marginally significant impact only on corruption at the 10% level.

As in the first (model) variant, gdp per capita has statistically positive impact on all three variables (at the 5%, 5% and 1% level respectively).

Expenses exert a statistically significant positive effect on law (at the 10% level) and negative effect on competitivenesss (at the 1% level).

The new variable, fdi inflows, has no statistically significant influence on any of the dependent variables.

The fourth (model) variant of the empirical analysisexamines the factors that affect corruption, law and competitiveness as dependent variables (dv). It uses e-government as well as fdi outflows as independent variable. It is produced by

$$dv_{i,t} = a + \beta_1 egovernment_{i,t} + \beta_2 pubinternet_{i,t} + \beta_3 ictbusiness_{i,t}$$
$$+ \beta_4 \ln gdp_{i,t} + \beta_5 expense_{i,t} + \beta_6 \ln outfdi_{i,t} + \varepsilon_{i,t}. \quad (4)$$

Table 7. Model estimations with e-government and fdi outflows.

Variables	(1) Corruption	(2) Law	(3) Competitiveness
egovernment	0.248	−0.698**	0.469***
	(0.169)	(0.280)	(0.159)
pubinternet	0.003**	0.001	0.003**
	(0.002)	(0.001)	(0.001)
ictbusiness	−0.004	0.007**	0.003
	(0.004)	(0.003)	(0.004)
lngdp	0.310**	0.288**	0.255***
	(0.129)	(0.130)	(0.077)
expense	0.004	0.006*	−0.005**
	(0.003)	(0.003)	(0.002)
lnoutfdi	0.012	0.003	−0.002
	(0.013)	(0.014)	(0.007)
Constant	−2.537	−2.102	1.711**
	(1.490)	(1.315)	(0.813)
Observations	192	192	161
R-squared	0.234	0.185	0.507
Hausman Test	45.52	-	-
Number of Country Code	23	23	23

Notes: Robust standard errors in parentheses. ***p < 0.01, **p < 0.05, *p < 0.1. Source: Table created by the authors with estimates based on data retrieved from The World Bank (2022), the United Nations (2022), Eurostat (2022), and OECD (2022).

The regression results, as presented in Table 7, are also similar to the first and thus third (model) variant, as e-government exerts statistically significant negative impact on law and positive on competitiveness. It shows positive but not statistically significant impact on corruption.

Similar to the first and third (model) variant, pubinternet exerts statistically significant positive impact on (control of) corruption and competitiveness (both) at the 5% level.

Further, ictbusiness posts a positive and marginally significant impact only on corruption at the 10% level.

Similar to the first (model) variant, gdp per capita exerts statistically positive impact on all three variables (at the 5%, 5% and 1% level respectively).

Expenses have statistically significant positive effect on law (at the 10% level) and negative effect on competitivenesss (at the 5% level).

The additional variable, fdi outflows, shows no statistically significant influence on any of the dependent variables.

A robustness check is a method used in research to test the validity of findings by examining the sensitivity of the results to different assumptions or model specifications. In this way, a robustness check serves as an important tool for building confidence in the validity of research findings. Running multiple models with different dependent variables could be one way to conduct a robustness check, but it depends on the research question and the purpose of the analysis. Another way would be to run models with different independent variables.

In this paper we run models with different dependent variables as well as different independent variables. By doing so, we ensure that the findings are not dependent on specific assumptions or specifications and are more likely to hold up across different scenarios or conditions. More precisely, we used 3 different but associated independent variables; corruption, rule of law and competitiveness. Furthermore, for each model, we examined four variants; one that replaces e-government with hci and two more that add fdi inflows and fdi outflows respectively. The effect of e-government, use of internet for interaction with the public authorities, as well the influence of gdp per capita and expenses is confirmed in all variants. Consequently, the robustness of our findings is confirmed.

Result Interpretation

The statistically significant positive impact of e-government on competitiveness in all model specifications that it is employed indicates that when ICT is used to improve the government processes and activities of a country then the country is perceived as a more competitive partner. This is due to the fact that the country is considered as a more reliable partner as e-governments increases transparency, efficiency as well the participation of the citizens in the government functions. The statistically negative impact of e-government on the rule of law in all models that it used needs to be further investigated as one would expect a posi-

tive effect. Finally, although the influence of e-government on corruption in all models that incorporate it is positive, yet it is not statistically significant. Consequently, it needs to be further investigated. The lack of statistical significance of the citizens' ability to use e-government services (as depicted by the human capital index) on all three dependent variables requires further investigation as well.

Contrary to e-government, the increased use of internet to interact with the public authorities (as proxied by pubinternet) has a significant positive impact both on corruption and competitiveness. The former means that the extended digitization of the transactions with the state increases the (perceived) corruption prevention. The increased use of electronic services limits the corruption opportunities as it fosters transparency. Combined with the lack of significance of the effect of e-government on corruption it indicates that e-government is probably not sufficient to fight corruption. Not only the government needs to electronify its processes; the citizens have to electronify their interaction with it. This is a prelude to e-governance rather than e-government. The statistical positive impact on competitiveness is explained by the fact that when the digital interaction with the public authorities is widespread, then transaction becomes immediate and swift and the country is perceived as more competitive. The lack of statistical significance on the rule of law although with a positive sign in the models that use e-government at the same time needs to be further investigated.

The increased digitization of enterprises (as represented by ictbusiness) through a website or home page is beneficial for the rule of law in all models that employ e-government with statistical significance in two out of the three models. This implies that the transparency of the entrepreneurial activities, ensured through their electronification, improves (the perceived) justice. The lack of (or marginal) significance of the said digitization on corruption (even with a negative sign) and competitiveness (with a positive sign) needs to be further investigated.

Going now to the control variables, gdp per capita appears to have positive impact (with varying significance levels) on all three dependent variables. One can infer that countries with higher levels of gdp per capita have already increased (perceived) corruption prevention, rule of law and competitiveness. This is potentially due to the fact that such comparatively "richer" countries can afford to pursue (and have higher declared individual income levels due to) lower corruption and higher feeling of justice as well as increased competitiveness.

Higher expenses incurred by the government for the provision of goods and services lead to higher rule of law (perception) and lower competitiveness as all models (with varying significance levels). Apparently, when a state has increased cash payments for its operating activities then the sense of justice improves. At the same time the country competitiveness deteriorates as such growing payments may discourage/dis-incentivize other countries and/or parties to transact with this country.

In summary, the findings provide evidence that depending on the independent variable (e-government, pubinternet and ictbusiness), the use of ICT improves corruption prevention, the rule of law and competitiveness. The impact is more apparent in competitiveness and less in corruption and rule of law. Especially with regards to corruption, it seems that e-government is not enough to fight corruption; the electronic interaction of citizens with the state is also required in order to improve corruption prevention. The same holds true with enterprises and rule of law.

5. Conclusion and Policy Implications

The fight against corruption as well as the establishment of the rule of law, and the pursuit of competitiveness are important for the countries of the EU. Governments implement a wide range of measures to succeed in these dimensions, among which is the electronification of their activities and processes with the use of ICT, which is known as e-government. This paper employs a series of econometric models to find evidence that e-government and the use of public internet to interact with the public authorities have significant positive impact on competitiveness. It is only the use of public internet to interact with the public authorities that exhibits significant positive effect on (the fight against) corruption. At the same time, the ICT access for business posts positive influence on the rule of law; it is significant in the model specifications that use foreign direct investment inflows or outflows as control variables.

The statistical significance of e-government on corruption prevention is not confirmed although its impact was found to be positive. This means that e-government on its own does not suffice to significantly influence the (perceived) corruption level; the electronic interaction of the citizens with the state is also necessary. Among the control variables, GDP per capita seems to consistently post a significant positive impact on all three dependent variables. Expenses improve the rule of law and have a negative effect on competitiveness.

Policymakers in the EU may put these results to work in order to improve the (perceived) corruption, the rule of law and competitiveness. The structure of the EU governance in these dimensions may facilitate initiatives that promote the fight against corruption, the enhancement of the rule of law and the achievement of competitiveness. More specifically, as the EU, being a regional organization operates within a blended form of governance, in many political sectors it has exclusive competences. This implies that the decision making is only at a European level. There are many other sectors in which national governments can legislate (shared competencies). Competition policy is placed in the first group, meaning that the EU is exclusively responsible for the decision-making process and legislation. There are horizontal rules applied in every member-state regarding competitiveness. Even though this creates a level playing field, the member states of the EU strive to remain competitive via their public adminis-

tration structures where national governments remain the dominant players.

Furthermore, the EU undertakes similar initiatives in the other two dimensions. In the rule of law, it is clear that the EU legislation, implemented via national legislations pushes practices that secure the prevalence of the rule of law and the containment of corruption. This is somehow pushed also via common regulatory frameworks in financial, banking, investments and insurance activities. Still though, the different countries exhibit a wide range of rule of law enforcement and corruption prevention, primarily due to different public administration structures.

Following the findings of the research, as well as the aforementioned balance between EU and national policies, it seems that a digitization nexus needs to be implemented for all the stakeholders of a country; the government, the citizens and the enterprises. The governments need to further employ ICT in order to render their functions leaner. At the same time, citizens need to make use of ICT in their transactions/interaction with the state. Finally, enterprises need to increase the use of ICT in their functions and transactions. All these three lead to increased transparency, efficiency and fair treatment of all stakeholders, which reduces the room left for corruption or injustice. Further, they expedite the transactions, reduce the communication and interaction barriers among countries and create a feeling of easiness in dealing with the said country; which in consequence increases the competitiveness the country.

The EU policymaking seems to incorporate already such a digitization effort since technology and innovation appear to have a positive impact on GDP growth (Apostolopoulos et al., 2022). The EU Green Deal, being at the epicenter of the European Recovery Strategy, provisions a wide range of initiatives that have the green and digital transition of the economies of the EU members as their focal points (Poufinas, 2022; Wacker et al., 2020). Green and digital transition is expected to facilitate the achievement of the EU Green Deal goals.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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