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THE ROLE OF ICT DEVELOPMENT IN PROMOTING CONTROL OF CORRUPTION: EVIDENCE FROM ASEAN COUNTRIES

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ABSTRACT

Corruption remains a pervasive global challenge that undermines government quality, hampers economic development, and erodes public trust, particularly in developing and emerging economies. Rapid advancements in information and communication technology (ICT) have been extensively advocated as a strategic tool for enhancing transparency and combating corruption. Nonetheless, current empirical evidence regarding the ICT-corruption relationship is weak and frequently restricted to single-country studies, linear assumptions, or brief observation durations. This study examines the long-term and short-term impacts of ICT growth on corruption control (CoC) in ASEAN nations, utilizing a balanced panel dataset from 1984 to 2023. This study utilizes the panel Autoregressive Distributed Lag (ARDL) methodology to account for dynamic adjustments and cross-country variability, accommodating various orders of integration. The findings indicate a non-linear, inverted U-shaped relationship between ICT development and corruption control, suggesting that initial ICT expansion enhances corruption control but may lead to declining and potentially negative impacts beyond a specific threshold. This study contributes to the literature and provides policy-relevant insights by emphasizing the importance of balanced and context-sensitive digital governance strategies that enhance transparency and accountability while mitigating unintended governance risks.

Keywords: ICT Development; ICT access; ARDL; ASEAN; Control of Corruption

INTRODUCTION

In recent years, corruption has gained international attention due to the devastating negative impact of corruption on the countries (Roht-Arriaza and Martinez, 2019, Ivory, 2019). Countries having high levels of corruption countries are usually characterized by low economic growth, high unemployment rate (Carr and Lewis, 2010; Aterido and Hallward-Driemeier, 2007) and small foreign direct investments (Masron and Abdullah, 2010), decrease tax revenue (Shleifer and Vishny, 1993, Ghura, 1998; Tanzi and Davoodi, 1998; Tanzi,1998), weak education system (Chen, 2019; Gardiner,2017, Borcan et al.,2017) and lack of the quality of life and poor quality of infrastructure and health care (Borcan et al., 2017; Wu and Zhu, 2016). In addition, the increase in corruption leads to a reduction in economic growth, increase in inflation and economic instability (Wang et al., 2018; Brianzoni et al. ,2018; Hongdao et al. ,2018; Cieślik and Goczek, 2018). In contrast, countries having a low level of corruption attract foreign direct investment which improves the gross domestic product (GDP) (Masron and Abdullah, 2010; Bhattacherjee and Shrivastava ,2018) as well as provides better-quality life for citizens (Montes and Paschoal, 2016).

In a report by UNODC (2005) it was found that every year, more than one trillion dollars are paid for bribing private and public officials. It was reported that 27% of the citizens of in 107 countries paid bribes when they deal with federal officials (Gorodnichenko and Peter, 2007; Hardoon and Heinrich, 2013). Prior studies found that ICT development is an important mechanism to implement control of corruption (CoC measure (O'Hara, 2012; Sassi and Goaied, 2013; Shim and Eom, 2009; Grönlund, 2010). Moreover, ICT developments are able to facilitate implement extensive CoC measure such as public trust in politics (Weibel and Latour, 2005; Grant, 2001; Ruscio, 1997), transparency and accountability among public and private officers (Cameron, 2004; Forrer et al., 2010; Fombad, 2014),

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transparency and accountability and corruption in rural area (Bhatnagar, 2003b; Kpundeh, 2004; Pathak et al., 2007; Pathak et al. ,2008; Kristiansen et al., 2009; Gray-Molina et al., 1999; Aiyar and Samji, 2009), public trust in politicians (Fiske and Durante, 2014; Schwarz and Bles, 1992: Van de Walle and Bouckaert, 2003), corruption in judiciary (Begovic et al., 2004; Dakolias and Thachuk, 2000; Buscaglia and Dakolias, 1998), corruption in government (Gardiner, 2017; Friedrich, 2017; Brierley, 2016), and corruption among public (Shim and Eom, 2009; Brierley, 2016; Navot et al., 2016; Gorsira et al., 2018).

Dishonest or unlawful activity, particularly by influential individuals, is referred to as corruption (WorldBank, 2016, Waite and Allen, 2003, Treisman, 2000). CoC evaluates the effectiveness and strength of a country's institutional architecture and anti-corruption policies (Klitgaard, 1988, Kpundeh, 2004, Cieślik and Goczek, 2018). ICT, including open government data, has been widely used by nations including Singapore, the UK, Denmark, and New Zealand to improve CoC and monitoring. These nations have thus held a prominent position as CoCs worldwide. Tarnoff (2009) asserts that the CoC program should reduce corruption in the public and private sectors, both minor and major. It has been demonstrated that using ICT development to combat corruption is a successful strategy for both short- and long-term corruption reduction (Anechiarico and Jacobs, 199; Bertot et al., 2010b).

According to Singh and Sahu (2008), ICT growth has the potential to advance accountability and transparency as well as be an effective weapon in the battle against corruption. ICT growth can successfully improve transparency, accountability, and ultimately limit corruption, according to literature (O'Hara, 2012; Sassi and Goaied, 2013; Shim and Eom, 2009; Grönlund, 2010). Social media, e-government, e-procurement, and open government data are examples of ICT advancements that make it easier for the public to engage with and keep an eye on government operations. Data disclosure to the public is made possible by ICT progress, and data is freely accessible to the public. The opening of land records, license applications, and tax payment statuses are a few instances of government procedures that are open. identifying public officials and civil servants who are being investigated for corruption and fraud; 3) revealing public officials' and civil servants' investments and assets.

Recently, government agencies, state-owned companies, and statutory bodies have started initiatives to make government data publicly to promote transparency and accountability (Huijboom and Van den Broek, 2011). For example, through open data, the public able to monitor government activities and provide feedback for better outcomes. ICT development offers many benefits to society such as submitting information, on government rules and citizen rights (Bhatnagar, 2003a); provide information about government decisions and actions; promote monitoring of government actions (Nam, 2018) and monitor government expenditures and government performance (López-López et al., 2018) dissemination information (Dabbous and Dimant, 2018). Another group of scholars argued that ICT development such as social media provides positive impacts on reducing corruption (Bertot et al., 2010b, Bertot et al., 2010a , Ali and Gasmi, 2017 , Palvia et al., 2017). However, studies that focuses on ICT development within the Association of Southeast Asian Nations (ASEAN) countries are currently limited.

Established in 1967, ASEAN is a regional intergovernmental organization made up of ten countries in Southeast Asia. ASEAN's main goal is to promote intergovernmental cooperation and make it possible for its member states and other Asian countries to integrate economically, politically, militarily, militarily, educationally, and culturally. Combining the economic strategies and practices of ten different countries is certainly no little task. ASEAN is making slow progress fifty-one years after its founding. According to a 2013 study by the Asia Global Institute, corruption is one of ASEAN's worst problems. For ASEAN's regional economic integration to be effective, corruption must be eliminated at all costs. As a result, anti-corruption initiatives must be implemented deliberately and methodically in all member countries. Analyzing the driving and impeding factors that could impact ASEAN's growth and development is crucial. In light of the Asia Global Institute's (2013) findings about corruption, this study attempts to explore the factors that could either support or undermine the Code of Conduct (CoC). It is crucial to investigate the effect of ICT development on reducing corruption in light of ASEAN's noteworthy ICT growth rate and rising levels of corruption. While effective ICT development can support efforts to prevent CoC, misuse of such development could have a negative effect on CoC. Previous studies on CoC have mostly analyzed the subject from a criminological perspective, including aspects related to law, fraud, and accounting (Huisman & Vande Walle, 2010, Moosavi, 2019). In order to find possible relationships between ICT development and CoC, this study examines the effect of ICT development on the CoC in the ASEAN region using macroeconomic indicators from 10 ASEAN

nations between 1984 and 2016 that were taken from the World Development Indicator and ICRG databases.

This study undertakes a macroeconomic approach to examine how ICT development effect on Control of Corruption in each of the 10 ASEAN countries. Effective control of corruption is a critical yardstick that will stimulate the development of ASEAN countries. Many scholars have widely discussed on ICT developments as a tool to mitigate fraud. However, existing studies tended to focus on a single country (Chowdhury and Abid, 2019, Iqbal and Seo, 2008, Sudibyo and Jianfu, 2015, Barnett et al., 2019). Currently, there are limited empirical studies that provide country cross-analysis on the role of ICT and CoC. In the next section, this study presents the related literature review resulting in the hypothesis for this research. Section three presents the research methodology. Section four offers the result and discussion. Finally, conclusions and further research suggestions are presented.

REVIEW OF LITERATURE AND HYPHOTHESIS DEVELOPMENT

Control of Corruption

Index (2020), Johnston (1996), and Kurer (2014) defines corruption as "the extent to which public power is exercised for private gains" (p.1). Also, Eton (2019) split the form of corruption base on a local and national level. Whereas, the corruption at the local level tends to be petty form, including low-level officials. Although, the corruption at the national level tends to be a grand form involving high-level officials and policy-makers. As such, control of corruption is a more comprehensive measure of an initiative to CoC. Table II.1 provides the measurement of control of corruption nexus corruption perception index (CPI). The CPI considers 11 data sources, as exhibited in table 2. These data sources provide a narrow view of corruption, whereas control of corruption provides a more integral measure of corruption. Table 2 presented the lists of the variables from each data source used to construct the measure control of corruption and CPI. There are 22 proxies that used to measure control of corruption.

Table II.1. The dimensions of Control Corruption (WorldBank, 2016)

No	Control of Corruption Data Sources	Type*	Organization	CPI	CoC
1	Country Policy and Institutional Assessments	Expert (GOV)	African Development Bank	√	√
2	Afrobarometer	Survey	Afrobarometer		√
3	Country Policy and Institutional Assessments	Expert (GOV)	Asian Development Bank	√	√
4	Business Enterprise Environment Survey	Survey	World Bank		√
5	Bertelsmann Transformation Index	Expert (NGO)	Bertelsmann Foundation	√	√
6	Countries at the Crossroads	Expert (NGO)	Freedom House		√
7	Country Risk Service	Expert (CBIP)	Economist Intelligence Unit	√	√
8	Nation in Transit	Expert (NGO)	Freedom House	√	√
9	Global Corruption Barometer Survey	Survey	Transparency International		√
10	Global Competitiveness Survey	Survey	World Economic Forum	√	√
11	Global Integrity Index	Expert (NGO)	Global Integrity	√	√
12	Gallup World Poll	Survey	Gallup		√
13	Rural Sector Performance Assessments	Expert (GOV)	International Fund for Agricultural Development		√
14	Institutional Profile Database	Expert (GOV)	French Government		√
15	Latinobarometro	Survey	Latinobarometro		√
16	Policy and Institutional Assessments	Expert (GOV)	World Bank	√	√
17	Corruption in Asia	Survey	Political Economic Risk Consultancy		√
18	International Country Risk Guide	Expert (CBIP)	Political Risk Service	√	√
19	Americas Barometer	Survey	Vanderbilt University		√
20	World Competitiveness Yearbook	Survey	Institute for Management and Development		√
21	Rule of Law Index	Survey	World Justice Project	√	√
22	Business Conditions and Risk Indicators	Expert (CBIP)	Global Insight	√	√

ICT Development

Information and communication technology (ICT) refers to a broad set of digital tools and infrastructure that enable the creation, processing, transmission, and dissemination of information through telecommunications networks. (Dictionaries, 2009; Collins, 2003). ICT encompasses internet connectivity, mobile communication technologies, and computer-based information systems that facilitate digital interaction and data exchange. Other scholars define ICT development as the components of a computer and digital technology (IT) that enable modern computing (Rouse, 2005). According to ITU (2017), ICT development consists of some proxies, including telephone, mobile phone, internet, and computer

Both developed and developing countries are utilizing ICT development for education advancement, public services provision, information security. For example, Sub- Saharan Africa use mobile phones as the diffusion of knowledge for better governance (Asongu and Nwachukwu,2016). Also, in Mumbai, India used m-government (mobile government) for Air Cargo Complex (Customs Department) by launching a short massager system (SMS)-based inquiry system. Similarly, in the UK, Sheffield City Council, provide a website to allow voters to choose their Councillor that the year 2003 that spends more than a billion pounds a year. Through the website, the citizens can vote by utilizing the internet, phone, SMS messenger, and public kiosks (Sheffield, Election, 2003). Furthermore, in Canada the use of mobile phones, email, and internet to search for information and services from the public government as well as to find out the latest update on issues related to economic, political, and social development (Government of Canada, 200).

On the other hand, in some countries, the implementation of ICT development faces some challenges. For example, in developing countries like Nepal, Ghana (Andoh-Baidoo et al., 2012), Nigeria (Charoensukmongkol and Moqbel, 2014), Fiji and Ethiopia (Pathak et al., 2008) and South Asia (Mahmood,2004). This is mainly due to lack of electricity, infrastructure, human capital, geographical, educational, economic, and cultural. According to Mothobi and Gillwald (2018), the internet is too expensive to be implemented in South Africa. Furthermore, more than 50% in South Africa population is not connected to the internet, and most of them are from low-income family background and live in a rural area

According to researchers, there are numerous ways in which the development of ICT could help reduce corruption (Bertot et al., 2010, Boamah et al., 2022). According to Sousa (2016), there are five significant ways that ICT development could allay worries about corruption: 1) Raising knowledge of certain governance challenges (corruption types) (Matheus et al., 2012; Charoensukmongkol and Moqbel, 2014); 2) Providing reasonably priced online platforms to monitor and promote more responsible, transparent, and inclusive decision-making (Janssen and Zuiderwijk, 2012). As a result, it can 3) reduce corruption incentives by reducing direct interactions and familiarity between end users and decision-makers (Kim et al., 2009); 4) improve the monitoring of financial transactions that could compromise the integrity of politically exposed individuals or entities (Bertot et al., 2012; Bertot et al., 2010b); and 5) increase public awareness of anti-corruption initiatives (Abu–Shanab et al., 2013).

ICT Development and Control of Corruption

According to some earlier research, countries can start to manage corruption more easily when ICT is developed. Kim et al. (2009), Lalountas et al. (2011), Carlo Bertot et al. (2012), Shim and Eom (2009), Shim and Eom (2008), Tanzi and Davoodi (1998), and Kim (2014) are a few examples of investigations. The development of ICT gives nations a new way to promote anti-corruption and generate transparency. Some nations attempt to integrate and link transparency with ICT-based programs. For instance, ICT advancements like computers, smartphones, the internet, and telephones help fight corruption by establishing e-government and e-procurement (Relly and Sabharwal, 2009). A team of academics studied the relationship between corruption and ICT development at various stages of economic development. They discovered that the development of ICT is a helpful instrument for combating corruption. A high CPI index score indicates a low level of corruption in the majority of developed nations with high ICT development (Ali and Gasmi, 2017; Shim and Eom, 2009, Ionescu, 2013, Bhatnagar, 2003b).

According to Bhatnagar (2003a), ICT development in India was able to promote transparency and fight corruption. Similarly, Kim et al. (2009) found the use of e-government as anti-corruption lead to eliminating human interaction, subsequently reduce the opportunity for corruption among 54 government departments in South Korea. In Pakistan, the use of ICT development for the tax system

and the department was rebuilt to reduce direct contact between tax officials and citizens to minimize opportunities for bribe (Andersen,2009). In the Philippines, the use of e-procurement system facilities public bidding for transparency and accountability (Andersen,2009). The same method used in Chile for e-procurement system that allows citizens and government to compare the prices for services purchased by the government (Shim and Eom, 2008).

In the same way, the use of ICT development to the created website for government spending. As a result, the public can monitor government spending, and this may reduce the possibility of corruption (Carlo Bertot et al.,2012). Using a panel data set of 175 countries from 1996-2014, Ali and Gasmi (2017) found ICT development through mobile phone, internet, and government effect on reducing corruption. In Malaysia, the use of e-procurement in some of the government's agencies has reduced the interaction between vendor and the procurement officer and subsequently reduce opportunity for lobbying and corruption (Aman and Kasimin, 2011, KALIANNAN et al.,2009).

But according to a different set of research, there is a significant chance that using ICT development to fight corruption will fail or be ineffective (Harindranath and Sein, 2007, Zinnbauer, 2012). According to Charoensukmongkol and Moqbel's (2014) cross-country investigation, ICT development may contribute to increased corruption. For instance, the adoption of ICT development in Nigeria's Edo state results in corrupt practices. The nation's government gave the contractor a contract to purchase ICT instruments, known as "communication dishes," which cost over $1000. However, the tools were never used since they were inoperable, costing the government billions of dollars. Additionally, ICT investment is a major source of corruption; the government, which is in charge of ICT investment projects, may exploit these investments as a means of committing corruption.

Additionally, corrupt practices typically take place through a convoluted and ineffective system of bidding and procurement. As a result, during the budget estimation process, the costs of ICT projects are excessively inflated; ultimately, low-quality ICT tools are obtained (Celentani and Ganuza, 2002). According to Burguet and Che (2004), the public administration may engage in collusion with suppliers or bidders by allowing them to offer a high price for the ICT's material cost in exchange for bribes. Therefore, by bribery, an unethical person has the chance to establish a beneficial relationship with the government. The company thereby obtains the government project with ease. This is among the causes of some nations' generally poor public infrastructure quality, even when significant sums of money have been invested in the projects (Bose et al., 2008).

(Jamil et al., 2016; Harindranath and Sein, 2007; Mahmood, 2004) assert that the use of ICT development, including e-government, is capable of fostering CoC. E-government, for instance, has been shown to be effective in reducing minor corruption involving street-level bureaucrats in Bangladesh and Nepal. However, e-government was unable to stop grand corruption. Similar to Nigeria and the Dominican Republic, ICT development is only legitimate when the public is motivated to provide feedback, the services are simple to manage, and the government responds favorably to the input. According to Sousa (2016), in order for ICT growth to be used as a tool for combating corruption, some requirements need be met, such as training public officials and institutional structures. After identifying potential corruption, the latter is required in order to conduct additional analysis and take appropriate action. Since corruption is deeply ingrained in culture, ICT growth must work in tandem with public governance, institutions, the media, and society in order to effectively alleviate corruption (Sousa, 2016). The empirical portion of this study will test the following consequent hypotheses:

H1: The development of ICT and the control of corruption are positively correlated.

Computer and Control of Corruption

The computer is “An electronic device for storing and processing data, typically in binary form, according to instructions given to it in a variable program” (Oxford). Also, Cambridge Dictionary defines a computer as “an electronic machine that is used for storing, organizing, and finding words, numbers, and pictures, for doing calculations, and for controlling other machines”. Furthermore, Dictionary.com defined a computer as “a programmable electronic device designed to accept data, perform prescribed mathematical and logical operations at high speed, and display the results of these operations. Mainframes, desktop and laptop computers, tablets, and smartphones are some of the different types of computers”. In general, thus, the computer is a bundle of electronic devices including desktop, laptop computers, tablets, and smartphones that used the electronic machine to transfer, manage, calculate the data.

According to (Sousa,2018 , Schopf,2019 , Ali and Gasmi,2017), a computer by itself is not sufficient to be used to mitigate corruption. A computer must be connected to the internet, managed by the human being to function as a mechanism to initiate control of corruption strategies. The user of the computer to detect corruption needs IT to skill for the admin in the government agencies (Grönlund,2010). In line with Srivastava et al. (2016) the computer users aim to improve the public services as well as to establish government to be efficient and effective in promoting countries to initiate control of corruption measures. For example, they used e-government in the UK, Soul South Korea, Holland (Kim et al.,2009, Andersen,2009). The interaction between a computer with other electronic devices to enhance access and delivery to all aspects of government services and operations for the benefit of government stakeholders (Bélanger and Carter,2012). Thus, this study proposed the following hypotheses :
H2: There is a positive relationship between the Computer on Control Corruption.

Internet and Control of Corruption

Transmission Control Protocol/Internet Protocol (TCP/IP) is used to send data across a variety of media between devices, such as computers and smartphones (Pilz et al., 2016). The internet is defined as "the vast global network of interconnected computers that enables people to exchange information and communicate with one another" by the Cambridge Dictionary. has discovered that people's willingness to report corruption incidents appears to be significantly influenced by how much time they spend on the Internet. The accuracy of corruption case estimation at the national level is positively impacted by internet use (Hunady). Additionally, people who use the internet regularly are more likely to report instances of corruption. According to the financing, internet usage encourages and facilitates the use of the internet as a weapon against corruption. The findings have a number of significant ramifications for anti-corruption and anti-bribery measures. The easiest way for the government to offer subsidies for Internet access is because installation costs appear to be the primary issue (Goolsbee and Guryan, 2006a, Goolsbee and Guryan, 2006b, Goldfarb and Prince, 2008).

Rural residents see less information asymmetry thanks to internet technology. Additionally, the Internet may have a significant role in lowering corruption across the board (Orviska and Hudson, 2009). Andersen et al. (2011) said that the internet offered some ways to combat corruption. First off, since the internet is the primary information source, there is a greater chance that corruption will be discovered. Second, e-government, which allows citizens to receive government services online, is mostly facilitated by the Internet, which reduces in-person interactions between citizens and potentially dishonest officials.

Furthermore, the e-government system should provide better rules and procedures, and it leads to remove bureaucratic discretion and improve transparency and accountability. The chance of the internet as control of corruption could be explained by greater access to information and a high level of transparency. The consequences further lead to a good level of corruption alertness and precise knowledge about where to report corruption. As such the following hypothesis is proposed.
H3: There is a positive relationship between the Internet on Control of Corruption.

Telephone and Control of Corruption

The dictionary defines a telephone as "a system for transmitting voices over a distance using wire or radio, by converting acoustic vibrations to electrical signals." Additionally, according to Collins Dictionary, "the telephone is the electrical system of communication that you use to talk directly to someone else in a different place by dialing a number on a piece of equipment and speaking into it." Additionally, telephones are defined as "devices that convert sound and electrical waves into audible relays and are used for communication" in another version of the business lexicon. A speaker and a microphone are the two main components of a telephone. This enables the user to hear other users' transmissions and speak into the gadget. It was in 1896 that the first telephone was invented. With the development of technology, calls are now connected automatically, however some of the earliest telephones needed an operator to connect calls between users. The majority of calls are now made over digital networks, whereas telephones used to send sounds using analog signals. Therefore, this study comes to the conclusion that a telephone is a long-distance communication tool.

The telephone alone is inadequate to fight against corruption. Instead, telephone needs other devices to be used to initiate control of corruption mechanism (Sousa,2018). The interaction between telephone with other electronic devices such as a computer, mobile phone, and internet enables the creation of e-

government (Iqbal and Seo,2008). In Korea, they used e-government to fight against corruption by using the OPEN system for e-procurement lead to reduce human intervention (Kim et al.,2009). In, Malaysia, Singapore, UK, and other countries. The OPEN system creates transparency and accountability in the city's administration by decreasing unimportant delays or preventing unjust handling of civil affairs. Consequently, the following theory is put forth.
H4: Telephone and Corruption Control Have a Positive Correletion

Mobile Phone and Control of Corruption

The definition of the mobile phone according to the dictionary is "a telephone with access to a cellular radio system, allowing it to be utilized over a large region without requiring a physical network connection. A mobile phone is also defined by the Collins English Dictionary as "a phone that you can carry with you and use to make or receive calls wherever you are." Furthermore, according to the Cambridge Dictionary, a mobile phone is one that is able to be used anywhere its signals may be received and is connected to the phone system via radio rather than a wire. Mobile phones are therefore a means of connecting one phone to another at any time and place. According to earlier research, mobile phones have been widely utilized to combat corruption, particularly in African nations including Kenya, Rwanda, Tanzania, and Uganda (Hellström, 2008; Bailard, 2009). Mobile phones can be used to report instances of corruption.
H5: There is a positive relationship between Mobile Phone on Control of Corruption

METHODOLOGY

In order to evaluate the dynamic impact of ICT growth on CoC, this work creatively employs the panel Autoregressive Distributed Lags (ARDL) approach, leveraging maximum likelihood estimation (MLE) as proposed by Pesaran et al. (1999). When dealing with a mixed order of integration (unit-root), ARDL is a useful estimator, according to Pesaran et al. (1999). This methodology takes into consideration the country-specific heterogeneity. Along with the error correction coefficient, ARDL also produces short-run and long-run coefficients. Both short-term heterogeneity and long-term homogeneity are mandated by PMG. Both the long-term and short-term heterogeneity criteria are enforced by MG. Both short-term and long-term uniformity are enforced by the DFE. As shown below, the PMG estimator incorporates dynamic heterogeneous panel regression into the error-correction model.

$$lnCoC_{it} = \mu_i + \sum_{j=1}^{p} \lambda_{ij} ICT_{it-j} + \sum_{j=0}^{q} \delta_{ij}^{/} X_{it-j} + \varepsilon_{it} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where the cross-sectional unit is denoted by i = 1, 2,..., N. t = 1, 2, 3,...T stands for time (annual), j for the number of time delays, p for the dependent variable's lag, and q for the independent variables' lag. The vector of independent factors, such ICT development, is represented by X′it, while the fixed effect is indicated by μi.

$$\Delta CoC_{it} = \mu_i + \varphi_i CoC_{it-1} + \beta_i' X_{it} + \sum_{j=1}^{p-1} \lambda_{ij^*} \Delta CoC_{it-j} + \sum_{j=0}^{q-1} \delta'^{*}_{ij} \Delta X_{it-j} + \varepsilon_{it} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where, $\varphi_i = -1(1-\sum_{j=1}^{p}\lambda_{ij}), \beta_i = \sum_{j=0}^{p}\delta_{ij}$,

$$\lambda_{ij^*} = -\sum_{m=j+1}^{p}\lambda_{im},\ j = 1,2,,....., p-1, \text{ and}$$

$$\delta_{ij^*} = -\sum_{m=j+1}^{p}\delta_{im},\ j = 1,2,,....., q-1.$$

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

$$\Delta CoC_{it} = \mu_i + \varphi_i(CoC_{it-1} - \theta_i' X_{it}) + \sum_{j=1}^{p-1}\lambda_{ij^*}\Delta CoC_{it-j} + \sum_{j=0}^{q-1}\delta_{ij}^{*\prime}\Delta X_{it-j} + \varepsilon_{it} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (03)$$

Where θi = - (βi/φi) delineates the long-term or equilibrium relationship between CoCit and Xit. In contrast, the short-run coefficients connect growth to its historical values and other variables like as Xit. The error-correction coefficient φi quantifies the rate at which CoCit adjusts to its long-term equilibrium in response to a variation in Xit. The condition φi<0 guarantees the existence of a long-term relationship. A substantial negative value of φi is considered indicative of co-integration between CoC2it and Xit. Consequently, the estimates are quantified by:

$$\theta_{PMG} = \frac{\sum_{i=1}^{N}\tilde{\theta}_i}{N}, \beta_{PMG} = \frac{\sum_{i=1}^{N}\tilde{\beta}_i}{N};\ \hat{\lambda}_{j\,PMG} = \frac{\sum_{i=1}^{N}\tilde{\lambda}_i}{N}, and\ \hat{\gamma}_{j\,PMG} = \frac{\sum_{i=1}^{N}\hat{\gamma}_i}{N} Where, j = 0,\ldots\ldots\ldots q-1, \quad \hat{\theta}_{PMG} = \tilde{\theta}$$

Thus, three models have been developed using the techniques described in equation 3. The equation represents the parameters to be estimated, and the differencing operator is indicated by Δ. The error term is an integrated order I(0) process for all i if the corresponding variables are integrated of order I(1). The fact that any short-term imbalance converges to the long-term equilibrium at the rate of φi is a crucial aspect of co-integration. Thus, the error-correcting speed of adjustment term is represented by the value φi. There would be no indication of a long-term relationship if φi = 0. Under the previous premise that the variables show a return to long-run equilibrium, this value is expected to be significantly negative. Numerous important findings are necessary for the PMG approach to be valid (Samargandi et al., 2013). To ensure that there is a long-term relationship between the variables of interest, the error-correction term needs to be negative and at least -2. Second, the explanatory variables should be considered exogenous determinants since the residual obtained from the PMG estimator needs to be serially uncorrelated. Nevertheless, by incorporating lags into an ARDL model for the dependent (p) and independent variables (q) in error-correction format, these requirements can be met. This estimator is particularly useful when one expects that the long-term equilibrium connections between variables will be similar across nations because of their similar economic growth characteristics.

Each cross-section's individual regression is estimated using the second method (MG). This method averages individual parameters from each country-specific regression to produce both long-run and short-run parameters. As a result, both short- and long-term coefficient heterogeneity is allowed by the MG approach. The large time-series dimension of the data is the primary determinant of MG estimators' dependability. One of the underlying presumptions upon which the DFE technique is ultimately implemented is 1) a country-specific intercept. It requires that the short-run and long-run coefficients, as well as the speed of adjustment coefficient, be consistent throughout all cross-sections. In the end, the Hausman test is used to determine each estimator's consistency and efficiency relative to the others.

Data Sources

This study gathered data from eight ASEAN nations—Brunei Darussalam, Indonesia, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam—to assess the influence of ICT growth on CoC. The accessibility of data spanning from 1984 until 2023. This study used corruption control as the dependent variable and information and communication technology (ICT) as the independent variable, which is measured through four indicators: computer, internet, telephone, and mobile phone. This research will utilize panel and time-series data on corruption control and ICT development obtained from the World Development Indicators (WDI) of the World Bank, as referenced in Table 2.

Table 2. Descriptive Statistics ICT development and CoC

Variable	Obs	Mean	Std. Dev.	Min	Max
ICT Development	264	1.357335	.1056831	1.084093	1.502947
Control of Corruption	263	2.726844	1.210808	0	6
Internet	264	318973.3	1013473	-1400000	6200000
Computer	264	34.50799	16.87788	3.42956	157.166
Line Telephone	264	2460158	5879150	-132747	4.10e+07
Mobile Phone	264	28.67048	56.85618	-94.6682	157.403

Conceptual Framework

The present study focuses on the following two areas: ICT development as the independent variables and control of corruption as a dependent variable proposed by ICRG. Therefore, the conceptual framework is suggested in figure 1.

Figure 1. Conceptual Framework

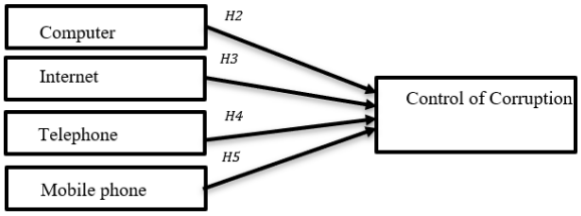

Figure 2. Sub Conceptual Framework

$$LCoC_{it} = \alpha_0 + \beta_1 ICT_{it} + \varepsilon_{it} \quad \text{.....(1)}$$

$$LCoC_{it} = \alpha_0 + \beta_1 Intr_{it} + \beta_1 Comp_{it} + \beta_1 Tlpn_{it} + \beta_1 MP_{it} + \varepsilon_{it} \quad \text{.....(2)}$$

Where LCoC is log Control of Corruption, ICT development is the indices of Computer, Internet, Telephone and Mobile Phone. ε is error correction.

RESULT AND DISCUSSION

In order to determine the appropriate order of integration, this study used the unit root test to analyze a number of interests. In order to prevent erroneous results, it is also important to remember that there is no variable exceeding integration order I(1) (Pesaran and Pesaran, 1997). Additionally, in order to select the appropriate econometric model, it is crucial to verify the sequence of integration of the variables. The results of the panel unit-root testing are shown in Table 3. Table 3 of Im et al. (2003) clearly shows that the test supports the null hypothesis about the presence of a unit root in the related variables. It is confirmed that the autoregressive distributed lag model (ARDL) (p,q) technique is appropriate for data analysis because the variables in this study are stationary at the first difference level.

Table 3. Panel Unit-root Analysis

Variables	**Level**	**1st difference**
	IPS	IPS
ICT Development	-1.6498	-5.4112
CoC	-1.8175	-4.4060
Internet	-1.1964	-7.8793
Computer	-2.5565	-7.1200
Line Telephone	-0.8691	-3.6295
Mobile Phone	0.4281	-3.8200

Table 4 shows the results of the dynamic analysis using the panel ARDL (p,q) framework. The validity of the correlation between ICT development and CoC in certain ASEAN nations is clarified by the ARDL technique. The mean group (MG), the pooled mean group (PMG), and the dynamic fixed effect (DFE) are the three approaches of the ARDL framework that are indicated in this study. The error-correction term's coefficient needs to be negative and at least -2. This coefficient is -0.340 and statistically significant at the 1% level, according to Table 4. In the end, the PMG technique's results show that ICT expansion has a favorable and significant impact on CoC. CoC is severely and negatively impacted by a square shape of ICT development. These findings were consistent with Kim et al. (2009)'s investigation. A successful example of e-government deployment for anti-corruption in Seoul, South Korea, is shown in this study (Kim et al., 2009). The Seoul Metropolitan Government's (SMG) OPEN (Online Procedures Enhancement for Civil Applications) system. (Bertot et al., 2010b; Johnson et al., 1998; Fukuyama, 2001; Ali and Gasmi, 2017; Palvia et al., 2017; Tanzi and Davoodi, 1998; Bhatnagar, 2003b; Bhatnagar, 2003a; Sassi and Ali, 2017) The development of ICT can promote transparency, act as a tool against corruption, and improve the quality of governance.

Table 4. ICT development and Control of Corruption

	PMG		MG		DFE	
Variables	Long Run	Short Run	Long Run	Short Run	Long Run	Short Run
Error Correction		-0.340***		-0.512***		-0.191***
		(0.115)		(0.0782)		(0.0383)
D.ICT Development		-833.3		-969.3		-22.55
		(930.2)		(1,127)		(54.03)
D.ICT Development 2		275.9		320.2		7.545
		(313.7)		(380.8)		(20.79)
L.ICT Development	109.6***		102.4		-37.59	
	(28.88)		(587.7)		(69.22)	
L.ICT Development 2	-47.98***		-50.25		9.669	
	(11.90)		(212.2)		(26.92)	
	(0.986)		(3.704)		(1.436)	
Constant		-18.06***		-28.28		6.450
		(6.251)		(145.8)		(8.000)
Observations	219	219	219	219		

10%*, 5%** and 1%***

Hypothesis Result Summary

H1: There is a positive relationship between ICT development on Control of Corruption

Table 4 indicates that the error-correction coefficient is -0.340 and is statistically significant at the 1% level. Furthermore, the findings derived from the PMG technique suggest that the development indicators of the ICT index exert a positive and significant influence on the CoC. Table 4 presents the analytical results about the impact of ICT development on CoC. Ultimately, the PMG technique demonstrates that ICT growth has a substantial and good influence on mitigating corruption, but the square method reveals a negative and considerable impact on corruption control in the long term. This conclusion corroborates Ali and Gasmi (2017), who discovered that ICT development via mobile phones and the internet is an effective instrument for combating corruption. Likewise, the adoption of e-government and social media facilitates societal engagement in combating corruption (Bertot et al., 2010b). Social transformation entails enabling citizens to oversee government actions through engagement in institutional reform, such as fostering a civil, law-based society to mitigate corruption (Johnson et al., 1998). The advancement of ICT and social media may serve as alternative means to enhance transparency and effect substantial change; yet, social and technological access considerations necessitate supplementary instruments to achieve meaningful outcomes. Furthermore, "regarding anti-corruption, social media possesses four principal potential advantages: collaboration, participation, empowerment, and timeliness" p.3.

The examination of the sub-ICT development dimension (Internet, Computer, Line Telephone, and Mobile Phone) impact on CoC is displayed in Table 5. The PMG method's long-term results show that sub-ICT development, like the internet, significantly and favorably contributes to the reduction of corruption. Previous studies like Ionescu (2013), Grönlund (2010), and Sassi and Ali (2017) have demonstrated that internet users are an effective tool for controlling corruption, which supports these findings. Table 4 demonstrates that, in contrast to the Internet, computers and line phones contribute to

corruption. It implies that corruption increases with improved computer and phone setup and vice versa. Additionally, the cell phone has a beneficial and negligible impact on corruption control

Table 5. Sub ICT development and Control of Corruption

	PMG		MG		DFE	
Variables	Long Run	Short Run	Long Run	Short Run	Long Run	Short Run
Error Correction		-0.303*		-0.652***		-0.320***
		(0.164)		(0.161)		(0.0462)
Internet		0.0395		0.0855		-0.00428
		(0.0475)		(0.198)		(0.0477)
Computer		0.00653		0.0127		-0.000597
		(0.00496)		(0.0116)		(0.00301)
Telephone		-0.681		0.0154		-0.0457
		(0.865)		(0.719)		(0.182)
Mobile Phone		-0.0446		-0.231*		-0.126
		(0.113)		(0.132)		(0.129)
Internet	0.258***		0.405		0.0717	
	(0.0455)		(0.448)		(0.0850)	
Computer	-0.00860**		0.0283		-0.00777	
	(0.00347)		(0.0355)		(0.01000)	
Telephone	-0.176*		-0.244		-0.213	
	(0.103)		(1.104)		(0.255)	
Mobile Phone	0.0223		-0.256		0.0956	
	(0.0340)		(0.183)		(0.0805)	
Constant		-0.398*		0.843		0.475
		(0.241)		(8.574)		(0.971)
Observations	256	256	256	256	256	256

10%*, 5%** and 1%***

Overview of the Hypothesis Findings

H2: Computer use and corruption control are positively correlated.

The empirical findings show that telephone penetration (−0.176, significant at 10%) and computer usage (−0.00860, significant at 5%) are inversely correlated with long-term corruption control. These results imply that, especially in the diverse governance contexts of ASEAN nations, not all ICT components consistently aid in the reduction of corruption. There are a number of interconnected structural, institutional, and governance-based explanations for this result. Furthermore, without strong institutional frameworks, the spread of ICT technology (such computers) does not automatically improve accountability or transparency (Rehman et al., 2023, Apriliyanti et al., 2021). Although computers are widely used in public sector organizations in a number of ASEAN nations, they are frequently only utilized to digitize current bureaucratic processes rather than to improve them. This tendency, which is sometimes described as "digitizing corruption rather than eliminating it," suggests that when manual systems are replaced by poorly controlled digital ones, corrupt behaviors may continue or even become more effective. Computers may enable data manipulation, selective access to information, and the concealing of fraudulent transactions rather than their exposure in the absence of

robust internal controls, audit trails, interoperability, and independent monitoring (Kadha et al., 2025, Addo and Avgerou, 2021).

H3: The Control of Corruption and Internet usage are positively correlated.

The analytical findings on the impact of the Internet indicator on CoC are shown in Table 5. In the end, the PMG method shows that, at the 5% level, the computer indicator has a significant negative and statistically significant impact on corruption reduction. The internet variable, on the other hand, has a positive and statistically significant impact on corruption control (0.258, $p < 0.01$), suggesting that internet diffusion is more effective in enhancing the quality of governance in ASEAN nations. Through e-government platforms, open data portals, online procurement systems, and digital reporting mechanisms, the internet facilitates increased transparency, information accessibility, and public participation in contrast to traditional ICT components (Darusalam et al., 2021b, Darusalam et al., 2024, Gnangnon, 2020). More people having access to the internet improves the traceability of administrative procedures, lessens the information asymmetry between residents and governments, and makes it easier to monitor public services in real time. The internet enables individuals, civil society, and the media to more thoroughly examine government actions in the ASEAN environment, as digital governance improvements increasingly depend on web-based platforms, hence limiting options for corrupt activity(Darusalam et al., 2023). This research emphasizes that ICT elements incorporated into transparent, participatory, and open digital ecosystems have a higher chance of producing significant anti-corruption results.

H4: Telephone use and the fight against corruption are positively correlated.

The slightly significant negative effect of telephone penetration on corruption control (-0.176, $p < 0.10$) implies that traditional communications infrastructure is not an effective anti-corruption measure in ASEAN administration. Telephones are mostly used for private, undocumented, and bilateral communication, limiting transparency and public monitoring (Shabbir et al., 2019, Shabbir et al., 2021). Telephone conversations may enhance informal networks, patronage links, and discretionary decision-making between public officials and private actors in various ASEAN countries (Kouladoum, 2023, Waweru et al., 2025). Fixed-line telephone systems lack auditability and digital traceability, limiting accountability and corruption monitoring. Thus, increased telephone dispersion may allow cooperation and discussion outside formal governance channels, reducing corruption control. This suggests that ICT components without transparency-enhancing aspects may have limited or even negative governance effects, especially in institutional settings with informal behaviors.

H5: The use of mobile phones and the prevention of corruption are positively correlated.

The analytical findings on the impact of the mobile phone indicator on CoC are shown in Table 5. In the end, the PMG approach's results show that the cell phone indicator has a negligible and unfavorable impact on reducing corruption. The variable of mobile phones has a positive but statistically insignificant influence on corruption control (0.0223), indicating that the spread of mobile phones by itself is not enough to yield quantifiable anti-corruption results in ASEAN nations (Darusalam et al., 2021a). Although mobile phones can help spread information, denounce corrupt activities, and engage citizens, their efficacy is primarily dependent on formal reporting procedures, institutional responsiveness, and interaction with internet-based platforms (Sohag et al., 2021, Lustrilanang et al., 2023). Instead of organized governance applications, personal communication and casual encounters continue to dominate mobile phone usage in many ASEAN environments. Furthermore, the potential of mobile technology to convert accessibility into accountability may be hindered by low enforcement capacity, uneven digital literacy, and limited utilization of mobile-based e-government services. Therefore, mobile phone proliferation may result in only slight improvements in corruption control if appropriate institutional frameworks and digital governance integration are not in place.

CONCLUSION

Using a dynamic panel ARDL framework, this study investigates how the growth of information and communication technology (ICT) affects the control of corruption (CoC) in ASEAN nations. The results show a non-linear, inverted U-shaped relationship between ICT growth and corruption control, suggesting that while ICT expansion initially improves governance quality, it has declining or negative effects after a certain point. Furthermore, the disaggregated study finds that although traditional ICT components like computers and phones have negligible or negative effects, and mobile phone adoption has only a small impact, internet dissemination greatly increases corruption control.

From the perspective of theory, this analysis challenges the notion that ICT development consistently enhances corruption control, adding to the literature on governance and digitalization. The work improves on current macro-governance models by showing that the efficacy of ICT is dependent on its institutional embedding and functional properties by integrating non-linear dynamics and disaggregated ICT components. The results support the ICT-for-governance theory by showing that digital tools that promote openness and encourage participation—like internet-based platforms—are more successful in reducing corruption than ICT infrastructure that only digitizes administrative procedures. By highlighting the conditional and context-dependent role of digital technology in public governance, this nuanced evidence enhances the theory of corruption control.

The findings have a number of significant ramifications for ASEAN governance organizations, public sector accountants, and policymakers. First, governments should prioritize institutional preparedness, regulatory oversight, and accountability mechanisms in addition to ICT investments, going beyond technology-driven anti-corruption strategies. Without governance change, an over-reliance on hardware expansion could inadvertently encourage administrative discretion and rent-seeking conduct. Second, policy initiatives should concentrate on bolstering internet-based e-government tools that improve traceability and transparency, such as digital procurement, open data platforms, and online audit trails. In order to make sure that digitization promotes integrity rather than covert misbehavior, the findings highlight the significance of combining ICT systems with internal controls, digital auditing tools, and real-time financial monitoring for public sector accountants and oversight authorities. The empirical results demonstrate that ICT development exerts a statistically significant influence on corruption control.

This study has a number of shortcomings in spite of its contributions. The report only looks at ASEAN nations and employs macro-level metrics, which might not adequately reflect sector-specific corruption practices or micro-institutional dynamics. Subsequent studies could look at the relationship between ICT development and institutional quality, legal enforcement, or cultural characteristics, add firm-level or administrative data, and expand this concept to other regional contexts. Further understanding of the changing relationship between digital governance and corruption control may also be gained by investigating cutting-edge digital technologies like blockchain, artificial intelligence, and big data analytics. Overall, this study shows that ICT growth is an essential but insufficient prerequisite for successful corruption prevention. Digital technology must be strategically aligned with institutional reforms, accountability frameworks, and active civic engagement in order to achieve sustainable gains in governance. ICT represents an important governance instrument for mitigating corruption.

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