


# The Influence of ICT on the Control of Corruption: A Study Using Panel Data From ASEAN Countries

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## ABSTRACT

Corruption might occur in many places within the government. Information and communication technology (ICT) can be used to create a more open and transparent government enabling the control of corruption (CoC). The research presented in this paper aims to analyze the effect of ICT on CoC in open government. Using panel data of ASEAN countries over 33 years from 1984 to 2016, this study examined the data utilizing panel auto-regressive distributed lags (ARDL). The results of this study reinforce the existing literature on the positive effects of ICT on CoC. However, the assumed relationship is more complicated than often assumed. This study shows the presence of a quadratic (non-linear) inverted u-shaped relationship between the ICT development and CoC, which implies that there is no further opportunity for ICT alone to reduce corruption once a threshold is reached. ICT might even be used to facilitate corruption. Hence, ICT needs to be complemented by institutional and organizational measures and education to fight corruption.

## KEYWORDS

ASEAN Countries, Control of Corruption, Corruption, E-Government, ICT, ICT4Development, Open Government

## 1. INTRODUCTION

Civil society's struggle against corruption is more and more facilitated by Information and Communication Technology (ICT). E-government can fight corruption by enhancing the supervision role of the public (Ionescu, 2015). Digital technologies are often viewed as a way to improve trust, transparency, and accountability by sharing information with the public (John Carlo Bertot, Paul T Jaeger, & Justin M Grimes, 2010; Marcovecchio, Thinyane, Estevez, & Janowski, 2019; Ohemeng & Ofosu-Adarkwa, 2014). Transparency is often considered as being essential for detecting fraud and empower those who are fighting corruption. Typically, corruption happens in secrecy, and by making transparent what happens can be used to detect corruption. Often information is only available to a

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limited number of stakeholders, and transparency ensures that the information is widely available for the public. Transparency supports the creation of accountability by providing the public with information about what is happening inside the government. This enables to detect that corruption might occur but can also prevent corruption as misbehavior becomes more easily visible. Being accountable implies responsibility for one's actions and their consequences (Roberts, 2002).

Corruption is a problem in the public and private sector and comes in many shapes and forms, including bribery (Huijboom & Van den Broek, 2011), embezzlement (Amundsen, 1999), theft (Shleifer & Vishny, 1993), extortion (Hindriks, Keen, & Muthoo, 1999), abuse of power (Waite & Allen, 2003), discretion (Johnson, Kaufmann, & Zoido-Lobaton, 1998), favoritism (Leitner, Meissner, & Martyna-David, 2015), conflicting interest (Fadiaro, Fadiaro, & Aminu, 2014), and improper political contribution (John C Bertot, Paul T Jaeger, & Justin M Grimes, 2010). The consequences of corruption are diverse. Corruption can harm society and result in increased poverty, diminishing money available for essential government services, destroy citizen trust in government, and undermining economic growth.

Often ICT is assumed to result in a reduction of corruption, but its relationship is rarely tested, and the testing has resulted in mixed and even contested results. ICT effect on Corruption remains empirically underexplored due to a lack of measurements (Žuffová, 2020). Vasudevan (2006) found mixed results for ICT impact on corruption and concluded that key policy choices, and not merely the technology employed, helps to reduce corruption. Furthermore, Lio, Liu, and Ou (2011) used a panel analysis of secondary data for 70 countries and found that Internet adoption is positively related to corruption reduction. However, they argued that the causality between Internet adoption and corruption is bidirectional. Mistry and Jalal (2012) found that corruption can be mitigated through initiatives that enable transparency and accountability. Charoensukmongkol and Moqbel (2014) demonstrated that a country's ICT investments could have both negative and positive effects on corruption. Heeks, Mundy, and Salazar (1999) suggested that using ICT in developing countries suffers from the "conception-reality gap," in which the expectations of preventing corruption using ICT are not reflected in practice.

At the same time, countries try to control corruption by measuring this. According to the WorldBank (2016), *Control of Corruption (CoC)* is an indicator measuring 1) the extent to which public power is exercised for private gain, 2) the extent that the state focused on by elites and private interests, and 3) the strength and effectiveness of a country's policy and institutional framework to prevent and fight corruption. CoC measures corruption among public officials, public trust in politicians, diversion of public funds, corruption in government, level of petty corruption between administration and citizens, level of corruption between administrations and local businesses, and the level of corruption between administrations and foreign companies (WorldBank, 2016). According to Tarnoff (2009), types of CoC measures include both petty and grand types of corruption involving both the public and private sectors. CoC also measures the strength and effectiveness of the policy of the nations and institutional framework to avoid and fight corruption.

In this paper, the focus is on the influence of ICT on corruption. The novelty originates from investigating multiple countries. The focus is on ASEAN countries that follow similar development paths, using panel data over 33 years, and by focussing on the CoC. The focus on ASEAN enables a comparison between the countries. We follow Sousa (2016) and postulate that ICT could help to fight corruption according to in various ways.

1. by identifying anomalies, outliers, and underperformance and in this way improving the government;
2. deterring improper conduct by enabling the media and civil society organizations (CSOs) to monitor public affairs closely;
3. empowering citizens to report wrongdoing and contest arbitrary treatment;

4. fostering social capital and ethical attitudes through public engagement and online discussions, and
5. ensuring accountability and transparency through functionalities such as action/decision-tracking and mechanisms for feedback or complaints.

In addition, Sousa (2016) argues that some conditions should be in place, like the training of public officials and having appropriate institutional arrangements. Training is needed to recognize corruption and to introduce effective mechanisms for preventing corruption. The latter is necessary for the ability to analyze further and take interventions after spotting possible corruption. Since corruption is rooted in culture, ICT alone is not sufficient to reduce corruption. ICT should collaborate with public governance, institution, media, and society (Sousa, 2016).

The objective of this study is to investigate the influence of ICT on the level of corruption. First, this paper explores the literature on ICT development as a mechanism to fight against corruption. After the literature review, the research objective, research questions, and methodology are presented. The fourth section presents the demographics and descriptive statistics, followed by the findings and discussion in section 5. In the final section, conclusions and further research suggestions are presented.

## **2. LITERATURE BACKGROUND**

Previous studies indicated that ICT could provide countries a new method to creating transparency and endorsing anti-corruption (John Carlo Bertot et al., 2010; Chun et al., 2012; C.-K. Kim, 2014; S. Kim, Kim, & Lee, 2009; Lalountas, Manolas, & Vavouras, 2011; Shim & Eom, 2008, 2009; Tanzi & Davoodi, 1998). Several researchers view the implementation of ICT as a resource to encourage transparency to create an open government (John C Bertot et al., 2010; Chun et al., 2012; Von Haldenwang, 2004). The creation of transparency is often viewed as a way to reduce corruption (Kolstad & Wiig, 2009). ICT is used to connect and provide information through many technologies, such as the Internet, apps, wireless networks, cell phones, and other communication mediums (Collins, 2003; Dictionaries, 2009). Subsequently, many countries try to implement and connected transparency with ICT-based initiatives (Relly & Sabharwal, 2009) to create an open government.

In the literature, the relationship between ICT and fighting corruption has been studied. There are many examples of initiatives to fight corruption in many countries. For instance, in Nigeria, ICT, such as a computer, Internet, mobile phones, radios, and television as a tool that can be used to detect corruption (Jha, 2020; Jha & Sarangi, 2017; Longe, Bolaji, & Boateng, 2020). By reducing face-to-face contact between citizens and public servants, bribery becomes more difficult (Shim & Eom, 2008). Using technology, citizens are more comfortable reporting the administration abuses, complaints, and corrupt activities resulting in an open government. In a similar vein, Sassi and Ali (2017) found that ICT, such as the Internet and mobile phone, can be used for CoC. Internet technology can help in reducing corruption by reducing the discretion of power by the public administration. The Internet is one of the tools that can be used to reduce information asymmetry and improve transparency and accountability by allowing citizens to access information and governmental administrative processes. Furthermore, the mobile phone can be used as a tool to detect corruption by allowing societies to report corruption activities and increases the speed of information broadcast, particularly in an important event such as elections. The mobile phone can be used to record and document the conversation with private or public officials asking for bribes (Lidman, 2011; Sassi & Ali, 2017).

Sousa (2016) argued that there are five major ways in which ICT can help reducing corruption risks. First, by raising awareness of specific governance problems (types of corruption). Second, by providing low-cost online platforms to monitor and promote more inclusive, transaction and accountable decision-making. As a result, it can reduce the cost of distribution, accessing, and collecting government information (John Carlo Bertot et al., 2010). Third, by reducing the incentives for corruption by reducing the direct contact and familiarity between end-users and decision-makers.

Fourth, by enabling more effective control of financial transactions that may put politically exposed agents (individual or collective) at stake. Fifth, by creating public awareness by initiating anti-corruption campaigns. In addition, Kolstad and Wiig (2009) suggested that education of the public and capability and incentives to act upon the processed information are needed. In these ways, governments can utilize ICT to reduce corruption in the public and private sectors.

Bhatnagar (2000) shows that in India, ICT use successfully improves the quality of governance. ICT provides decision support to public administrators to improve planning and monitoring of development programs, enhance service delivery to citizens, and create transparency and empower citizens through access to information and knowledge. Furthermore, by using the Internet, people can reduce their communication costs.

Following that, the literature emphasized the role of ICT implementation in reducing corruption. For instance, Shim and Eom (2008) argued that ICT could promote the reduction of corruption by reducing the potential for corrupt activities, improving the connection between citizens and public employees, permit the citizen to follow government activities, and monitoring and controlling the public employee actions. As a result, the public, NGOs, researchers, and politicians can track government employees' decisions and actions.

In general, ICT envision as a practical tool to reduce corruption, although social culture can reduce the effectiveness of ICT as anti-corruption (Shim & Eom, 2009). Statistical analyses and case studies show that ICT is demonstrating a great deal in reducing corruption. Especially, ICT can improve the effectiveness of managerial and internal control ended by fraudulent behavior as well as endorsing the transparency and accountability on governments (Shim & Eom, 2008). A study by Andersen (2009) concluded that corruption can be reduced significantly by implementing ICT, "even after controlling for any propensity for corrupt governments to be more or less aggressive in adopting e-government initiatives" (Andersen, 2009) p. 210.

Other studies examined the successes of e-government in reducing corruption in countries like Americans, Europe, and Asia (Bhatnagar, 2003; Shim & Eom, 2008). For example, in India, providing the property record online in a rural area has significantly improved the speed at which the records are retrieved and updated, whereas, at the same time erasing the opportunities for the local employee to receive bribes, which was previously a widespread practice (Bhatnagar, 2003). The property records online have approximately saved 7 million to the local employee in its first several years. Before implementing the system, it required Rs.100 to transfer money to a domestic employee, though the electronic system only takes Rs.2 (WorldBank, 2016). Similarly, in Pakistan, by using e-government for tax transactions. The government restructured all tax systems. The aims are to decrease the face to face contact between tax employees and citizens to reduced chances for requests for bribes (Andersen, 2009). In the Philippines, the Department of Budget and Management created an e-procurement system for bidding on government contracts to both avoid price-fixing and provide accountability to the public. In a similar vein in an e-procurement system was established to allow citizens to see and compare the cost and services of the bids purchased by the government of Chile. The e-procurement system provides 500 outsourced services from more than 6,000 providers (Shim & Eom, 2008). The system is estimated to have savings of USD 150 million per year by avoiding price-fixing or inflation by corrupt officials and contractors. This new system positively contributes to reducing corruption and allows small businesses to participate in the government bidding process (Heeks, 2005).

Next to the reduction of corruption, the efforts to control corruption might have positive side effects. In Fiji, the success of ICT to reduce corruption has built a positive public perception of government. As a result, public employees' responsiveness is improved, and better services to citizens are provided (Pathak, Naz, Rahman, Smith, & Nayan Agarwal, 2009). The USA has used ICTA to involve society to control government spending for earlier identification and removal of wasteful projects (House, 2009). Some states in the USA adopted similar websites involving the citizens to control and monitor government spending for waste and fraud. ICT is very diverse, and there many

different initiatives for fighting corruption. ICT can impact the efficiency of administrative processes, create transparency and accountability, and at the same time, reduce corruption.

### 3. RESEARCH APPROACH

This research aims to understand the relationship between ICT and CoC. We will do this by using panel data for the ASEAN region. This data enables us to compare countries with each other. Specifically, the following research questions will be addressed in this study:

1. Is there a relationship between ICT development index and CoC?
2. Is there a relationship between Socioeconomic GDP, Government Expenditure (Gove), and Human Capital (HC) on CoC?

Measuring the relationship is challenging (Marcovecchio et al., 2019). This study applies the panel *Autoregressive Distributed Lags* (ARDL) approach under *maximum likelihood estimation* (MLE) developed by Pesaran et al. (1999). According to Pesaran et al. (1999), ARDL is an efficient estimator in the presence of a mixed order of integration (unit-root). The advantage of this approach is that the country-specific heterogeneity can be captured. ARDL provides short-run and long-run coefficients along with the error correction coefficient. *Pooled Mean Group* (PMG) imposes the long-run homogeneity and short-run heterogeneity conditions. *Mean group* (MG) imposes long run heterogeneity and short-run heterogeneity conditions. *Dynamic Fixed-Effect* (DFE) imposes the long-run homogeneity and short-run homogeneity conditions. The PMG estimator incorporates dynamic heterogeneous panel regression into the error-correction model as follows:

$$\ln CoC_{it} = \mu_i + \sum_{j=1}^p \lambda_{ij} ICT_{it-j} + \sum_{j=0}^q \delta'_{ij} X_{it-j} + \varepsilon_{it} \quad (1)$$

Where,  $i = 1, 2, \dots, N$  represents cross-sectional unit  $t = 1, 2, 3, \dots, T$  represents time (annual),  $j$  is the number of time lag,  $p$  is the lag of the dependent variable, and  $q$  is the lag of the independent variables.  $X'_{it}$  is the vector of independent variables, e.g., ICT development, and finally,  $\mu_i$  is the fixed effect.

$$\Delta CoC_{it} = \mu_i + \varphi_i CoC_{it-1} + \beta'_i X_{it} + \sum_{j=1}^{p-1} \lambda_{ij}^* \Delta CoC_{it-j} + \sum_{j=0}^{q-1} \delta_{ij}^{*'} \Delta X_{it-j} + \varepsilon_{it} \quad (2)$$

Where,  $\varphi_i = -1(1 - \sum_{j=1}^p \lambda_{ij})$ ,  $\beta_i = \sum_{j=0}^p \delta_{ij}$ ,  
 $\lambda_{ij}^* = - \sum_{m=j+1}^p \lambda_{im}$ ,  $j = 1, 2, \dots, p-1$ , and  
 $\delta_{ij}^* = - \sum_{m=j+1}^q \delta_{im}$ ,  $j = 1, 2, \dots, q-1$ .

Now by grouping the variables in levels further, Eq. (2) is rewritten as an error correction equation:

$$\Delta CoC_{it} = \mu_i + \varphi_i (CoC_{it-1} - \theta'_i X_{it}) + \sum_{j=1}^{p-1} \lambda_{ij}^* \Delta CoC_{it-j} + \sum_{j=0}^{q-1} \delta_{ij}^{*'} \Delta X_{it-j} + \varepsilon_{it} \quad (3)$$

Figure 1. Decomposing the ARDL Method



Where  $\theta_i = -(\beta_i/\varphi_i)$  defines the long-run or equilibrium relationship among  $CoC_{it}$  and  $X_{it}$ . In contrast  $\lambda_{ij}$  and  $\delta_{ij}$  are short-run coefficients relating growth to its past values and other determinants like  $X_{it}$ . Finally, the error-correction coefficient  $\varphi_i$  measures the speed of adjustment of  $CoC_{it}$  toward its long-run equilibrium following a change in  $X_{it}$ . The condition  $\varphi_i < 0$  ensures that a long-run relationship exists. Therefore, a significant and negative value of  $\varphi_i$  is treated as evidence of co-integration between  $CoC_{2it}$  and  $X_{it}$ . Thus, finally, the estimates are measured by:

$$\theta_{PMG} = \frac{\sum_{i=1}^N \hat{\theta}_i}{N} \cdot \beta_{PMG} = \frac{\sum_{i=1}^N \hat{\beta}_i}{N} ; \lambda_{j,PMG} = \frac{\sum_{i=1}^N \hat{\lambda}_i}{N}$$

and  $\gamma_{j,PMG} = \frac{\sum_{i=1}^N \gamma_i}{N}$  Where,  $j = 0, \dots, q - 1$ ,  $\hat{\theta}_{PMG} = \hat{\theta}$

Therefore, based on the above methodology presented in equation 3, the following three models have been developed see figure 1. In the equation,  $\lambda_i$  Represents parameters to be estimated, and  $\Delta$  indicates a differenced operator. If the respective variables are integrated order I(1), then the error term is integrated order I(0) process for all  $i$ . A principal feature of co-integration is that any short-run disequilibrium converges towards the long-run equilibrium at the rate of  $\varphi_i$ . Therefore, the parameter  $\varphi_i$  is the error-correcting speed of the adjustment term. If  $\varphi_i = 0$ , then there would be no evidence of a long-run relationship. This parameter is expected to be significantly negative under the prior assumption that the variables show a return to long-run equilibrium. Whether the PMG approach is valid or not depends on several elements (Samargandi et al., 2013). First, the error-correction term has to be negative and not lower than -2 to ensure the existence of a long-run relationship among the variables of interest. Secondly, the obtained residual from the PMG estimator has to be serially uncorrelated then the explanatory variables have to be treated as exogenous determinants. But these conditions can be fulfilled by incorporating lags into an ARDL model for the dependent (p) and independent variables (q) in error-correction form. Finally, this estimator is particularly useful when there are reasons to expect that the long-run equilibrium relationships between variables to be similar across countries because they might have a similar nature in terms of economic growth.

The second method (MG) is carried out by estimating separate regression for each cross-section. This method provides long run and short-run parameters by taking an average of individual parameters from each country-specific regression. Therefore, the MG method allows the coefficient to be heterogeneous in the short run and long run. The validity of MG estimators largely depends on the large time-series dimension of the data. Finally, the DFE method is carried out based on a few assumptions, like 1) country-specific intercept 2) it restricts the speed of adjustment coefficient and the short-run and long-run coefficient to be identical for all cross-sections. Finally, the Hausman test is applied to identify the efficiency and consistency of each estimator over others.

Table 1. Descriptive Statistics

Variable name	Obs	Mean	Std. Dev.	Min	Max
ICT	272	48.66	22.30	6.10	89.10
CoC	272	-.077	1.023	-1.67	2.3
gdpc	272	11079.71	15200.45	187.46	57378.86
ge	272	12.28	5.30	5.46	29.87
hci	272	2.285	0.46	1.33	3.97

#### 4. DEMOGRAPHICS AND DESCRIPTIVE STATISTICS

This study collected data from 8 ASEAN countries, including Brunei Darussalam, Indonesia, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam. Table 1 presents the descriptive statistic of the variables included in the model. Descriptive statistics provide the initial picture of data; for instance, it provides minimum, mean, standard deviation and maximum value for each variable. The value of the standard deviation shows the spread.

This study uses the CoC as the dependent variable and ICT as an independent variable with four indicators, including a computer, Internet, telephone, and mobile phone. For the ICT (Independent variable) data, we used the World Development Indicators<sup>1</sup> (consisting of 4 dimensions, e.g., secure internet server, individual using the Internet, mobile cellular subscription, and fixed broadband subscription. For the CoC (dependent variable) data provided by Worldwide Governance Indicator<sup>2</sup> in which CoC is a single index is used.

The ICT index refers to the level of *Information and Communication Technology in a country*. The magnitude of the ICT variable in this study ranges from 0 to 100. The maximum value is 100, indicating a strong ICT development, whereas the minimum value is 0 indicating very poor ICT development in the country. Based on the 8 ASEAN countries, this study found the highest ICT development is 89.1, indicating a very high level of ICT development. The lowest value from the overall is 6.10, indicating the lowest level of ICT development.

The CoC is the magnitude of the CoC index and has a range from -2.5 to 2.5. The maximum value is 2.5, indicating a high CoC in the country. The minimum value is -2.5 indicating very poor CoC of the country. The mean value of control of the corruption of ASEAN countries from -1.31 to 2.17. Score -1.31 is indicating very poor CoC and 2.17, indicating a very good CoC.

GDP per capita refers to *Gross Domestic Product per Capita*. The magnitude of GDP per capita in this study has ranged from 187.46 to 57378.86. In 2016, GDP per capita in Singapore amounted to around 57,378.86 U.S. dollars. The lowest GDP per capita has Myanmar, around 187.46 U.S. dollars

GE is an abbreviation for *Government Expenditure*. Government expenditure in ASEAN countries ranges from 5.4% to 29.86%. Government expenditure definition is the budget spent by the public sector on the purchase of goods and provision of services, for instance, education, social protection, defense, and healthcare. Brunei has the highest percentage of government spending, e.g., 29.86%. The lowest government spending is Thailand having 5.4%.

HCI refers to the *Human Capital Index*. Human Capital is examining the skills, education, attributes, and capacity of the employment that influence the earning potential and productive capacity. OECD defined human capital as “the knowledge, skills, competencies and other attributes embodied in individuals or groups of individuals acquired during their life and used to produce goods, services or ideas in market circumstances” ((Brian, 2007), p. 29). A country with a higher level of human capital is Singapore, with a score of 3.9. a country with a lower level of human capital is Myanmar, with a score of 1.3.

Table 2. Correlation analysis

Variables	coc	ict	ge	hc	lgdpc
<i>coc</i>	1.0000				
<i>ict</i>	0.3007***	1.0000			
<i>ge</i>	0.2899***	-0.0113	1.0000		
<i>hc</i>	0.7761***	0.3149***	0.3466***	1.0000	
<i>lgdpc</i>	0.8903***	0.2315***	0.5982***	0.8433***	1.0000

The present study focuses on the following two areas: ICT development as the independent variable and CoC as a dependent variable. For the independent variable, the ICT development index was used, whereas, for CoC the log was used from the data provided by the World Development Indicators.

$$LCoC_{it} = \alpha_0 + \beta_1 ICT_{it} + \beta_2 GDP_{it} + \beta_3 Gove_{it} + \beta_4 HC_{it} + \varepsilon_{it} \quad (4)$$

Where LCoC stands for log CoC. Also, ICT development is the indices of the Internet (Int), Internet Server (IntS), Internet Server per 1 Million people (IS1M), Fixed Broadband Subscription per 100 people (FBS1P), Fixed telephone subscription per 100 people (FTS1P), and Mobile Phone (MP). Thus, the GDP is a gross domestic product, Gove is government expenditure, and HC is human capital,  $\varepsilon$  is error correction.

Table 2 shows the correlation matrix along with the level of significance (p-values) of all variables. This table shows a strong and significant positive relationship between all variables with *QoG*. The sign of all variables included in the model is according to our expectations. However, this matrix only provides the initial indication of independent variables' possible effect on the dependent variable.

For this study, the IPS unit root test to check the order of integration of variables included in the model. We find mixed order of integration for all variables. This implies that some variables are stationary at the level, and some are stationary at first difference. Table 3 portrays that CoC and Gove at a level while ICT, LGDPC, and HC are stationary at first difference. The unit root test result indicates that the Panel ARDL estimation technique is most suitable for further analysis. So, based on unit root results, we will use Panel ARDL for empirical analysis.

## 5. FINDINGS AND DISCUSSION

The result found from the dynamic analysis by using panel ARDL (p,q) framework is presented in Table 4. The ARDL method clarifies the authenticity of the relationship between ICT and CoC in

Table 3. Panel Unit-root test

	IPS	IPS
ICT	4.54	-8.33***
CoC	-2.11**	-9.03***
Gove	-3.11***	-10.77***
LGDPC	5.42	-5.99***
HC	1.38	-8.95***



Table 4. ICT Development and CoC

Variables	PMG		MG		DFE	
	Long Run	Short Run	Long Run	Short Run	Long Run	Short Run
		-0.34***		-0.51***		-0.19***
Error Correction		(0.11)		(0.07)		(0.03)
$\Delta$ ICT		-833.3		-969.3		-22.55
		(930.2)		(1,12)		(54.03)
$\Delta$ ICT2		275.9		320.2		7.545
		(313.7)		(380.8)		(20.79)
$\Delta$ GOVE		-0.01		-0.02		-0.01
		(0.01)		(0.02)		(0.01)
$\Delta$ LGDPC		0.06		0.24		-0.48
		(0.80)		(1.29)		(0.93)
$\Delta$ HC		-6.49		-10.04		0.63
		(9.56)		(12.09)		(1.62)
$ICT_{t-1}$	109.6***		102.4		-37.59	
	(28.88)		(587.7)		(69.22)	
$ICT_{t-1}^2$	-47.98***		-50.25		9.66	
	(11.90)		(212.2)		(26.92)	
$GOVE_{t-1}$	-0.08***		-0.08		0.002	
	(0.02)		(0.06)		(0.06)	
$LGDPC_{t-1}$	-1.50***		-3.25		-0.11	
	(0.31)		(2.76)		(1.17)	
$HC_{t-1}$	3.88***		7.482**		1.311	
	(0.98)		(3.70)		(1.43)	
Constant		-18.06***		-28.28		6.450
		(6.251)		(145.8)		(8.000)
Observations	219	219	219	219	219	219

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

selected ASEAN regions. We reflect that the three modes of ARDL framework: PMG, MG, and DFE. The coefficient on the error-correction term is required to be negative and not less than -2. Table 4 shows that this coefficient is -0,34 and statistically significant at the 1% level. In the long run, the result under the PMG method indicates that ICT development has a positive and significant impact on CoC.

Table 4 shows the analysis result of the ICTs impact on the control CoC. In the long run, the result under the PMG method indicates that ICTs have a positive and significant impact on reducing corruption. This result confirms Ali and Gasmi (2017) work concerning the impact on the spread of ICT to combat corruption using a panel data set of 175 countries from 1996 – 2014. By comparing the ICT-corruption nexus to different levels of economic development, they found ICT is a useful tool to control corruption.

Similarly, the finding is also supported by Sassi and Ali (2017) by using ICT development indicators such as the Internet and mobile phone. Internet technology helps in implementing the law and rules by reducing the discretion of power by the public administration. As a result, the citizen is more comfortable reporting the administration abuses, complaints, and corrupt activities. The Internet is one of the tools that reduce information asymmetry and improves transparency accountability by allowing citizens to access information and governmental administrative processes. This also confirms the work of DiRienzo, Das, Cort, and Burbridge (2007) that more transparency is associated with lower corruption.

Furthermore, the mobile phone tool also useful to detect corruption by allowing societies to report corruption activities and increases the speed of information broadcast, particularly in an important event such election. The mobile phone is also an effective tool to record and document the conversation with private or public officials asking for bribes (Sassi & Ali, 2017).

In line with our finding, in Kazakhstan, e-government success in reducing petty corruption; however, it should collaborate with other anti-corruption measures (Sheryazdanova & Butterfield, 2017). The finding reveals that e-government may be making headway in the fight against corruption with respect to the petty corruption faced by small businesses and individuals on a regular basis. For example, e-government can reduce complicated procedures, long wait times, nontransparent processes, and small salaries of public officials combine to build conditions ripe for bribery.

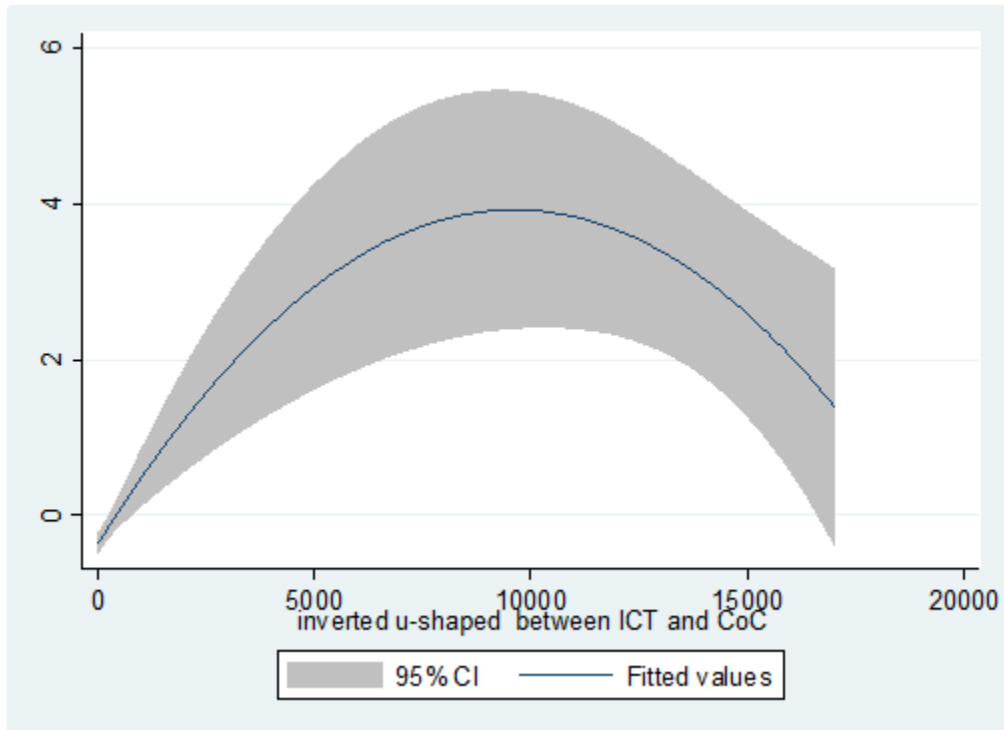
Open government and participation can be used to fight against corruption (John C Bertot et al., 2010). For example, by allowing the public to monitor government budget and by allowing them to participate in institutional reform (Johnson et al., 1998). Andersen (2009) examined how ICT and open government can be used as an anti-corruption strategy. This study investigated the impact of e-government on the CoC indicators using a panel of 149 countries. E-government led to reducing corruption over the decade 1996 – 2006 in non-OECD countries. Tang, Chen, Zhou, Warkentin, and Gillenson (2019) found that social media played an important role in the reduction of corruption. The authors suggested that greater use of social media is positively related to stronger perceived CoC.

The relationship between ICT and CoC was found to be non-linear. ICT only has a certain effect on CoC until a threshold has been reached. Figure 2 shows the inverted U-shaped relationship between ICT and CoC. The inverted U-shape implies that no further opportunity for ICT to foster CoC after the threshold is reached. Hence, our work confirms the positive relationship between ICT and CoC, but also suggests that the relationship is more complex. Merely spending more money on ICT will not work to tackle corruption.

This complex relationship is confirmed by the work of Bastida, Estrada, and Guillamón (2020), who found that Honduran municipalities were primarily concerned about meeting central government legal requirements and there was no increase of transparency to their citizens. Some data was released that would be helpful to fight corruption, but other information disclosed might not be useful at all and made a limited or no contribution to CoC. More ICT spending would result in the mere opening of more useless data. Hence, increasing ICT spending alone is not sufficient.

Corruption might prevent ICT investments from being effective in fighting corruption (Billger and Goel 2009). The ICT investments might reduce some types of corruption, but ICT also might reinforce

Figure 2. Inverted U-shaped relationship between ICT and CoC



existing patterns of corruption. ICT might reduce corruption in face-to-face interactions with public servants, but corruption might continue online by withholding information or not granting permits online. In addition, Charoensukmongkol and Moqbel (2014) suggested that more investment in ICT can also provide an opportunity for corruption to occur. ICT might be used to facilitate corruption, instead of reducing this. They recommend introducing control mechanisms and policies aimed to monitor ICT investments to avoid misuse.

Also, this study found a positive correlation between human capital on CoC. Asongu and Nwachukwu (2015) found that education can be a powerful policy to fight corruption. Education should enable public officers to implement effective mechanisms for preventing corruption, detecting conflict of interest, violation of ethical standards, whereas the public should be educated and given the tools to detect corruption. Training should be complemented by anti-corruption campaigns to create public awareness (Sousa, 2016). Our findings suggest that investments in human capital helped can help to reduce corruption in the ASEAN region.

Žuffová (2020) found that the effects of open government data on corruption are conditional upon media and internet freedom quality. By providing not all information or selectively releasing information, corruption might be facilitated. Furthermore, free and fair elections, independent and accountable judiciary were found to be critical for tackling corruption. Kolstad and Wiig (2009) suggested that education of the public and capability and incentives to act upon the processed information are needed for creating transparency. This is confirmed by our findings, which found a positive correlation between human capital and CoC. Data does not only need to be opened to fight corruption, but the opened information should also be used by the public, which often lacks the expertise and skills to do so. Furthermore, once corruption is detected, there is a need for having mechanisms to take the next step.

Bhattacharjee and Shrivastava (2018) found that ICT laws moderate the effect of ICT use on corruption. This suggests that legislation might be needed to ensure that ICT reduces CoC once the threshold has been reached. ICT investments may have a limited impact on corruption, unless complemented with sufficient ICT laws (Bhattacharjee & Shrivastava, 2018; Lalountas et al., 2011). Arayankalam, Khan, and Krishnan (2020) emphasized the need to have distinct government responsibilities among the legislature, executive, and judiciary branches. Institutional measures are needed to enact the funding of corruption. Reporting possible abuse should be possible, and public agencies in charge of fighting corruption should have the capacity to follow up and intervene. Apart from education, leadership and policies are needed to ensure that ICT can be effective in CoC, else only some forms of corruption might be tackled. This has the risk that other forms of corruption are not tackled or even might be reinforced by the ICT investments.

The risk of the opening of a large amount of data to the public might only result in an information overload. The public might not be able to find and process the data. Technologies might help to overcome this problem in the future. Predictive data analytics based on Artificial intelligence (AI) computational algorithms might be used for the automated detection of corruption. The potential is highlighted in the work of Lima and Delen (2020). They demonstrated that the predictive power of machine learning algorithms, coupled with data from multiple sources, can be used to reveal corruption. We recommend evaluating the effects of computational algorithms on CoC in further research.

## 6. CONCLUSION AND FUTURE WORK

Given the detrimental impact of corruption, ICT has been embraced as a tool to fight corruption. The relationship between more ICT and corruption is often assumed and hardly tested. Our findings show that more investment in ICT can help to reduce corruption, but does not always result in lower levels of corruption. This study confirms an initial positive relationship between ICT and CoC, however, after a threshold has been reached, the CoC declined. The findings show the presence of a quadratic (non-linear) inverted U-shaped relation between ICT development and CoC. This implies that no further opportunity for ICT to foster CoC after the threshold is reached. An explanation for this finding is that investments in ICT are worthwhile but not sufficient and should be accompanied by other measures, such as legislation and institutions reforms. The risk is that existing patterns of corruption are reinforced by ICT. Legislation, policies and institutional mechanisms are needed to prevent this. Also, this study found a positive correlation between human capital on CoC. Suggesting that investments in human capital helped to reduce corruption in the ASEAN region. In the future, AI can enable the automated detection of corruption and the preventive detection of corruption. These technology types look promising, but likely policy and institutional measures might be needed to make them effective. Studying the impact of AI on CoC is recommended as a further research direction.

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## ENDNOTES

- <sup>1</sup> <https://databank.worldbank.org/source/world-development-indicators#>
- <sup>2</sup> <https://databank.worldbank.org/source/worldwide-governance-indicators>

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