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Assessing the impact of e-government on control of corruption and government effectiveness: Developed and developing countries

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ABSTRACT

This study seeks to investigate the relationship between e-government, fiscal transparency, and corruption across two distinct categories of developed and developing nations. Data were collected from reliable secondary sources spanning the period from 2003 to 2022. The study also integrated additional factors that may influence fiscal transparency and corruption, including budget components (tax revenues and expenses), population density, and economic freedom. To analyze the data, panel data econometric techniques were employed. The results revealed that e-government had a positive and statistically significant effect on controlling corruption and improving government effectiveness in developing countries. In contrast, it exhibited a negative and significant impact on corruption control and government effectiveness in developed countries. The robustness of these findings was confirmed through sensitivity analysis. Overall, the study concluded that e-government plays a crucial role in reducing corruption and enhancing government effectiveness in developing nations. However, in developed countries, it appears to have a counterproductive effect, potentially due to emerging risks in the ICT sector, such as cybercrime, online bribery, and digital fraud, which create new avenues for corruption. This study underscores the importance of implementing e-governance systems and fostering a transparent and accountable environment to mitigate corruption effectively.

Contribution/ Originality: This study contributes to the literature by comparatively analyzing e-government's impact on corruption and government effectiveness across developed and developing countries, addressing a critical gap in existing research from 2003 to 2022.

1. INTRODUCTION

During the late 1990s, the concept of E-government emerged as the Information and Communication Technology sector continued to develop. With the growth of telecommunications, the internet, robotics, and artificial intelligence (Mittal & Kaur, 2013; Zhao et al., 2022), E-government can be conceptualized as the application of Information and Communication Technologies (ICTs)—including the Internet, Wide Area Networks (WAN), and mobile computing—by governmental bodies to revolutionize their engagement with citizens, businesses, and other government entities (World Bank Website; Accessed on: 28/8/2023). It serves to streamline interactions between government and citizens (G2C), government and businesses (G2B), and inter-agency collaborations (G2G), fostering a more accessible, transparent, efficient, and cost-effective framework (Obi, 2007).

The rapid global adoption of E-government is due to governments' ability to create value-added online public services (Pitchay Muthu@ Chelliah, Thurasamy, Alzahrani, Alfarraj, & Alalwan, 2016), enhance efficiency, accountability, and transparency in government functions, revenue generation, and cost reduction (Alenezi, Tarhini, & Sharma, 2015; Lanvin, 2002). Additionally, e-government reduces corruption, particularly in the public sector, by limiting interactions between officials and citizens, accelerating decision-making, and minimizing human error (Hopper, Tsamenyi, Uddin, & Wickramasinghe, 2009) due to e-government supporting numerous purposes. The objective of curbing corruption may remain unachieved unless transparency and accountability are systematically integrated into the public service delivery system, starting from the initial planning and design stages (Singh, Pathak, Naz, & Belwal, 2010).

E-government is considered an essential tool for modernizing governments in the twenty-first century for all countries, both developed and developing, which are classified according to their level of technological and innovative progress (Georgescu, Androniceanu, Kinnunen, & Drăgulescu, 2021). Currently, developing countries are following the initiatives of developed countries to implement e-government systems.

As a result, e-government initiatives are becoming a necessary goal for all countries to enhance accountability and transparency in government, particularly in developing countries that require more support from developed nations and international organizations to renovate, reform, and improve governance (Al-Naimat, Syazwan Abdullah, Rozaini Sheikh Osman, Kabir Ahmad, & Al, 2012; United Nations, 2003). Consequently, e-government initiatives successfully implemented in developed nations may not be directly transferable to developing countries, as each country requires tailored implementation models that account for unique contextual factors, including economic, political, and social dimensions (Yildiz, 2007).

According to Heeks (2003), 85% of E-Government initiatives in developing countries failed to meet their objectives, with 50% categorized as partial failures and 35% as total failures. These shortcomings were primarily attributed to the insufficient resources required for implementing E-Government systems. Only 15% of these initiatives were deemed successful.

Finally, e-government faces challenges and problems in conventional areas of information policy. These challenges might have a negative impact on countries' resources, such as cybercrime, loss of privacy, and risks to environmental sustainability (Seele & Lock, 2017).

The success of e-government initiatives largely hinges on the alignment between their stated objectives—such as economic, political, and social goals—and the specific context in which they are implemented. Key contextual factors, including the governmental framework, economic conditions and stability, cultural norms, ICT infrastructure, and sociopolitical dynamics, play a critical role in enabling governments to effectively realize the aims of e-government (Nour, AbdelRahman, & Fadlalla, 2008).

According to Roztocki and Weistroffer (2009), significant disparities exist between developed and developing countries in the utilization of ICT, particularly in areas such as planning, strategy, design, implementation, sourcing, management, service delivery, security, and user and business engagement.

These gaps contribute to the lower E-Government Development Index (EGDI) observed in developing nations. As illustrated in Figure 1, developed countries consistently achieve high EGDI scores, exceeding the global average of 0.7302 during the period 2003–2022, while developing countries remain in the lower tier of the global EGDI average, classified under the H1 Group within the high EGDI category.

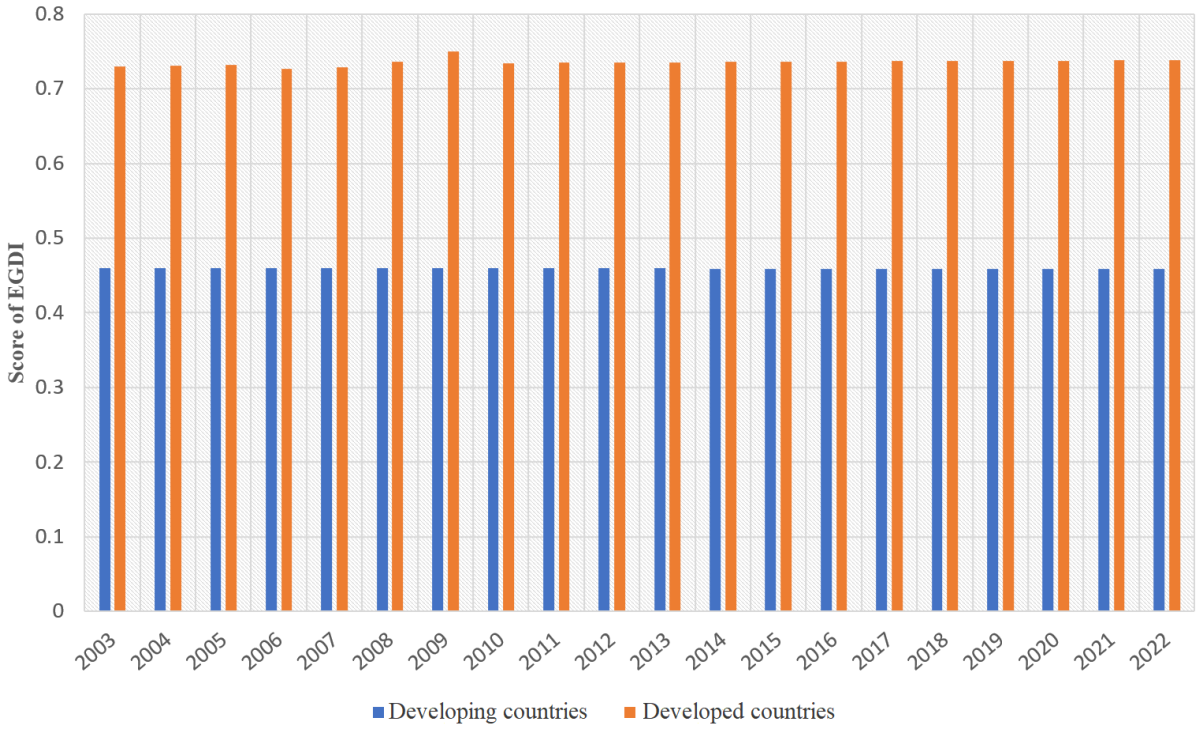

Figure 1. E-government development index (EGDI) trends in developed and developing countries from 2003 to 2022.

In general, developing countries face challenges such as limited ICT expertise, underdeveloped ICT infrastructure, and a focus on short-term operational gains rather than long-term strategic planning. Additionally, the lack of foreign direct investment in the ICT sector further exacerbates these issues. These factors pose significant barriers to advancing E-Government initiatives, which demand a combination of human expertise in commercial, technological, and managerial domains (UNDESA, 2001).

E-government has the potential to foster a more dependable ecosystem. However, as highlighted in the preceding discussion, there remains a contentious theoretical debate regarding the extent to which e-government influences corruption control and the efficacy of government actions, compounded by a scarcity of empirical studies on this relationship. Consequently, several critical questions arise: Is the adoption of e-government essential for economies? Does the interplay between e-government, corruption control, and government effectiveness differ between developed and developing nations? Driven by these inquiries, this paper seeks to provide a comprehensive comparative analysis between countries with varying levels of development and significant disparities in technological integration within their governmental systems.

The remainder of this paper is organized as follows: Section 2 outlines the research hypotheses, grounded in a review of existing literature, to examine the relationship between e-government, corruption control, and government effectiveness. Section 3 describes the methodology and data sample used for the empirical analysis. Section 4 provides an in-depth analysis and discussion of the preliminary and cointegration results for the variables under study, with a distinct focus on developed and developing countries. Finally, Section 5 summarizes the key findings and offers policy recommendations based on the results.

2. LITERATURE REVIEW

Information and communication technologies (ICTs) and e-government have developed and expanded rapidly over the last decade across the world. This significant growth has spurred policymakers' interest in leveraging these advancements to increase GDP per capita. Similarly, investments in ICT infrastructure positively impact economic growth (Khan & Majeed, 2019; Koutroumpis, 2009). However, few studies have explored the relationship between e-government, corruption, and government effectiveness. Therefore, we divided empirical studies into two groups: the

first examines the nexus between e-government and corruption, while the second investigates the nexus between e-government and government effectiveness.

2.1. E-government and Corruption Nexus

By implementing a random effects model for the period 2001–2015 across 42 developed and developing countries, Chen and Ye (2023) revealed that e-government has a significant effect on reducing corruption within governments.

According to Chen and Ye (2023), the results demonstrated a positive effect of e-government in reducing corruption, as analyzed using a random effects model for the period 2001–2015 across 42 developed and developing countries. These findings align with the results of numerous other studies. For instance, Linhartová and Tvrdíková (2018) examined the potential effects of e-government on corruption levels in 28 European Union member nations by employing simple linear regression analysis and correlation coefficients over the period 2003–2016. Similarly, Shim and Eom (2008) used corruption levels to measure corruption in 80 countries during 1995–2000, concluding that corruption could be reduced by strengthening internal and external interactions with citizens and improving the monitoring and control of employees. Additionally, Park and Kim (2020) confirmed the positive role of e-government in controlling corruption across 214 countries during 2003–2016, using a fixed effects model.

In contrast, some studies have found that the effect of e-government on reducing government corruption is marginal. For instance, Krishnan and Teo (2012) used data from 178 countries and employed a simple regression model to reach this conclusion. Similarly, Basyal, Poudyal, and Seo (2018) found no significant effect of e-government on reducing corruption, using a heterogeneous panel data model to investigate this relationship across 176 countries during the period 2003–2014.

Table 1 presents the literature review summary between e-government and corruption.

Table 1. Literature review summary between E-government and corruption.

Study	Model	Dependent variable	Independent variable	Sign.
Chen and Ye (2023)	Random effect	CPI	EGDI	_
Shim and Eom (2008)	Sample regression	CPI	EGDI	_
Park and Kim (2020)	Fixed-effect model	Control of Corruption	EGDI	+
Basyal, Poudyal, and Seo (2018)	FEM.REM	CPI	EGDI	No impact
Kalesnikaite, Neshkova, and Ganapati (2023)	Sample regression	Corruption experience as extra payments	EGDI	-
Chen and Aklikokou (2021)	Two-step cluster analysis	Control of corruption	EGDI	+
Agbozo and Asamoah (2019)	Sample regression	Control of corruption	EGDI	-
Dhaoui (2022)	FEM.REM	Control of corruption	OSI - EGDI HCI- EGDI TII- EGDI	+ - +
Georgescu et al. (2021)	PCA	Control of corruption	EGDI	+

2.2. E-government and Government Effectiveness Nexus

Basyal et al. (2018) examined the relationship between e-government and government effectiveness using panel data from 176 countries during the period 2003–2014. Employing a probability reduction approach in empirical modeling, they found a strong positive relationship between e-government and government effectiveness, indicating that the E-Government Development Index (EGDI) positively influences government effectiveness. Similarly, Agbozo and Asamoah (2019) used linear regression analysis on data from 15 countries and concluded that e-government plays a significant role in enhancing government effectiveness. Their results revealed a positive

relationship between e-government and government effectiveness, highlighting e-government as a key factor in shaping government effectiveness. Krishnan and Teo (2012) also confirmed the positive effect of e-government on government effectiveness across 178 countries using a simple regression model.

Using cluster analysis (with two clusters, A and B), Doran et al. (2023) investigated the effect of e-government—represented by the three pillars of EGDI (Online Service Index [OSI], Telecommunication Infrastructure Index [TII], and Human Capital Index [HCI])—on government effectiveness in European Union countries during 2001–2021. They found that the Telecommunication Infrastructure Index (TII) positively impacts government effectiveness in both clusters. The Human Capital Index (HCI) also positively affects government effectiveness in both clusters, though its impact is greater in Cluster A than in Cluster B. However, the Online Service Index (OSI) was not statistically significant in Cluster A and had a negative impact on government effectiveness in Cluster B. In a similar vein, Dhaoui (2022) observed that government effectiveness is positively influenced by e-government across all EGDI pillars in a sample of 15 MENA region countries during 2003–2018, based on the FEM-REM model.

Table 2 presents the literature review summary between e-government and government effectiveness.

Table 2. Literature review summary between E-government and gov effectiveness.

Study	Model	Dependent variable	Independent variable	Sign
Wallis and Zhao (2018)	GMM model	Gov effectiveness	EGDI	+
Chen and Aklikokou (2021)	Two-step cluster analysis	Gov. effectiveness	EGDI	+
Nam (2019)	2SlS	Gov. effectiveness	EGDI	+
Agbozo and Asamoah (2019)	Sample regression	Gov. effectiveness	EGDI	+
Krishnan and Teo (2012)	Sample regression	Gov. effectiveness	EGDI	+
Doran et al. (2023)	Robust least squares	Gov. effectiveness	OSI - EGDI HCI- EGDI TII- EGDI	- + +
Mensah (2020)	From questionnaire	Government efficiency recorded from questionnaire	E-government performance - level of internet usage and access, education level of citizens/Users,	+
Dhaoui (2022)	FEM.REM	Gov. effectiveness	OSI - EGDI HCI- EGDI TII- EGDI	+ + +
Georgescu et al. (2021)	PCA	Gov. effectiveness	EGDI	+

Based on the summary of the literature presented above, it is evident that e-government has significant effects on governments, corporate organizations, citizens, and economic growth. However, gaps remain in previous studies. The primary focus of earlier research has been to investigate the impact of e-government on corruption and government effectiveness without differentiating among various country groups. Such differentiation is crucial to understanding the unique challenges and experiences of each group in implementing e-government policies. Therefore, the primary objective of this research is not only to measure the effect of e-government on corruption and government effectiveness but also to compare this impact across a sample of 40 countries divided into two groups: developed and developing countries.

3. RESEARCH METHODS AND DATA EXPLANATION

3.1. Variables and Data

In the context of investigating the connections among the usage of information technology, fiscal transparency, and control of corruption, data was collected for a sample of 40 countries (divided into two groups of developed [1]and developing[2]) over the period 2003-2022. The main sources of data are the UN E-Government knowledgebase for the E-Government Development index (EGDI), World Bank Databank (for fiscal transparency proxied by government effectiveness (GE) as estimated by Dhaoui (2022) ,control of corruption (CC), tax revenue (TR), expenses (EXP) and population density(pop), finally the heritage foundation for economic freedom (EF). Table 3 includes definitions of different variables and data sources.

Table 3. Variable description and data sources.

Variables	Symbol	Source
E-government development index	EGDI	**UN E-Government knowledgebase** https://publicadministration.un.org/egovkb/en-us/Data-Center
Government effectiveness	GE	https://databank.worldbank.org/source/world-development-indicators
Control of corruption	CC	
Expense (% of GDP)	EXP	
Population, total	POP	
Tax revenue	TR	
Economic freedom	EF	https://www.heritage.org/index/

3.2. The Model

A general functional form of our analysis modeled in the equation below.

$$GE_{it}, CC_{it} = f\left(EGDI_{i,t}, (TR_{it}), (EXP_{it}), (POP_{it}), (EF_{it})\right) \quad (1)$$

Where: Dependent variables are GE (government effectiveness), CC (control of corruption); EGDI $_{i,t}$ addresses the primary explanatory variable related to the countries.

$$GE_{it} = a + \in_1 (EGDI_{it}) + \in_2 (TR_{it}) + \in_3 (EXP_{it}) + \in_4 (POP_{it}) + \in_5 (EF_{it}) + \mu_t \quad (2)$$

$$CC_{it} = a + \in_1 (EGDI_{it}) + \in_2 (TR_{it}) + \in_3 (EXP_{it}) + \in_4 (POP_{it}) + \in_5 (EF_{it}) + \mu_t \quad (3)$$

Where i denotes the number of the countries (i = 1,2,3,4....20) in Developing countries and(i = 1,2,3,4…..20) in developed countries, t indicates the time dimension (from 2003 to 2022), a an intercept, and μ itis the stochastic term, $\in_1, \in_2, \in_3, \in_4, \in_5$ are the parameters.

3.3. Econometric Methodology

This research employs a dual methodological framework, incorporating both panel regression and panel cointegration analytical approaches. The empirical analysis commenced with the application of three panel regression estimators: pooled ordinary least squares (OLS), fixed effects, and random effects specifications. To ensure model specification robustness, we subsequently implemented the Hausman test to statistically identify the most appropriate estimator between the fixed effects and random effects formulations (Hausman, 1978).

The estimation of the panel cointegration model incorporates Pedroni's group mean Fully Modified Ordinary Least Squares (FMOLS) and Dynamic Ordinary Least Squares (DOLS) methodologies. This approach demonstrates superior capability relative to conventional panel regression techniques in accounting for heterogeneous country-

[1] Italy, New Zealand, Portugal, Bosnia and Herzegovina, Spain, France, Germany, Hungary, Iceland, Ukraine United States of America, Slovakia, Armenia, Norway, Canada, Luxembourg, Poland, Netherlands, Australia, Sweden

[2] Egypt, Brazil, Morocco, Malaysia, Malawi, Saudi Arabia, United Arab Emirates, Angola, Ethiopia, Ghana, Jordan, Mali, South Africa, Uruguay, Zambia ,Cote d'Ivoire ,Sri Lanka ,Singapore ,Lebanon ,Guatemala.

specific effects. The selection of group mean FMOLS and DOLS estimators was predicated on their methodological advantages in handling both cross-sectional dependence and parameter variability across cointegration relationships. (Pedroni, 2001). Model specification employed the Schwarz Information Criterion (SIC) to establish the optimal lag structure for the Dynamic OLS (DOLS) estimation. Furthermore, comprehensive diagnostic testing—including panel unit root and cointegration analyses—was performed to verify the appropriateness of both FMOLS and DOLS frameworks, given their fundamental requirement that all variables specified in Equation 1 maintain cointegrated relationships.

The empirical implementation of FMOLS and DOLS methodologies is contingent upon establishing cointegration among the variables in Equation 1. These estimators become inapplicable when unit root and cointegration tests fail to demonstrate cointegrated relationships. For the unit root analysis, we implemented two established first-generation panel tests: (1) the Maddala and Wu-Fisher Augmented Dickey-Fuller (ADF) test, and (2) the Maddala and Wu-Fisher Phillips-Perron (PP) test - both seminal approaches in panel unit root analysis (Maddala & Wu, 1999).

After determining the order of integration of the time series data using these stationarity tests, we conducted the Pedroni panel cointegration test. This residual-based cointegration test is particularly advantageous as it accommodates heterogeneous coefficients within the panel model. (Pedroni, 1999, 2004)

4. EMPIRICAL RESULTS AND ANALYSIS

The empirical analysis was conducted using the FMOLS and DOLS models. The study examined a sample of 20 developed and 20 developing economies, focusing on composite e-governance indicators, government effectiveness, and corruption control. The analysis was carried out across the full panel and through cross-country evaluations, providing long-run estimators to inform country-specific policy decisions and implications.

4.1. Descriptive Statistics

Table 4 presents a summary of the dynamic data for all variables included in Equation 1. The dataset comprises 40 cross-sections, divided into 20 developed (ED) and 20 developing (ING) economies, spanning 19 time periods. In total, this results in 380 observations for each sample.

Table 4. Summary statistics for developed and developing countries.

Descriptive statistics	CC		GE		EGDI		TR		EXP		POP		EF	
	ED	ING	ED	ING	ED	ING	ED	ING	ED	ING	ED	ING	ED	ING
Mean	1.05396	-0.1	1.0495	-0.0833	0.73	0.4617	19.6549	13.1977	34.8481	20.8378	4017636	3688305	69.4384	60.8368
Median	1.33	-0.32	1.4095	-0.2278	0.7677	0.4767	20.4816	13.3913	36.7519	20.546	1668561	2167000	69.5	59.1
Max	2.35	2.3	2.07	2.47	0.9432	0.915	37.6128	25.6501	52.0329	38.4811	3.3308	2.1508	84.4	89.7
Min	-1.12	-1.48	-1.08	-1.46	0.309	0	8.5632	0.042	16.402	3.7921	289521	3310202	40.6	43.5
Std. dev.	0.9815	0.8206	0.8194	0.8239	0.1371	0.1966	5.2919	5.496	7.9193	8.2185	6842542	4622619	8.4473	9.0118

For the governance indicator (i.e., control of corruption (CC) and government effectiveness (GE)), the negative mean values for developing countries showed that they performed poorly in their stated governance indicators, while positive values for developed countries and those moving towards the threshold point indicate a progressive move towards the judicious distribution of resources. In the empirical literature, the development process is widely regarded as a critical factor influencing the diffusion of governance. It is often posited that wealthier nations exhibit lower levels of corruption and greater governance effectiveness. This is attributed to higher income levels, which facilitate advancements in human capital, public resource management, the rule of law, and related areas. Additionally, the development process is typically accompanied by institutional, sociological, and demographic transformations that further reinforce these outcomes (Treisman, 2000).

In terms of e-government development, it has been noted that developed countries possess higher EGDI scores than developing countries. According to a United Nations (2003), the global average EGDI is roughly 0.599, which is higher than the developing sample average (0.476). This might be understood to mean that developing countries have large public sectors along with complicated regulatory regimes. The adoption of Information and Communication Technologies (ICTs) to modernize public institutions has emerged and continues to grow. However, the benefits derived from such initiatives remain limited. Additionally, digital and data-related skills are still in short supply and unevenly distributed across regions. Fiscal constraints further pose a significant challenge to the implementation of digital government programs (OECD, 2017).

4.2. Correlational Statistics

Table 5 presents the correlation coefficients and their corresponding probability values for the variables under study. The results indicate that all variables are significantly correlated with the control of corruption (CC) and government effectiveness (GE) in both developed and developing economies. Notably, the development of e-governance exhibits a correlation exceeding 50% in both groups, with CC and GE values for developed countries at 74.9% and 74.6%, respectively, and for developing countries at 74.2% and 80.5%. This suggests that greater expansion in e-governance improves governance indicators more significantly than other regressors.

Table 5. Correlation matrix for developed and developing countries.

Variable symbol	CC		GE		EGDI		TR		EXP		POP		EF	
	ED	ING	ED	ING	ED	ING	ED	ING	ED	ING	ED	ING	ED	ING
CC	1.0000	1.0000												
GE	0.9570 ***	0.9169 ***	1.0000	1.0000										
EGDI	0.7491 ***	0.7428 ***	0.7463 ***	0.8054 ***	1.0000	1.0000								
TR	0.2158 ***	-0.0695	0.1573 ***	-0.0526	0.0983 *	-0.0526	1.0000	1.0000						
EXP	-0.1274 ***	-0.0509	-0.1074 **	-0.0398	-0.0688	0.2622 ***	0.4472 ***	0.5939 ***	1.0000	1.0000				
POP	0.0637	-0.2082 ***	0.1208 **	-0.1782 ***	0.3101 ***	0.0371	-0.5528 ***	0.0209	-0.2881 ***	0.3545 ***	1.0000	1.0000		
EF	0.7798 ***	0.9012 ***	0.7705 ***	0.8984 ***	0.6556 ***	0.7027 ***	0.0831 *	-0.0479	-0.4448 ***	-0.0872 *	0.1207 **	-0.3103 ***	1.0000	1.0000

Note: ***, ** and * are 1%,5% and 10% significance level respectively.

Table 6. Augmented dicky fuller (ADF) and Phillips- perron (PP) unit root test.

Variable symbol	ED						ING					
	ADF			PP			ADF			PP		
	Level	1st difference	Order	Level	1st difference	Order	Level	1st difference	Order	Level	1st difference	Order
CC	12.757	(107.006) ***	I (1)	38.678	(843.586) ***	I (1)	37.284	167.348 ***	I (1)	65.457	1070.80 ***	I (1)
GE	28.915	(150.419) ***	I (1)	59.680	(1001.29) ***	I (1)	46.320	154.651 ***	I (1)	62.217	562.024 ***	I (1)
EGDI	15.034	158.546 ***	I (1)	36.632	983.686 ***	I (1)	9.734	150.945 ***	I (1)	16.856	1214.66 ***	I (1)
TR	36.391	153.711 ***	I (1)	59.185	607.523 ***	I (1)	35.602	181.378 ***	I (1)	51.948	637.054 ***	I (1)
EXP	32.0985	167.137 ***	I (1)	64.7312	759.415 ***	I (1)	25.032	161.097 ***	I (1)	48.574	701.135 ***	I (1)
POP	6.15147	103.273 ***	I (1)	9.49983	3081.36 ***	I (1)	6.039	130.216 ***	I (1)	6.1092	3990.20 ***	I (1)
EF	41.2346	109.641 ***	I (1)	55.5750	210.158 ***	I (1)	31.042	101.981 ***	I (1)	50.161	204.621 ***	I (1)

Note: *** 10%significance level respectively.

4.3. Data Diagnostics

4.3.1. Panel Unit Root Tests

To assess the stationarity of the dataset, panel unit root tests, including the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests, were conducted.

The results, summarized in Table 6, indicate that all variables were consistent and stationary at the first difference in both the ADF and PP tests.

This suggests that each variable is integrated of order one, warranting further analysis of the cointegration relationship between the dependent variables and regressors. The null hypothesis (H0: presence of a unit root) was rejected, and the alternative hypothesis (H1: absence of a unit root) was accepted across all tests, supporting the inference of first-order stationarity.

Initially, descriptive statistics and panel unit root estimations were employed to identify potential cointegration relationships. Subsequently, various cointegration tests, such as the Pedroni panel cointegration test, were applied to explore these relationships further.

The Pedroni cointegration test is designed to accommodate large time series (T) and cross-sectional (N) dimensions, enabling the examination of cointegrated relationships among the specified variables. The model produces seven test statistics, categorized into individual and group dimensions, with the significance levels determining the presence of cointegration.

As shown in Table 7, the alternative hypothesis is accepted at the 1% significance level, supported by two within-dimension tests (PP statistics and ADF statistics). Consequently, four out of the seven tests confirm that all variables exhibit long-term cointegration at the first difference, I (1, 1).

Table 7. Pedroni cointegration test.

Tests	ED		ING	
	Statistic	**Prob.**	**Statistic**	**Prob.**
PANEL V-STATISTIC	-1.876	0.9697	-1.3594	0.9130
PANEL RHO-STATISTIC	2.00493	0.9775	2.365	0.9910
PANEL PP-STATISTIC	-6.175	0.0000	-6.046400	0.0000
PANEL ADF-STATISTIC	-5.7410	0.0000	-5.845	0.0000
GROUP RHO-STATISTIC	3.599	0.9998	4.608	1.0000
GROUP PP-STATISTIC	-9.5009	0.0000	-7.775	0.0000
GROUP ADF-STATISTIC	-7.15010	0.0000	-6.607	0.0000

4.3.2. Panel Modelling and Hypotheses

In this study, the following hypotheses are considered to examine the impact of e-government on the control of corruption and government effectiveness for the analysis of 40 countries, divided into two groups—developed and developing—two methodological approaches were employed to investigate the relationship. The first approach utilized pooled OLS, fixed effects, and random effects models, as presented in Tables 8 and 9. The second approach applied the Fully Modified OLS (FMOLS) and Dynamic OLS (DOLS) models, with the results detailed in Tables 10 and 11.

Hypothesis 1: The impact of e-government on control of corruption is positive.

Hypothesis 2: The impact of e-government on the control of corruption differs between developed and developing countries.

Hypothesis 3: The impact of e-government on government effectiveness is positive.

Hypothesis 4: The impact of e-government on government effectiveness differs between developed and developing countries.

Table 8. Regression estimation for control of corruption.

Variable symbol	POOLED		FIXED		RANDOM	
	Ed	Ing	Ed	Ing	Ed	Ing
EGDI	2.8543***	1.0471***	-0.4957***	0.273***	-0.4220	0.4698***
TR	0.0058	0.0039	0.0040	0.0147***	0.0078	0.0138***
EXP	0.0150***	-0.0082***	0.0032	-0.0115***	-0.0036	-0.0116
POP	-0.0000**	0.0000	-0.0000**	0.0000***	-0.0000	-0.0000***
EF	0.0673***	0.0665***	0.0065***	0.0187***	0.0184 ***	0.0240***
R2	0.7367	0.8394	0.9782	0.9703	0.0727	0.2473
HAUSMAN TEST	177.5671	63.5750				
PROB	0.0000	0.0000				

Note: ***, ** are 5%and10%significance level respectively.

Table 9. Regression estimation for government effectiveness.

Variable symbol	POOLED		FIXED		RANDOM	
	Ed	Ing	Ed	Ing	Ed	Ing
EGDI	2.1194***	1.8464***	-0.9532***	0.5873***	-0.8602***	0.8613***
TR	-0.0062	0.0164***	0.0058	0.0228***	0.0105***	0.0216***
EXP	0.0218***	-0.0188***	-0.0039	-0.0062	-0.0081***	-0.0083 **
POP	-0.0003	0.0000***	-0.0009***	-0.0000	0.000000	-0.0000*
EF	0.0619***	0.0543 ***	0.0090***	0.024045***	0.0208***	0.0354 ***
R2	0.7244	0.8810	0.9809	0.963	0.1736	0.4222
HAUSMAN TEST	286.3027	102.6366				
PROB	0.0000	0.0000				

Note: ***, **and*are 1%,5%and10%significance level respectively.

Table 10. Estimation results for the FMOLS and DMOLS models of control of corruption.

Variable symbol	FMOLS		DOLS	
	Ed	Ing	Ed	Ing
EGDI	-0.6902 ***	0.339 **	-2.557 ***	0.2794
TR	0.0074	0.0183 ***	0.053151 *	0.0054
EXP	0.0042	-0.0139 ***	0.009070	-0.0089
POP	-0.0000	0.0000	-0.0000	0.0000
EF	0.008636 ***	0.02202 ***	0.0438 **	0.0168
R2	0.978224	0.9706	0.9993	0.9910

Note: ***, **and*are 1%,5%and10%significance level respectively.

Table 11. Estimation results for the FMOLS and DMOLS models of government effectiveness.

Variable symbol	FMOLS		DOLS	
	Ed	Ing	Ed	Ing
EGDI	-1.0699 ***	0.6645***	-1.3138 ***	1.0663 **
TR	0.0096*	0.0278***	0.0262	0.0006
EXP	-0.0013	-0.0070	-0.0091	-0.0158
POP	-0.0000 ***	-0.0000	-0.0000	-0.0000
EF	0.0105 ***	0.0281 ***	0.0191	0.0245
R2	0.9819	0.9639	0.9993	0.9985

Note: ***, **and*are 1%,5%and10%significance level respectively.

4.3.3. The Impact of E-Government (EGDI) on Control of Corruption (CC) and Government Effectiveness

Tables 8 and 9 Tables 10 and 11 present the results of the pooled OLS, fixed effects, and random effects models. After applying these methodologies, the Hausman test indicated that the fixed effects model provided the most robust estimation of the impact of e-government (EGDI) on the control of corruption (CC) and government effectiveness (GE). The fixed effects model revealed a statistically significant positive relationship between EGDI and both CC and GE in developing countries (Ing), with coefficients of 0.272*** and 0.587***, respectively. This suggests that a 1% increase in EGDI improves the control of corruption by 0.272 and enhances government effectiveness by 0.587 in

developing countries. Conversely, in developed countries (Ed), EGDI exhibited a statistically significant negative impact on CC and GE, with coefficients of -0.495*** and -0.953***, respectively. This implies that a 1% increase in EGDI reduces the control of corruption by 0.495 and government effectiveness by 0.953 in developed countries.

These findings are consistent with the long-run results from the FMOLS and DOLS models, as shown in Tables 10 and 11, which also demonstrate a positive and statistically significant relationship between EGDI and CC/GE in developing countries, but a negative and statistically significant relationship in developed countries. These results are consistent with prior studies (Chen & Aklikokou, 2021; Park & Kim, 2020).

According to the empirical results presented in Tables 8–11, a statistically significant positive relationship between e-government (EGDI) and both control of corruption (CC) and government effectiveness (GE) has been confirmed in developing countries. In contrast, a statistically significant inverse relationship was observed in developed countries. This suggests that developing countries benefit more from e-government initiatives in reducing corruption compared to developed countries. Historically, developing countries have faced higher levels of corruption, providing greater room for improvement, whereas developed countries, with historically lower corruption levels, have limited scope for further reduction.

Furthermore, as argued by Tanzi and Davoodi (2013), corruption in developed countries may function as a form of payment for expedited services and efficiency, particularly among wealthier individuals. Additionally, we contend that the challenges faced by developed countries in controlling corruption stem from emerging risks in the ICT sector, such as cybercrime, online bribery, and digital fraud. These risks create new avenues for corruption and undermine transparency, thereby limiting the effectiveness of e-government initiatives in these nations.

5. CONCLUSION AND POLICY IMPLICATION

Utilizing panel data techniques, this study examines the impact of e-government on the control of corruption and government effectiveness. The analysis covers a dataset spanning from 2003 to 2022, encompassing 20 developed and 20 developing countries. The findings reveal that e-government has a significant and positive influence on the control of corruption and government effectiveness in developing countries. Conversely, it exhibits a negative and significant impact in developed countries for both variables.

To date, the effects of digitalization on developing economies have been limited. Unlike in developed regions, where digital advancements have transformed business climates, enhanced connectivity, stimulated economic activity, generated employment, and improved public service delivery, digitalization has yet to achieve a similar transformative impact in developing countries. These nations continue to lag behind in the digitalization of public services, as well as in the adoption of digital technologies by businesses and the financial sector.

Previous studies highlight several critical success factors and strategies essential for enhancing e-government performance in both developed and developing countries. Each nation must carefully evaluate these factors when designing and implementing e-government programs. Key elements include the development of e-government infrastructure, enhancing employee capabilities within governmental organizations, strengthening educational institutions, and training government officials. Additionally, countries must address challenges related to political, social, cultural, and technical factors, as well as public sector reforms and human resource development.

The findings of this study carry significant policy implications for both developing and developed countries. For developing nations, the positive and significant impact of e-government on the control of corruption and government effectiveness underscores the importance of investing in digital governance initiatives. Policymakers should prioritize building robust e-government infrastructure, enhancing digital literacy, and fostering institutional reforms to maximize the benefits of digital transformation. In contrast, the negative impact observed in developed countries highlights the need for these nations to address emerging risks associated with digitalization, such as cybercrime, online bribery, and digital fraud. Developed countries should focus on strengthening cybersecurity measures, improving transparency, and adapting e-government frameworks to mitigate unintended consequences. These

insights emphasize the necessity of context-specific strategies, as the effectiveness of e-government initiatives varies significantly across different stages of economic and institutional development.

Future research should explore the challenges, opportunities, strengths, and weaknesses associated with the implementation of e-governance programs in both developed and developing countries. Such studies would provide deeper insights into how these initiatives can be optimized to combat corruption and improve government effectiveness. By examining the diverse experiences of countries at different stages of development, researchers can identify best practices, address barriers, and develop tailored strategies to enhance the impact of e-governance. This will contribute to a more nuanced understanding of the role of digital transformation in governance and inform evidence-based policymaking.

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