



The role of education in modulating the effect of ICT on governance in Africa

Muhamadu Awal Kindzeka Wirajing¹ · Tii N. Nchofoung^{1,2} 

Received: 30 June 2022 / Accepted: 30 January 2023 / Published online: 2 March 2023

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Abstract

This study investigates the role of education in modulating the effect of ICT on governance in 53 African countries between 2002 and 2020. The Two-Step System Generalized Method of Moment (GMM) strategy is adopted to address the potential endogeneity problem. Governance is computed as a composite index that encompasses the six indicators of the Worldwide Governance Indicators (Control of corruption, rule of law, political stability, regulatory quality, government effectiveness, and voice and accountability). ICT is measured by the number of individuals using the internet, mobile cellular subscribers and fixed broadband subscription. The findings of the study reveal that the quality of governance in Africa is enhanced by growth in ICT. The findings further indicate that the interaction between ICT and education procure positive net effects on governance. In addition, we observed that ICT still enhances the quality of governance in African countries that have adopted the French civil law and the British common law system. The study suggests the design of policies for enhancing e-governance and ICT in African institutions, and are recommended to be used as part of the school curriculum for quality management.

Keywords Mediation effect · Education · Governance · GMM · ICT

1 Introduction

Digital technologies have played an important role in the socioeconomic development of Africa. The prevalent technology in Africa has enhanced the quality of education (Tchamyou et al., 2019) and the quality of institutions (Beecroft et al.,

✉ Tii N. Nchofoung
ntii12@yahoo.com

Muhamadu Awal Kindzeka Wirajing
wirajingmuhamadu@gmail.com

¹ Department of Economic Policy Analysis, University of Dschang, Dschang, Cameroon

² Ministry of Trade, Yaounde-Cameroon, University of Dschang, Dschang, Cameroon

2020). Information and communication technology (ICT) has enabled governments in African countries to transform and enhance their information systems to improve the quality of their governance (Alfoul, 2022). Structural transformation and socioeconomic development in any economy require a better adaptation to the knowledge economy which is facilitated by ICT diffusion. Besides, the digitalization of the economy enhances inclusive finance through its ability in stimulating digital innovations in the financial sector (Kouladoum et al., 2022). ICT adoption and technological transfer have prompted and updated the functions performed in the administrative sectors by assuring transparency and effectiveness, which point to the characteristics of a high-quality organisation. The important ICT adaptations have had wider implications on society and institutions. The pace of ICT growth and the technological landscape has facilitated globalization at all levels (Ponelis & Holmner, 2015). The African educational sector has developed considerably over the years due to ICT penetration and advances in science (Meyer & Gent, 2016; Samarakoon et al., 2017). Technological innovation is deemed to only have a substantial effect on the structural and economic transformation of the African economy but also a long-lasting effect on mentality change and the quality of institutions that support policy decisions.

Given the importance of digitalization for sustainable development, countries have in recent decades embraced the adoption of digital technologies. In this respect, the rate of digitalization in Africa has improved since the beginning of the twenty-first century (Asongu & Odhiambo, 2019). The percentage of individuals within the population using the internet has increased considerably in Sub-Saharan Africa. This particularly has been the case in the last decade, which increased from 4% in 2010 to 30% in 2020. This increase is far below the World's average percentage of internet users which increases from 29% in 2010 to 60% in 2020 (World Bank, 2021). As a response to this dispersion of technological diffusion, the World Bank established the initiative of Digital Economy for Africa (DEA) launched in 2019 in support of the "African Union's Digital Transformation Strategy" to enhance technological infrastructure, public platforms and businesses while minimizing the risks associated with digital transformation. This plan has helped to establish more than 149 World Bank projects in 34 African economies to ensure a safe digital economy (World Bank, 2022a, 2022b). This initiative is to reduce inequality of opportunities in the digitalization sectors across the globe and also serve as a means toward the attainment of sustainable development. ICT diffusion and technological transfer have modernized the activities perform in public administration to ensure transparency and government effectiveness. Given the importance of education in setting the pace of ICT diffusion, we seek to determine the modulating effect of education on the effect of ICT on institutional quality in Africa.

The quality of institutions in any economy nowadays employs systematic governing roles facilitated by ICT through the collection, processing, and transmission of data using digital tools (Toader et al., 2018). Governance is in parlance with targeting institutional, political and socioeconomic goals, which are prerequisites for sustainable development. This is particularly aligned with sustainable development goal 16 (SDG16) which seeks to Promote peaceful and inclusive societies for sustainable

development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels (Nchofoung & Asongu, 2022a, 2022b; Tchamyou et al., 2019). Good governance entails proper management of public affairs and resources in a manner that realisation of human rights and equal representation is ensured. The enhancement of the information system is a development policy objective which is a key driver for future effective governance and policy modelling techniques through the assessments, exploitation and integration of data and knowledge management capacities. The rate of globalization and ICT diffusion can help policymakers to anticipate future happenings and risks based on past data and to set better policy objectives to take advantage of future opportunities. Examining the scenarios for open governance in an increasingly digital environment in Africa is very significant due to unprecedented access to information and educational quality which facilitate the movement from cognitive capacities of memorising and processing data onto machine storage and the development of sophisticated analytical skills for management (Hollington, 2022; Misuraca et al., 2012).

The quality of institutions and governance fosters and builds pillars to support development policy decisions. The sustainability of the information system is enhanced by good governance and the knowledge economy. Good governance objectives are accomplished within appropriate ICT tools which establishes a favourable platform to achieve SDGs (Aguboshim et al., 2019; Koltay, 2016). The adoption of ICT for governance depends on its sustainability and the pace of diffusion in which users have to be motivated to use its tools to raise the level of trust (Aguboshim & Udobi, 2019). Sustainable ICT has significant importance in leveraging in meeting sustainable development goals and improving the quality of governance in Africa (Aguboshim et al., 2019; Bennett, 2017). The level of corruption control in Africa has not been of a good standard due to the less adoption of ICT tools in public institutions. To a certain extent, corruption, ignorance, culture and illiteracy are factors that hinder the adoption of digital technology tools in public institutions (Ngouhouo et al., 2021). Militating attempts against the adoption of digital tools is a way of deteriorating the quality of institutions and mismanagement of state funds.

Self-enabled and organised societies develop proactive measures that address emerging problems faster than traditional governments that have not adapted to the global economy facilitated by ICT (Asongu et al., 2018; Misuraca et al., 2012), also, ICT tends to provide a self-regulated communication network for governance to the ICT adapted economy (Hollington, 2022; Sabani et al., 2019). The creativity of emerging and developed economies with advanced technologies could lead to more resilience in a period of crisis than in developing economies with low digitalization whose communities are lagging in the information system. In addition, ICT bring a sense of social cohesion and belonging between different communities which facilitates the government's decisions on a global community with social belongings (Sabani et al., 2019). Efficient and fast communication, data treatment, processing, retrieval and storage, its exchange and utilisation by organizations, businesses and governments have transformed the levels of expectations in terms of business profit, government policy effectiveness and institutional quality (Imhonopi & Urim, 2011; Misuraca et al., 2012; Hollington, 2022).

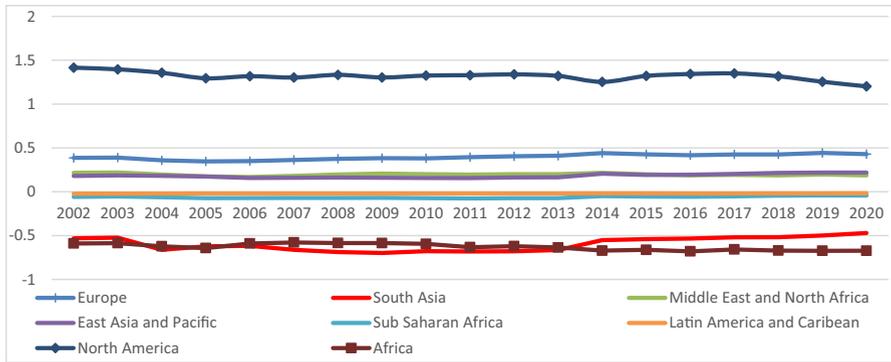


Fig. 1 Regional comparison of governance / Source: Authors’ computation using World Bank (2022)

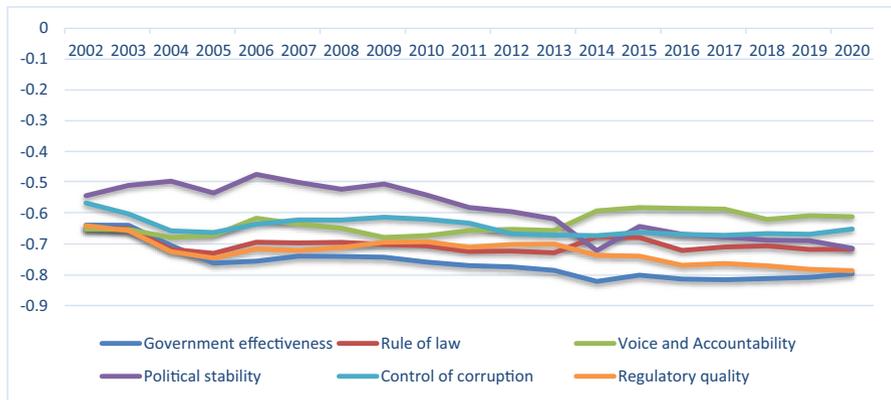


Fig. 2 Trends in the World Governance Indicators in Africa / Source: Authors’ computation

With the growing concerns of poor governance and the quality of institutions worsened by increased corruption and mismanagement of funds, the search for strategies to combat its corrosive effects has been a great action facilitated by technological diffusion. As compared to other regions of the world, the governance quality of African countries remains degrading as identified in the World Governance database of the World Bank (2021). Figure 1 compares the trends in the quality of institutions in the different regions classified by the World Bank. The governance measure is computed as the average of the Kaufmann et al. (2011) six governance indicators to compare the quality of governance in Africa with that of other regions.

Figure 1 shows that the quality of governance in Africa is far below that of other regions of the World. The average evolution of African governance has indicated decreasing trends between 2002 and 2020. Relatively, North America, Europe and East Asia are above Africa, South Asia and Latin America in terms of government effectiveness, rule of law, political stability and control of corruption. Africa has the

worst quality of governance with a high degree of political pressure that needs to be addressed by policymakers. Figure 2 indicates trends of the six World Bank Governance Indicators from 2002 to 2022 in Africa. The figure compares the different aspects of governance to bring an overview of how the different dimensions evolve over the years.

Figure 2 demonstrates a decreasing quality of governance in Africa between 2002 and 2020. This deterioration of the quality of institutions acts as a hurdle in meeting the sustainable development goals that require good policies with quality institutions. The average government effectiveness decreases from -0.6388085 in 2002 to -0.7966833 in 2020. Political stability as an indicator of governance also decreases between 2002 and 2020, raising concern about the ability of governments to respond to governance challenges with anti-corruption initiatives. Due to the inability of the African governments to respond to poor governance challenges, the World Bank established the “Governance and Institutions” Special Theme highlighting the importance of transparency in governance with proposed measurable policy actions. As demonstrated in Fig. 1, North America and Europe relatively have better institutional quality and are regions with developed technological infrastructures and advanced knowledge economies. For Africa to reach their levels, African policymakers should design policies promoting ICT diffusion and educational development for better knowledge accumulation and quality governance. The level of education determines the speed of ICT diffusion in any economy which can enhance and strengthen the quality of institutions (Asongu & Nwachukwu, 2019). This study, therefore, seeks to answer the following questions: (i) what is the effect of ICT on governance in Africa? (ii) What is the modulating effect of education on the ICT-governance nexus?

The contributions of the study to the literature are as follows: The study examines the role played by education in modulating the effect of ICT on governance which has been neglected in the literature. The closest works to our study are that of Asongu and Odhiambo (2019), Asongu and Nwachukwu (2019). The later study investigated the role of trade openness in modulating the effect of ICT on governance. This study is the closest to our study as it addresses the ICT-Governance nexus but we distinguished our work by investigating the role of education in modulating the ICT-governance nexus. This will be beneficial especially to policymakers in the educational sector, in elaborating educational programs for the efficient use of ICT for governance through education. Secondly, the study has addressed different governance aspects of political, institutional and economic governance to test if the modulating role of ICT varies across different dimensions of governance in Africa. The importance of addressing these dimensions is to have better policy recommendations on different governance aspects. The study also accounts for differences in income levels due to the argument in literature that there is a high ICT diffusion in high-income countries than in lower-income countries to test if the effect of ICT on governance will differ between these countries (Hollington, 2022). Also as a major contribution of the study, we addressed differences in legal systems between the African countries that practice the French civil law system and those that practice the English common law system as a factor that influences the quality of institutions. This is important because judicial systems are of primary importance to determine

how public institutions function and the quality of their governance. The quality of institutions indicated by the abidance to the rule of law in these countries can be facilitated by e-governance, justifying why the differences in the legal systems are important to address in our study. The rest of the work is structured in 4 sections. Section 2 discusses the relevant theoretical underpinnings and empirical findings on education, ICT and governance. In Section 3, we present the data and methodology. Section 4 presents and discusses the results and Section 5 presents the conclusion and policy recommendations, with future research perspective.

2 Literature review

2.1 Theoretical literature

There is a substantial theoretical underpinning on the quality of institutions and ICT diffusion in the context of ameliorating the quality of governance and ensuring transparency. Among these documented theories is that of evolutionary institutional change which suggests that the quality of institutions depends on the actions of humans and social behaviours learned with the facilitation of technological diffusion and human capital accumulation (Eggertsson, 2009). The evolutionary theory confirmed the changing behaviours of individuals as a result of globalization which affects the quality of governance through imitation. In the evolutionary change theory, societal changes due to a decentralized selection process inflict negative consequences on institutions that cannot adapt and make adaptive institutions more successful (Knight, 1997; North, 1990). In Hayek's (1973) early theory of institutional change based on the selection at the level of the social group, the successful groups are those that adapt to new rules and put them into practice, he documented in his famous words which says: "thinking and acting are governed by rules which have by a process of selection been evolved in the society".

Considering the major changes induced by ICT and not accounted for in the previous evolutionary institutional change documented in the works of Hayek (1973), Libecap (1989) highlighted in the Designed-based theories of institutional change the importance of a collective choice process in which rules and regulations governing any society has to be designed by a collective political entity, such as a group of individuals belonging to a political party with the same ideology, a community or a state. The designed-based theory has as a basic argument to ensure a collective action that can reduce tensions and conflicts (Coccia, 2018). The designed-based theory considers an institution governed by collective actions irrespective of changes in the societies. Tucker and Ostrom (2005) documented the role played by technological change in influencing the quality of institutions which he identified technology as an exogenous cause of a possible amelioration or deterioration in the quality of institutions through operational rules that govern daily interactions between the citizens and the government. The two established theories of institutional change acknowledged the importance of technology in influencing both the actions of individuals and the implementation of new governing rules. Highlighting the importance of the equilibrium view of institutions based on the essential role of

both formal and informal rules, Coccia (2018) argued that the quality of institutions determines the level at which objectives are met which is greatly influenced by both internal and external factors. These factors include human actions influenced by both exogenous and endogenous factors such as technological innovations and education, income distribution, and information availability (Greif & Laitin, 2004; Imhonopi & Urim, 2011; Misuraca & Viscusi, 2015). The equilibrium theory of governance and institutions had shifted from concentrating on the rules governing institutions to human actions which distinguished itself from the institutional change theories that focus on the rules governing the institutions and the factors that induced this change (Aoki, 2001; Myerson, 2004).

Another notable piece of literature that discusses the ICT impact on governance is the business process re-engineering theory which is popularized by the works of Guha et al. (1993), Hammer and Champy (1993), Weicher et al. (1995) and consistent with those of Bannister and Connolly (2012). The theory is based on the fact that technological advancement facilitates management decisions and activities. Changes in the managerial process as documented in this theory, is a factor that determines institutional performance and change. Technology facilitates the transformative processes implemented to ameliorate the quality of institutions, though, Bannister and Connolly (2012) argued that there is no evidence that these structural and performance changes are technology-driven or induced characteristics that would not have been possible without technology. Investigating the technology's role in the quality and the performance of institutions suffices a thorough review of empirical works conducted on the ICT-governance nexus which is presented in the next section. The weakness in the reviewed theoretical underpinnings is that previous studies did not consider the impact of technology on the quality of institutions to be influenced by the level of human capital which is well demonstrated in this study since the level of technological diffusion is higher in economies with advanced knowledge economies.

2.2 Empirical literature

A significant number of authors have documented that technological innovation in the public sector has resulted in transparency and the improvement of the quality of institutions through e-governance while others have documented that ICT diffusion has increased corruption and illegal practices in both the private and the public sectors. Among the authors who perceived ICT for the enhancement of governance and the quality of institutions is Hollington (2022) who examined the effect of internet penetration on the perceptions of corruption in African countries inspired by increased corruption and state funds embezzlements during the period of the Covid-19. The author found that corruption in Africa is reduced by higher levels of investment in ICT. Similarly, Imhonopi and Urim (2011) conducted a study investigating the effect of ICT diffusion on governance. The authors found out that ICTs have contributed to the enhancement of e-governance in Nigeria and created more open spaces for citizens, businesses, associations and interagency interaction with the government. The authors found that digital technology has facilitated the

delivery of social goods by the national, and state governments. Similarly, Misuraca et al. (2012) obtained similar results after investigating the effect of technological progress in a developed framework and the resulting views of what the European Information Society might be by 2030. Their findings show that ICT for governance help in policy modelling and increases the quality of institutions. Aguboshim et al. (2019) obtained similar results after investigating the effect of ICT and big data on Sustainable Governance in Nigeria. The results of the authors indicate that ICT has made landmark innovational trends in empowering data governance and transparency in businesses and organizations. In the same direction, Koltay (2016) revealed that sustainable ICT enhances the quality of institutions, and is in the same line with the findings of Aguboshim and Udobi (2019). Oliveira et al. (2020) after investigating the effect of digital technologies on the quality of institutions and the level of socio-economic development confirmed that ICT promote innovation, and enhances e-governance which is a fundamental tool for a decentralized democracy. Misuraca and Viscusi (2015) investigated the ICT-enabled innovation for governance, assessing whether the ICT-based applications can be used to achieve the target of evidence-based and participative governance, and improve the quality of institutions and policy-making outcomes. Their findings show that ICT-enabled innovations enhance the quality of governance processes. Loukis et al. (2016) after investigating the relationships between ICT and governance of organizational networks found that network governance is an evolving technical process that helps to tackle complex and dynamic contemporary challenges in organizations.

Another strand of literature focuses on the effect of ICT on corruption control and decentralization processes. Bhattacharjee and Shrivastava (2018) revealed that ICT reduces corruption by increasing the certainty and celerity of laws to be followed by citizens and the sanctions related to corrupt practices. Charoensukmongkol and Moqbel (2014) after investigating the effect of ICT on governance revealed a linear relationship between ICT investment and the control of corruption. The negative effect of ICT on corruption is also confirmed in the works of Soper and Demirkan (2012) and DiRienzo et al. (2007) who argued that ICT increases transparency in organizations and businesses which reduces corruption and illegal activities. Similarly, Sabani et al. (2019) investigated the role of ICT on governance in Indonesia, investigating the barriers and potential drivers to the implementation of ICT. The findings of the author indicate that ICT ameliorate the quality of institutions and enabled good governance in support of eradicating corruption in the Indonesian public sector. Also, Gaskins (2013), Mistry and Jalal (2012), and Ionescu (2013) found a positive effect of ICT infrastructure in the control of corruption and increasing transparency in public services.

Some studies focused on demonstrating how ICT has affected the implementation of the rule of law. Kennedy (2016) revealed in his investigations on the effect of ICT on rule of law that increasing use of the internet has helped in bureaucratic and regulatory processes. Eger and Maggipinto (2009) found that the use of the internet and ICT innovation in e-regulation can enhance the operation of the rule of law and facilitate the fulfilment of the conditions of good governance. The findings of Pagallo (2021) demonstrate some fruitful solutions for the operations of the legal system facilitated by ICT. Similarly, Kohl (2004) in his analysis of past literature

investigating the effect of the internet on the rule of law concluded that the rise of law in cyberspace and the internet make it possible to know the legal consequences of an individual's actions. Contrarily, Murray (2017) in his investigations found that the internet does not provide an effective rule of law and regulations.

In the same light, among the fewer studies that have demonstrated the negative sides of ICT by demonstrating either its insignificance or the harmful effect on the quality of institutions and business is Orji (2015) who showed that the pace of internet penetration in the African continent has raised concerns about cyber criminality and has created an environment for forum shopping by cyber criminals, thus questioning institutions of laws for non-abiding citizens. Quarshie (2014) and Agwu (2013) obtained similar findings on the positive effect of ICT and criminal acts in Africa. Similarly, Burrell (2008) in his findings shows that internet penetration brought difficulties of trust in oneself due to high criminality facilitated by ICT in both the private and the public sectors. Adam (2020) argued that the level of ICT in Africa is still very low for it to ensure transparency and good governance. He found an insignificant effect of e-government on corruption and suggests that ICT for improved quality of a country's institutions.

In addition, we consider another strand of literature that underpins the relationship between education, ICT and governance. Among the studies conducted in this aspect, are those of Noor-Ul-Amin (2013), Santiago et al. (2015), Mallick (2021), Williamson (2016), Donina and Hasanefendic (2019) who argued that education positively influences the quality of institutions through ICT diffusion and regional integration. In this strand of literature, education does not only contribute to facilitating ICT diffusion but also raises awareness of the sanctions related to the non-abidance to the role of law. Considering tertiary education as the main stage that influences institutional quality, Donina and Hasanefendic (2015), and Asongu and Odhiambo (2019), acknowledge the importance of both national and international reforms, trade and foreign direct investments in determining the level of transparency in government institutions facilitated by ICT. Similarly, this is partly because the advent of digital education had resulted in the creation of digitalized database platforms and related forms of technical expertise for quality governance, and also due to the widespread diffusion and the complete transformation of the learning process, especially in higher education. Noor-Ul-Amin (2013) in his study, acknowledged that the high pace of ICT diffusion in western countries with advanced knowledge economies and good governance is enough to defend the role of ICT and education for transparency and good governance, given that it provides a tool of curriculum differentiation authenticity when managed by educated elites.

Studies conducted investigating the effect of ICT on the quality of institutions or governance have limited governance to control corruption, institutional transparency and rule of law. Most studies conducted in this domain have enumerated well how ICT has been employed to reduce illegal practices and establish surveillance systems to reduce corruption and ensure good governance. Other aspects of governance such as voice and accountability, regulatory quality and political stability have not been considered which has called for our attention for serious considerations. The study fills this gap considering that a lot has to be done to ensure good governance both

in the economic, social, institutional and political domains at the private and public sector levels. This study employs educational development as a channel through which ICT influences the quality of governance in Africa, since the pace of ICT diffusion depends on the rate of human capital accumulation. Some studies conducted on governance and ICT, such as that of Asongu and Odhiambo (2019), Asongu and Nwachukwu (2019) employed the GMM strategy to address the problems of simultaneity bias and heterogeneity through an instrumentation process which is in this effect that we adopt the same strategy to avoid poor specification of our results.

3 Methodology

3.1 The nature and the source of data

The study employs secondary data on 53¹ African countries obtained from different sources. Data on governance indicators are obtained from the World Bank Governance Indicators (WGI) and spans from 2002 to 2020. The data on ICT indicators are obtained from the World Development Indicators (World Bank, 2021) spanning from 2002 to 2020 with some missing data for some countries. Also, the data on domestic credit, trade openness, educational development and the gross domestic product are obtained from the World Bank (2021). The duration and the sample size of the study are selected based on data availability. Data on governance indicators for African countries is consistent between 2002 and 2020 which serves as a justification for the period of the study.

3.1.1 Dependent Variable

The study examines the effect of ICT on governance in Africa. The dependent variable of the study is governance. Governance is computed as an average of the six governance indicators of Kaufmann et al. (2011). These indicators are control of corruption, rule of law, regulatory quality, voice and accountability, government effectiveness and political stability. The composite indicator of governance is obtained by calculating the average of these six indicators and is consistent with Ngouhouo et al. (2021).

Figure 3 presents the average governance of the six indicators for African countries over the period 2002–2020 sourced from the WGI of the World Bank. These governance indicator scores range on a scale of -2.5 and 2.5. The worst possible governance is attributed the value: -2.5 (poor governance) and 2.5 represents good

¹ Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Cabo Verde, Cameroon, Central African Republic, Chad, Comoros, Congo, Dem. Rep., Congo, Rep., Cote d'Ivoire, Cote d'Ivoire, Egypt, Arab Republic, Equatorial Guinea, Eritrea, Eswatini, Ethiopia, Gabon, Gambia, The Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Libya, Madagascar, Malawi, Mali, Mauritania, Mauritius, Morocco, Mozambique, Namibia, Niger, Nigeria, Rwanda, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, Somalia, South Africa, South Sudan, Sudan, Tanzania, Togo, Tunisia, Uganda, Zambia and Zimbabwe.



Fig. 3 Governance in Africa / Source: Authors' construction from the WGI (2022)

governance. The governance level of Africa dropped considerably between 2002 and 2020. The governance figures are all negative indicating a poor governance level. The quality of institutions decreases from -0.5899779 in 2002 to -0.6729501 in 2020. This decrease suggests deterioration in both the economic, institutional and political governance in Africa.

3.1.2 Independent variable of interest

The main independent variable is ICT measured by the number of individuals using the internet per 100 people, the number of fixed telephone subscribers per 100 people, the number of fixed broadband subscribers and mobile cellular phone subscribers with a composite indicator that is obtained as a sum of all these four indicators. We have adopted all these indicators to have a good policy implication on how ICT can be used to enhance the quality of institutions in Africa. ICT has been employed in literature as a determinant of governance indicators, specifically as a determinant of control of corruption and rule of law. Among authors who have employed ICT as a determinant of governance are Alfoul (2022), Aguboshim et al. (2019) and Koltay (2016). These indicators are expected to have a positive effect on the quality of governance through increased transparency and control of corruption. The trends in ICT indicators are presented in Fig. 4.

The rate of ICT diffusion has increased in Africa in the last two decades. Figure 4 presents the evolution of ICT indicators between 2002 and 2020. All ICT indicators which comprise individuals using the internet, fixed telephone subscription, mobile cellular subscription, fixed broadband and a composite indicator that encompasses all the four indicators have all demonstrated increasing trends between 2002 and 2020 except for fixed phone subscribers have decreased from 3.902932 in 2002 to 3.790365 in 2020. The number of internet users per 100,000 adults has increased considerably from 1.564853 in 2002 to 68.39955 in 2020. The number of mobile cellular subscribers per 100 people increases from

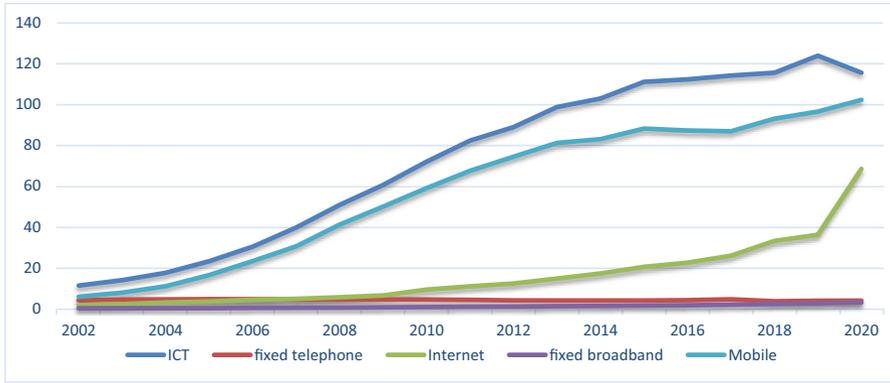


Fig. 4 The ICT trends in Africa / Source: Authors' construction from World Bank (2022)

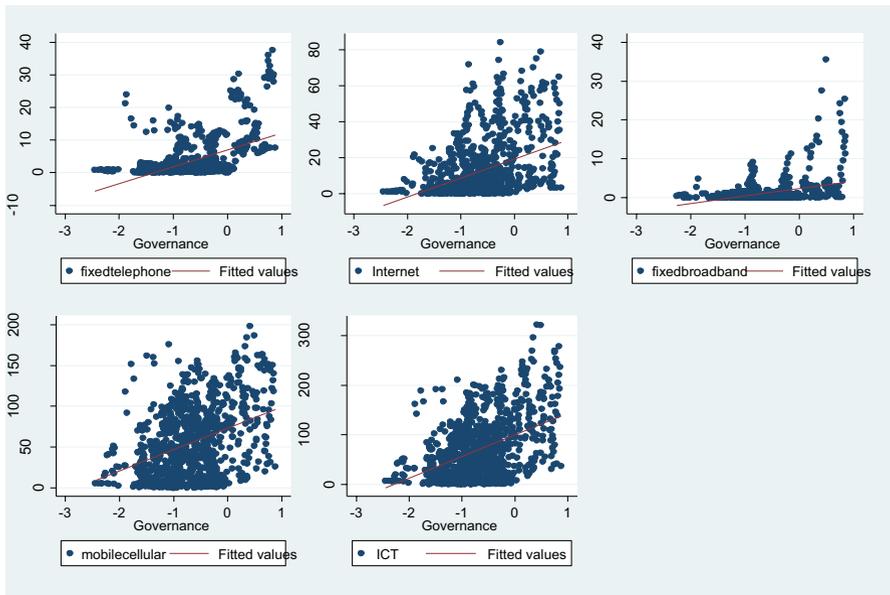


Fig. 5 The correlation between ICT and Governance in Africa/ A fitted scatter plot analysis

5.686512 in 2002 to 102.2631 in 2020. The number of fixed broadband subscribers per 100 people increases from 0.025001 in 2002 to 2.863327 in 2020. The figure presents an insight into how technological infrastructures in Africa have evolved since the turn of the century.

Figure 5 establishes a relationship between governance and ICT in Africa. The correlation analysis shows a strong positive correlation between ICT and governance in Africa. The figure shows that both indicators of ICT enhance the quality of governance measured as a composite indicator. The correlation analysis appeared

as a preliminary finding to what could be the effect of ICT on governance in Africa which will be further tested by a more robust GMM strategy since the scatter plot does not account for estimation issues such as the problem of endogeneity and the error term related problems.

3.1.3 Control variables

We selected the control variables of the study based on the existing literature on the determinants of governance and specifically from the studies conducted in Africa. Varghese (2013) employed education as a determinant of governance in Africa. Also, Asongu and Nwachukwu (2017) employed trade openness as a determinant of governance measured as the sum of imports and export as a % of GDP. We expect a positive relationship between governance and economic growth since good institutions establish platforms that can ensure the productivity of investments and human capital accumulation which increases economic growth. Trade openness can either have a positive or a negative effect on governance.

Also, economic growth is widely used in literature by many authors as a determinant of governance, among some of these authors are Asongu and Nwachukwu (2017), Asongu and Nnanna (2019). Also, as a determinant of governance in Africa, Asongu and Nwachukwu (2017) argued that education can influence the quality of institutions. Sayılır et al. (2018) establish the relationship between financial development and governance. Financial development in the study is measured by domestic credit to private businesses. Table 1 summarizes these variables in terms of the number of observations, mean, standard deviation and the range.

Table 1 Descriptive Statistics

Variable	Obs	Mean	Std. Dev	Min	Max
Governance	999	-0.677	0.627	-2.449	0.88
government effectiveness	998	-0.763	0.645	-2.475	1.057
control of corruption	998	-0.644	0.624	-1.905	1.23
political stability	998	-0.592	0.912	-3.315	1.2
regulatory quality	998	-0.725	0.64	-2.645	1.127
rule of law	998	-0.703	0.65	-2.606	1.077
voice and accountability	998	-0.635	0.746	-2.226	0.979
Internet	880	12.650	16.0468	0.0310	84.120
mobile cellular	965	55.778	44.091	0.21	198.152
fixed broadband	765	1.158	3.216	0.000021	35.554
fixed telephone	951	3.673	6.148	0.0014	37.64
ICT	973	19.095	16.237	0.142	110.812
Education	823	60.427	24.997	0.436	143.725
financial development	940	20.24	18.141	0	106.26
GDP	974	3.915	7.089	-62.076	123.14
trade	898	70.83	33.486	0.785	225.023

3.2 Regression methodology

The study adopts a two-step GMM strategy to investigate the effect of ICT on governance in Africa. From Roodman (2009a), and consistent with Nchofoung et al. (2022), Nchofoung et al. (2021), Nchofoung and Asongu (2022a) adopting the GMM strategy suffices for the cross-sectional dimension to exceed the time dimension. The study is conducted in 53 African countries spanning from 2002 to 2020, signifying a cross-sectional dimension of 53 and a time dimension of 19 confirming the basic condition documented in Roodman (2009b). Secondly, the consistency of the governance indicators has been verified since the correlations between the governance indicators and their corresponding first lagged values are 0.997, 0.984, 0.984, 0.984, 0.988, 0.968 and 0.986 which are all higher than the threshold of 0.800 considered as an established rule of thumb for assessing persistence in a dependent variable (Asongu & Odhiambo, 2019; Kouladoum et al., 2022). The GMM is a strategy widely applied for data structured in a panel form since it does not eliminate cross-country variation as they are inherent in panel data analyses. The panel nature of our data consists of 53 cross sections for 19 years. Fourthly, the GMM is an instrumental strategy that addresses the problem of endogeneity from two angles, on one hand by accounting for time-invariant omitted variables through the control of unobserved heterogeneity and on the other hand by addressing reverse causality (Nchofoung & Asongu, 2022a; Asongu and Nwachukwu, 2016; Blundell & Bond, 1998; Asongu & Odhiambo, 2019).

The GMM technique adopted in the study can be summarised with its subsequent equations in levels (2) and in first difference (3) as follows:

$$Gov_{it} = \beta_0 + \beta_1 Gov_{i(t-\tau)} + \beta_2 ICT_{it} + \sum_{h=1}^k \delta_h Z_{hi(t-\tau)} + \mu_i + \gamma_t + \varepsilon_{it} \quad (1)$$

$$Gov_{it} - Gov_{i(t-\tau)} = \beta_1 (Gov_{i(t-\tau)} - Gov_{i(t-2\tau)}) + \beta_2 (ICT_{it} - \beta_2 ICT_{i(t-\tau)}) + \sum_{h=1}^k \delta_h (Z_{hi(t-\tau)} + Z_{hi(t-2\tau)}) + (\gamma_t - \gamma_{(t-\tau)}) + (\varepsilon_{it} - \varepsilon_{i(t-\tau)}) \quad (2)$$

As established in Eqs. 1 and 2, Gov stands for governance proxied as a composite indicator, ICT represents information and communication technologies proxied by internet users, fixed broadband, fixed and mobile cellular phone subscribers per 100,000 adults. In Eqs. (2) and (3), Z signifies the vector of control variables (domestic credit, education, GDP and trade openness). μ_i represents the country-specific effect in panel analysis while γ_t is the time-specific constant term, ε_{it} is the error term and τ the lagging coefficient. To deal with the problem of identification, simultaneity and restrictions usually associated with the GMM, all explanatory variables are suspected of endogeneity and treated as such in accordance with current literature on GMM estimation (Nchofoung & Asongu, 2022a; Asongu and Nwachukwu, 2016; Asongu & Odhiambo, 2019). We further used the forward orthogonal deviation to limit instruments proliferation in line with Roodman (2009a). Besides, we used the two-step instead of the one-step procedure because the one-step procedure is consistent with homoscedasticity.

4 Results and discussions

4.1 Results

Section 4 presents and discusses the findings of the study. The results are presented in three sub-sections; the first sub-section presents the direct effect results and its robustness analysis in Section 2. The results end with the indirect effect findings.

4.1.1 The direct effects results

This section presents the direct effect results starting with the baseline results of the Ordinary Least Square presented in Table 2. The findings of the baseline analysis show that ICT enhances the quality of governance in Africa. The results of the OLS estimates do not account for the problem of endogeneity and unobserved heterogeneity which need to be addressed. In this regard, we employ the GMM as a more

Table 2 The baseline results

VARIABLES	(1)	(2)	(3)	(4)	(5)
	Dependent variable: Governance				
Internet	0.00158 (0.00131)				
mobile		0.00159*** (0.000437)			
Fixed broadband			0.00791 (0.00625)		
Fixed telephone				0.0193*** (0.00400)	
ICT					0.00440*** (0.00122)
Education	0.000960 (0.000769)	0.00126* (0.000720)	0.000312 (0.000821)	0.00105 (0.000741)	0.00115 (0.000723)
Credit	0.0171*** (0.00111)	0.0163*** (0.000998)	0.0162*** (0.00107)	0.0134*** (0.00123)	0.0162*** (0.00102)
GDP	0.0117*** (0.00409)	0.0154*** (0.00381)	0.0218*** (0.00474)	0.0139*** (0.00381)	0.0161*** (0.00382)
Trade	0.00323*** (0.000539)	0.00313*** (0.000514)	0.00394*** (0.000593)	0.00233*** (0.000569)	0.00305*** (0.000518)
Constant	-1.290*** (0.0596)	-1.373*** (0.0564)	-1.290*** (0.0638)	-1.212*** (0.0612)	-1.356*** (0.0558)
Observations	674	726	581	705	727
R-squared	0.447	0.453	0.462	0.459	0.454
R2_adjusted	0.443	0.449	0.457	0.455	0.450

Standard errors in parentheses

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 3 Direct effect results of the global sample

VARIABLES	(1)	(2)	(3)	(4)	(5)
	Dependent variable: Governance				
L.governance	0.987*** (0.00691)	0.980*** (0.00600)	0.978*** (0.00653)	0.984*** (0.00737)	0.982*** (0.00649)
Internet	0.000474*** (0.000153)				
mobile		0.000114* (6.56e-05)			
Fixed broadband			0.00364*** (0.000466)		
Fixed telephone				0.00104** (0.000501)	
ICT					0.000625*** (0.000200)
Education	0.000338 (0.000203)	-8.38e-05 (0.000125)	-0.000136 (0.000110)	0.000304 (0.000217)	0.000209 (0.000164)
Credit	-0.000273 (0.000185)	0.000144 (0.000158)	0.000112 (0.000120)	-1.66e-05 (0.000194)	-0.000158 (0.000140)
GDP	0.000213 (0.000929)	0.000765 (0.000724)	0.00355*** (0.000811)	0.000916 (0.000715)	0.00101 (0.000853)
Trade	0.000155* (8.98e-05)	0.000169** (8.33e-05)	3.22e-05 (8.45e-05)	4.52e-05 (9.45e-05)	0.000142* (7.99e-05)
Constant	-0.0434** (0.0169)	-0.0331** (0.0148)	-0.0253* (0.0132)	-0.0393** (0.0178)	-0.0494*** (0.0182)
Observations	436	485	357	467	474
Number of countries	44	44	40	44	44
Prop > AR1	2.05e-06	2.50e-06	6.84e-06	2.82e-06	2.49e-06
Prop > AR1	0.750	0.987	0.932	0.979	0.968
Instruments	19	19	19	19	21
Prop > Hansen	0.561	0.190	0.740	0.409	0.391

Standard errors in parentheses

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

robust strategy whose findings are presented in Table 3. The results are presented in five equations representing four ICT indicators with its composite indicator.

We have examined the statistical validity of the exclusion restriction to ensure the efficiency of the GMM results, testing through the difference in Hansen Test for instrument exogeneity. Following the conditions laid down in Roodman (2009a) the null hypothesis of the test should not be rejected for the underlying instruments explaining the outcome variable through an instrumentation process.

4.1.2 Robustness checks findings

Assessing the effect of ICT on governance suffices to establish robustness checks considering different income groups. Higher-income countries have higher levels

Table 4 Robustness checks by income grouping

VARIABLES	(1)	(2)	(3)	(4)	(5)	(1)	(2)	(3)	(4)	(5)
	Low income (GMM)					Middle income countries (IV-TOBIT)				
	Dependent variable: Governance									
L. Governance	0.977*** (0.00471)	0.972*** (0.00446)	0.977*** (0.00551)	0.976*** (0.00441)	0.973*** (0.00406)					
Internet	0.000284*** (8.53e-05)					0.0167*** (0.00464)				
mobile		8.95e-05* (4.94e-05)					0.000931 (0.00105)			
Fixed broadband			0.00251*** (0.000337)					1.201* (0.674)		
Fixed telephone				0.000158 (0.000295)					0.0682* (0.0385)	
ICT										0.00492* (0.00289)
Education	-0.000346* (0.000190)	-0.000317*** (0.000113)	-0.000199 (0.000131)	-0.000225* (0.000129)	-0.000393*** (9.91e-05)	-0.000283 (0.00149)	0.00194 (0.00132)	-0.00119 (0.00165)	0.00333** (0.00147)	0.00173 (0.00137)
Credit	0.000146 (0.000137)	0.000392*** (0.000115)	0.000112 (8.98e-05)	0.000341** (0.000142)	0.000358*** (0.000123)	0.0227*** (0.00444)	0.0236*** (0.00457)	0.0172*** (0.00572)	0.0224*** (0.00447)	0.0255*** (0.00441)
GDP	0.00105* (0.000590)	0.00132** (0.000535)	0.00146*** (0.000467)	0.00103* (0.000556)	0.00138*** (0.000431)	0.0211*** (0.00756)	0.0322*** (0.00688)	0.0419*** (0.00834)	0.0467*** (0.00796)	0.0304*** (0.00685)
Trade	0.000230*** (6.06e-05)	0.000242*** (3.70e-05)	0.000117*** (3.95e-05)	0.000196*** (6.15e-05)	0.000211*** (3.67e-05)	-0.00412*** (0.00150)	-0.000287 (0.00136)	-0.000425 (0.00147)	0.000616 (0.00150)	-0.000404 (0.00134)
Constant	-0.0166 (0.0100)	-0.0294** (0.0116)	-0.0163 (0.0110)	-0.0230** (0.00951)	-0.0198** (0.00756)	-1.054*** (0.130)	-1.439*** (0.117)	-1.225*** (0.123)	-1.597*** (0.132)	-1.474*** (0.118)
Observations	285	307	232	306	298	176	195	155	162	183

Table 4 (continued)

VARIABLES	Middle income countries (IV-TOBIT)				
	(1)	(2)	(3)	(4)	(5)
Low income (GMM)					
Dependent variable: Governance					
Number of id	27	27	26	27	27
Prop>ARI	7.19e-05	6.74e-05	0.000224	7.08e-05	6.80e-05
Prop>ARI	0.318	0.318	0.538	0.359	0.314
Instruments	19	19	19	19	21
Prop>hansen	0.457	0.386	0.830	0.495	0.411
chi2_exog					
chi2					
tobitnl					
	2.296	3.465		2.307	1.498
	64.17	60.91		49.31	65.87
	0.0208	0.0208		0.0208	0.0208

Standard errors in parentheses

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 5 Robustness checks by legal systems

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	English legal system									
French legal system										
Dependent variable: Governance										
L. Governance	1.004*** (0.00833)	0.989*** (0.00648)	0.979*** (0.00564)	0.998*** (0.00651)	0.992*** (0.00721)	0.964*** (0.00958)	0.958*** (0.00668)	0.937*** (0.0134)	0.974*** (0.0157)	0.955*** (0.00555)
internet	0.000467*** (9.32e-05)					0.000816*** (0.000273)				
mobile		4.07e-05 (6.09e-05)					0.000234** (8.85e-05)			
Fixed broadband			0.00275*** (0.000510)					0.00718*** (0.00103)		
Fixed telephone				0.00113*** (0.000351)					0.00117 (0.000743)	
ICT					0.000338* (0.000185)					0.000913*** (0.000216)
Education	0.000802*** (0.000150)	0.000231*** (7.76e-05)	6.36e-05 (7.99e-05)	0.000544*** (0.000155)	0.000332*** (0.000126)	-0.000576** (0.000270)	-0.000442*** (0.000134)	-0.000237 (0.000156)	-0.000219 (0.000387)	-0.000372** (0.000135)
Credit	-0.000398** (0.000165)	-1.62e-05 (0.000113)	-0.000186 (0.000156)	-0.000368* (0.000179)	-0.000223 (0.000155)	-1.36e-05 (0.000396)	0.000527** (0.000230)	0.000466** (0.000191)	0.000298 (0.000482)	0.000134 (0.000168)
GDP	0.000466 (0.000743)	0.00102* (0.000527)	0.00226*** (0.000301)	0.00116** (0.000408)	0.00133** (0.000585)	0.000909 (0.00172)	0.00124 (0.00158)	0.0112*** (0.00165)	0.000429 (0.00159)	0.00257* (0.00141)
Trade	-0.000222 (0.000168)	-5.74e-05 (0.000131)	0.000118 (7.60e-05)	-0.000192 (0.000119)	-0.000117 (0.000162)	0.000420*** (0.000111)	0.000384*** (7.79e-05)	0.000108 (9.01e-05)	0.000225 (0.000143)	0.000289*** (7.34e-05)
Constant	-0.0363*** (0.00986)	-0.0221 (0.0168)	-0.0285** (0.0113)	-0.0246 (0.0151)	-0.0260 (0.0172)	-0.0415** (0.0166)	-0.0679*** (0.0144)	-0.107*** (0.0229)	-0.0393** (0.0187)	-0.0677*** (0.0149)
Observations	171	211	161	210	204	237	245	173	228	244

Table 5 (continued)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	French legal system		English legal system							
VARIABLES	Dependent variable: Governance									
Number of id	21	21	21	21	21	21	21	21	21	21
Number of id	0.00113	0.00179	0.00243	0.00163	0.00182	0.00111	0.00113	0.000724	0.00148	0.00107
Prop>ARI	0.736	0.545	0.384	0.708	0.568	0.582	0.568	0.497	0.664	0.615
Prop>ARI	19	19	19	19	21	19	19	19	19	21
Instruments	0.528	0.480	0.731	0.475	0.569	0.271	0.230	0.347	0.550	0.174

Standard errors in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 6 Robustness checks (institutional, political and economic governance)

	(1)	(2)	(3)	(4)	(5)
Variables	Dependent variable: Institutional governance				
L.institutional govern- ance	0.988***	0.982***	0.987***	0.989***	0.982***
	(0.00670)	(0.00865)	(0.00696)	(0.00667)	(0.00842)
Internet	0.000478*** (0.000154)				
Mobile	0.000176** (8.54e-05)				
Fixed broadband	0.00474*** (0.000524)				
Fixed telephone	0.00106* (0.000551)				
ICT	0.000561** (0.000224)				
Control variables	Yes	Yes	Yes	Yes	Yes
Observations	436	558	357	467	546
Number of countries	44	45	40	44	45
Prop > AR1	7.64e-05	4.34e-05	0.000552	4.98e-05	4.24e-05
Prop > AR1	0.504	0.436	0.721	0.469	0.423
Instruments	19	19	19	19	21
Prop > Hansen	0.907	0.813	0.714	0.674	0.787
Variables	Dependent variable: Political governance				
L.political governance	0.972***	0.965***	0.963***	0.962***	0.977***
	(0.00989)	(0.00838)	(0.0111)	(0.00856)	(0.00817)
internet	0.000179 (0.000220)				
mobile	0.000136 (0.000114)				
Fixed broadband	0.00357*** (0.000871)				
Fixed telephone	0.00112 (0.000927)				
ICT	0.000390 (0.000318)				
Control variables	Yes	Yes	Yes	Yes	Yes
Observations	436	558	357	467	546
Number of id	44	45	40	44	45
Prop > AR1	0.000230	0.000152	6.05e-05	0.000161	0.000141
Prop > AR1	0.385	0.636	0.0967	0.761	0.645
Instruments	19	19	19	19	21
Prop > Hansen	0.126	0.0844	0.419	0.296	0.104
Variables	Dependent variable: Economic governance				
L.economic governance	0.970***	0.969***	0.973***	0.984***	0.970***

Table 6 (continued)

	(0.00708)	(0.00857)	(0.00990)	(0.00818)	(0.00879)
internet	0.000332*				
	(0.000173)				
Mobile		0.000208**			
		(9.17e-05)			
Fixed broadband			0.00152**		
			(0.000735)		
Fixed telephone				0.00187**	
				(0.000794)	
ICT					0.000654***
					(0.000234)
Control variables	Yes	Yes	Yes	Yes	Yes
Observations	436	558	357	467	546
Number of id	44	45	40	44	45
Prop> AR1	0.00167	0.000471	0.00102	0.000835	0.000457
Prop> AR1	0.0685	0.0432	0.0751	0.0638	0.0402
Instruments	19	19	17	19	21
Prop> Hansen	0.642	0.157	0.263	0.358	0.463

Standard errors in parentheses

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

of ICT diffusion relative to low-income countries, justifying the income effect in our investigation. The findings of the different income groups are presented in Table 4. The findings of the low-income countries are estimated using the IV-Tobit instrumental regression since the number of the low income-countries is less than the time periods without the fixed effects. The IV-Tobit accounts for the limited range of governance indicators and provides efficient estimates when endogeneity is controlled by an instrumentation process. Also, we establish another robustness check by accounting for differences in the legal systems. The jurisprudence and the legal systems adopted by African countries affects the quality of institutions. Many African countries have adopted the French civil law system while others have adopted the British common law to set the rules and regulations governing their institutions. The robustness checks presented in Table 5 account for differences in the legal systems presenting the effect of ICT on the quality of institutions adopting the common law and countries that have adopted the civil law system. We account for the different indicators of governance for further checks on the consistency of the findings. In this case, we adopt the six indicators of governance bundling them into a group of three. (i) Political governance consisting of political stability and voice and accountability, (ii) institutional governance which is bundled by control of corruption and rule of the law and (iii) economic governance which encompasses regulatory quality and government effectiveness. The findings of the effect of ICT on economic governance, political governance and institutional governance are presented in Table 6.

Table 7 Indirect effect results of ICT on governance (composite indicator)

VARIABLES	(1)	(2)	(3)	(4)	(5)
	Dependent variable: Governance				
L. Governance	0.976*** (0.00645)	0.979*** (0.00604)	0.979*** (0.00844)	0.981*** (0.00691)	0.981*** (0.00637)
internet	0.00331*** (0.000863)				
mobile		0.000465** (0.000226)			
Fixed broadband			0.0187*** (0.00322)		
Fixed telephone				0.0128*** (0.00241)	
ICT					0.00143*** (0.000509)
Education	0.000879*** (0.000236)	0.000191 (0.000249)	0.000803*** (0.000185)	0.000858*** (0.000214)	0.000327 (0.000224)
Credit	-2.68e-05 (0.000175)	0.000222 (0.000183)	3.40e-05 (0.000168)	-6.60e-05 (0.000200)	-7.84e-05 (0.000141)
GDP	0.000482 (0.000987)	0.000853 (0.000692)	0.00438*** (0.00107)	0.00108 (0.000692)	0.000542 (0.000801)
Trade	0.000169** (7.54e-05)	0.000168** (8.08e-05)	-5.61e-05 (9.83e-05)	-2.94e-05 (9.61e-05)	0.000148* (7.38e-05)
Internet*Education	-0.000419*** (1.13e-05)				
Mobile*Education		-5.60e-06 (3.50e-06)			
Broadband*Education			-0.000228*** (4.49e-05)		
Fixed*Education				-0.000158*** (2.77e-05)	
ICT*Education					-0.0000136** (6.16e-06)
Net effect	-0.0220	—	0.004922	0.00325	0.000644
Constant	-0.0908*** (0.0216)	-0.0524** (0.0221)	-0.0781*** (0.0213)	-0.0728*** (0.0198)	-0.0547** (0.0212)
Observations	420	470	344	453	474
Number of id	43	44	40	43	44
Prop > AR1	1.77e-06	2.53e-06	5.92e-06	2.67e-06	2.44e-06
Prop > AR1	0.812	0.966	0.696	0.965	0.980
Instruments	22	22	22	22	23
Prop > Hansen	0.494	0.237	0.482	0.664	0.333

Standard errors in parentheses

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 8 Indirect effect results of ICT on Kaufmann et al. (2011) six governance indicators

VARIABLES	(1) Government effectiveness	(2) Regulatory quality	(3) Control of corruption	(4) Rule of law	(5) Voice and accountability	(6) Political stability
L.government effectiveness	0.952*** (0.0103)					
ICT	0.00159* (0.000878)	-0.000168 (0.00108)	0.00176** (0.000731)	0.00219*** (0.000770)	0.00170* (0.000857)	0.00340* (0.00198)
Education	0.000198 (0.000390)	-0.000204 (0.000544)	0.000354 (0.000302)	0.000401 (0.000282)	0.000669** (0.000270)	0.000517 (0.000787)
Credit	0.000374 (0.000251)	0.000217 (0.000338)	-0.000162 (0.000164)	0.000540*** (0.000193)	-6.79e-05 (0.000236)	0.000623 (0.000553)
GDP	0.000140 (0.00102)	0.000117 (0.00102)	0.000815 (0.00105)	0.00235** (0.00105)	0.00371*** (0.00126)	0.00189 (0.00174)
Trade	5.79e-09 (0.000140)	5.53e-05 (0.000140)	0.000107 (0.000125)	9.32e-05 (7.74e-05)	0.000192 (0.000128)	0.000694** (0.000267)
ICT*Education	-5.32e-06 (1.21e-05)	2.31e-06 (1.70e-05)	-0.0000176* (9.72e-06)	-0.000022** (1.01e-05)	-0.0000212* (1.15e-05)	-4.55e-05 (3.26e-05)
L.regulatory quality	0.975*** (0.00870)					
L.control of corruption			0.988*** (0.0100)			
L.rule of law				0.954*** (0.00941)		
L.voice and accountability					0.993*** (0.00661)	

Table 8 (continued)

VARIABLES	(1) Government effectiveness	(2) Regulatory quality	(3) Control of corruption	(4) Rule of law	(5) Voice and accountability	(6) Political stability
L.political stability						0.944*** (0.0125)
Net effect	---	---	0.000695	0.000086	0.0004189	---
Constant	-0.0775** (0.0372)	-0.0125 (0.0338)	-0.0489 (0.0328)	-0.0981*** (0.0289)	-0.0767*** (0.0248)	-0.154*** (0.0526)
Observations	523	486	429	435	521	469
Number of id	45	44	44	44	45	44
Prop> ARI	1.14e-05	0.0199	1.10e-05	3.18e-05	0.000116	7.97e-05
Prop> ARI	0.0836	0.107	0.560	0.617	0.119	0.652
Instruments	22	22	22	22	22	22
Prop> Hansen	0.195	0.359	0.920	0.733	0.407	0.116

Standard errors in parentheses

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

4.1.3 Indirect effect results

This section presents the interactive effect of education and ICT indicators on governance. This section investigates the role education plays in modulating the effect of ICT on governance. As established in the literature, education facilitates ICT diffusion and technological development. The results of the transmission channel considering the composite indicator of governance are presented in Table 7.

The net effects are computed when the conditional effect and the direct effect are significant. The net effect is calculated as follows: for the net effects of internet and its mediating effect with education: $0.00331 + (-0.000419 \times 60.427) = -0.0220$. Where 0.00331 represents the unconditional effect of internet, -0.000419 is the conditional effect and 60.427 represents the mean of education. The net effect of fixed broadband is obtained from the following calculations: $0.0187 + (-0.000228 \times 60.427) = 0.004922$. Unconditional effect of fixed broadband = 0.0187, conditional effect = (-0.000228). The net effects of fixed telephone is 0.00325 and that of the composite indicator of ICT is 0.000644.

In addition, the Kaufmann et al. (2011) governance indicators have been employed to determine how they are influenced by the interactive effect of education and ICT. The findings of the six indicators of governance are presented in Table 8 which we considered just the composite indicator of ICT to determine the interactive effect due to a large number of ICT indicators.

The net effect of ICT and its interaction with education on the six governance is computed as follows.

$\frac{\partial \text{Control of corruption}}{\partial \text{ICT}}$: $0.00176 + (-0.0000176 \times 60.427) = 0.000695$. Where 0.0017 is the unconditional effect of ICT on control of corruption, -0.0000176 the unconditional effect and 60.427 represents the mean of education. The net effects results of the rule of law and accountability equations are obtained by applying the same formula and the mean of education.

4.2 Discussion of findings

This section discusses the findings of the study from the direct effect to the indirect effect results. The direct effect results presented in Table 4 indicate positive statistically significant effects of the internet, mobile cellular subscription and ICT on governance in Africa. The findings are in support of the adoption of digital tools for better governance that improve the quality of institutions. The findings of the direct effect results are consistent with those of Sabani et al. (2019), Aguboshim et al. (2019), Oliveira et al. (2020), Misuraca and Viscusi (2015), Bhattacharjee and Shrivastava (2018) whose findings show that technology infrastructures provide an effective monitoring system that ensures more transparency associated with increasing levels of control of corruption and the application of rule of law. The findings of the direct effect results in Table 3 also reveal that the level of economic development enhances the quality of institutions in Africa. Similarly, the results depict a positive effect of trade openness on the quality of governance. The findings of the positive effect on governance

are supported by those of Asongu and Nwachukwu (2017), and Asongu and Nnanna (2019). Domestic credit as an indicator of financial development also has a positive effect on governance in Africa, consistent with the findings of Sayılır et al. (2018).

Testing for the consistency of our findings, we adopt robustness checks by dividing the study sample into low and middle-income groups whose findings are presented in Table 4. The findings indicate that ICT has a significant positive effect on governance across different ICT indicators except for fixed phone which has an insignificant effect on governance in low-income countries. Irrespective of the income levels of these countries, ICT still acts as an enhancing factor of governance. The existing studies on ICT and governance have argued that the pace of ICT diffusion and structural transformation is very fast in higher-income countries which tends to have a more significant influence on their institutions (Asongu & Odhiambo, 2019). The findings presented in Table 4 further reveal that trade openness and domestic credit to private enterprises enhance the quality of institutions in the middle-income group but procure negative effects on the governance of low-income economies. Similarly, the gross domestic product also appeared to be the most enhancing factor of governance in both income groups. Also, for more robustness checks, we analyze the countries that adopt the French civil law system that differs from that of the English common law system. The two legal systems differ in terms of their constitutions, rules and regulations governing the citizens. Accounting for the differences in rules of law and jurisprudence has provided another dimension of our investigations to determine if ICT in governance differs amongst countries with civil law and common law systems.

The findings presented in Table 5, show that ICT enhances governance in both French and English-speaking countries whose legal systems differ. Given that the countries that have adopted the French civil law system have similar effects of ICT on their institutions to those countries that adopt the English common law system, shows that ICT diffusion is a tool that can enhance the quality of institutions and help meet the sustainable development goals. The findings are still consistent with those of Misuraca and Viscusi (2015), and Bhattacharjee and Shrivastava (2018) after accounting for differences in income levels and jurisdictions.

The findings presented in Table 6 have accounted for three dimensions of governance which are institutional, economic and political governance. Table 6 reveals a positive significant effect of internet penetration, mobile cellular subscription and fixed broadband on institutional governance. The findings signify that ICT enhance the rule of law and control of corruption which has been bundled to obtain institutional governance. The level of educational development and gross domestic product appeared to have negative relationships with institutional governance. The findings further reveal that political governance which is obtained by bundling political stability and voice and accountability is enhanced by ICT indicators. The findings show that internet penetration, mobile cellular subscription and fixed broadband have a positive relationship with political governance in Africa. Similarly, the findings presented in the last

section of Table 6 reveal a positive relationship between ICT indicators and economic governance in Africa. These findings have been consistent throughout the study confirming that technology diffusion can help to improve the quality of institutions in Africa.

We also consider the indirect effect analysis whose results are presented in Table 7 to respond to the modulating role of education in the ICT-governance nexus. The results indicate a positive significant effect of ICT on governance in Africa across all the ICT measures. The results further reveal that education plays a negative role in modulating the effect of ICT on governance in Africa. The resulting interactive effect of education and ICT on governance shows that education is not a channel through which the quality of governance in Africa could be improved but indicate a negative net effect of the interactions between education and ICT, signifying that the positive conditional effect of ICT on governance indicators predominate the conditional negative effects thereby producing positive net effects. Internet penetration produces negative net effects on governance when interacting with the level of education. This negative net effect is nullified at a threshold of $(0.00331/-0.000419)$ or 7.89976% of individuals using the internet to produce a positive significant effect. To avoid blanket policy recommendations from our indirect effect results, we consider all six indicators of governance in their various perspectives. The results of the specific governance indicators presented in Table 8 indicate a positive effect of ICT on government effectiveness and regulatory quality, control of corruption and rule of law, government effectiveness and voice and accountability. This signifies that ICT positively influence economic, institutional and political governance in Africa. This, therefore, implies that ICT diffusion provides quality coordination of economic policies to ensure societal progress, and a better system for policy implementation with better regulatory provisions to ensure effectiveness. The findings presented in Table 8 are consistent with those presented in other tables.

The role of education in modulating the effect of ICT on different governance indicators provides similar results indicating a negative role played by education in modulating the effect of ICT on governance. Table 8 indicates a positive interactive significant effect of education and ICT on regulatory quality, rule of law and political stability. The relation with other governance indicators remains negative but insignificant. The findings also show that there exist positive net effects that predominate the negative indirect effects. This negative role played by education in modulating the effect of ICT on governance has been pre-dominated by the conditional positive effects of ICT on the different governance indicators.

5 Conclusion and policy implications

The study investigated the role played by education in modulating the effect of ICT on governance in 53 African countries between 2002 and 2020. This study, therefore, seeks to answer the following questions: (i) what is the effect of ICT on governance in Africa? (ii) What is the modulating effect of education on the ICT-governance nexus? The study adopted a composite indicator of governance that encompasses control of corruption, government effectiveness, rule of law, regulatory quality, voice and accountability and political stability. The study employed Internet, fixed broadband, fixed telephone and mobile subscription as indicators of ICT with a composite indicator that covers the four measures. The GMM strategy has been adopted to account for the problem of possible sources of endogeneity. The findings of the study reveal that ICT enhances the quality of governance in Africa. The results remained consistent after accounting for differences in income levels and legal systems. Higher-income countries have higher levels of ICT diffusion than lower-income countries as is the case with the developed countries whose ICT sectors are more developed than that of the developing countries. Differences in the legal systems have affected the quality of institutions. Many African countries have adopted the French civil law system while others have adopted the British common law to set the rules and regulations governing their institutions. Also, the findings depict that ICT through education has a negative influence on governance, signifying that education is not a channel through which ICT can enhance the level of governance in Africa. These negative interactive effect is being counteracted by a positive interactive net effect of education and ICT on governance, indicating that the positive net effect predominates the negative conditional effect. The results indicate that factors such as trade openness, GDP and domestic credit have positive effects on the level of governance in Africa which is consistent with the findings in past empirical studies conducted in Africa.

The study suggests more investments in technological infrastructures to harness the potential of ICT tools for governance and policy modelling techniques. The study also recommends the adoption of digital technology tools in all public and private institutions to improve policy intelligence and ICT-driven decision analytics that could facilitate more complex human decision-making. All the suggestions of our study are to build momentum of ICT for quality governance. From a research perspective, we recommend further research works on the effect of ICT on governance in respective African countries, especially in the public sector. Also, we recommend studies to test the scrutiny of established positive effects of ICT on governance documented in the literature by establishing linkages within cultural diversities and landlocked.

Appendix

Appendix 1 Matrix of correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
(1) Governance	1.000															
(2) government effectiveness	0.924	1.000														
(3) control of corruption	0.921	0.867	1.000													
(4) political stability	0.810	0.639	0.688	1.000												
(5) regulatory quality	0.898	0.879	0.776	0.600	1.000											
(6) rule of law	0.962	0.917	0.897	0.718	0.883	1.000										
(7) voice and account-ability	0.852	0.708	0.739	0.593	0.744	0.778	1.000									
(8) fixed telephone	0.536	0.600	0.506	0.413	0.413	0.580	0.379	1.000								
(9) mobile cellular	0.337	0.375	0.336	0.196	0.282	0.356	0.288	0.394	1.000							
(10) fixed broadband	0.375	0.443	0.377	0.257	0.294	0.380	0.279	0.679	0.504	1.000						
(11) fixed telephone	0.536	0.600	0.506	0.413	0.413	0.580	0.379	1.000	0.394	0.679	1.000					
(12) ICT	0.417	0.474	0.418	0.255	0.341	0.446	0.336	0.555	0.960	0.654	0.555	1.000				
(13) Education	0.411	0.492	0.458	0.183	0.402	0.439	0.293	0.379	0.104	0.273	0.379	0.203	1.000			
(14) Credit	0.618	0.690	0.563	0.370	0.587	0.650	0.510	0.693	0.410	0.500	0.693	0.538	0.427	1.000		
(15) GDP	0.042	0.024	0.024	0.033	0.061	0.029	0.054	-0.044	-0.081	-0.096	-0.044	-0.087	0.071	-0.103	1.000	
(16) trade	0.360	0.305	0.365	0.484	0.161	0.308	0.240	0.522	0.332	0.381	0.522	0.392	0.156	0.271	0.001	1.000

Data availability The data supporting the findings of this study is available upon a reasonable request addressed to the corresponding author.

Declarations

Ethical approval This manuscript has not been submitted to, nor is under review in another outlet.

Informed consent Not applicable.

Conflict of interest The authors declare no potential conflict of interest.

References

- Adam, I. O. (2020). Examining E-Government development effects on corruption in Africa: The mediating effects of ICT development and institutional quality. *Technology in Society*, *61*, 101245.
- Aguboshim, F. C., Ezeasomba, I. N., & Ezeife, J. E. (2019). Sustainable Information and Communication Technology (ICT) for Sustainable Data Governance in Nigeria: A Narrative Review. *Journal of Information Engineering and Application (JIEA)*, *9*(5), 15–20.
- Aguboshim, F. C., & Udobi, J. I. (2019). Security Issues with Mobile IT: A Narrative Review of Bring Your Own Device (BYOD). *Information Technology (IT)*, *8*(1).
- Agwu, E. (2013). Cyber criminals on the internet super highways: A technical investigation of different shades and colours within the Nigerian cyber space. *International Journal of Online Marketing (IJOM)*, *3*(2), 56–74.
- Alfoul, M. N. A. (2022). Effects of ICT Investment and Usage on Economic Growth in MENA Countries: Does Governance Matter (Doctoral dissertation, Swinburne University of Technology).
- Aoki, M. (2001). *Toward a comparative institutional analysis*. USA: MIT Press.
- Asongu, S. A., & Nnanna, J. (2019). Foreign aid, instability, and governance in Africa. *Politics & Policy*, *47*(4), 807–848.
- Asongu, S. A., & Nwachukwu, J. C. (2019). ICT, financial sector development and financial access. *Journal of the Knowledge Economy*, *10*, 465–490.
- Asongu, S. A., & Nwachukwu, J. C. (2016). The mobile phone in the diffusion of knowledge for institutional quality in sub-Saharan Africa. *World Development*, *86*, 133–147.
- Asongu, S. A., & Nwachukwu, J. C. (2017). The impact of terrorism on governance in African countries. *World Development*, *99*, 253–270.
- Asongu, S. A., & Odhiambo, N. M. (2019). Basic formal education quality, information technology, and inclusive human development in sub-Saharan Africa. *Sustainable Development*, *27*(3), 419–428.
- Asongu, S. A., Le Roux, S., & Biekpe, N. (2018). Enhancing ICT for environmental sustainability in sub-Saharan Africa. *Technological Forecasting and Social Change*, *127*, 209–216.
- Bannister, F., & Connolly, R. (2012). Defining e-governance. *e-Service Journal: A Journal of Electronic Services in the Public and Private Sectors*, *8*(2), 3–25.
- Beecroft, I., Osabuohien, E. S., Efobi, U. R., Olurinola, I., & Osabohien, R. A. (2020). Manufacturing export and ICT infrastructure in West Africa: Investigating the roles of economic and political institutions. *Institutions and Economics*, 1–36.
- Bennett, S. (2017). What is information governance and how does it differ from data governance? *Governance Directions*, *69*(8), 462–467.
- Bhattacharjee, A., & Shrivastava, U. (2018). The effects of ICT use and ICT Laws on corruption: A general deterrence theory perspective. *Government Information Quarterly*, *35*(4), 703–712.
- Blundell, R., & Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of Econometrics*, *87*(1), 115–143.
- Burrell, J. (2008). Problematic empowerment: West African Internet scams as strategic misrepresentation. *Information Technologies & International Development*, *4*(4), 15.
- Charoensukmongkol, P., & Moqbel, M. (2014). Does investment in ICT curb or create more corruption? A Cross-Country Analysis. *Public Organization Review*, *14*(1), 51–63.
- Coccia, M. (2018). An introduction to the theories of institutional change. *Journal of Economics Library*, *5*(4), 337–344.
- DiRienzo, C. E., Das, J., Cort, K. T., & Burbridge, J. (2007). Corruption and the role of information. *Journal of International Business Studies*, *38*(2), 320–332.

- Donina, D., & Hasanefendic, S. (2019). Higher Education institutional governance reforms in the Netherlands, Portugal and Italy: A policy translation perspective addressing the homogeneous/heterogeneous dilemma. *Higher Education Quarterly*, 73(1), 29–44.
- Eger, J. M., & Maggipinto, A. (2009). Technology as a tool of transformation: e-Cities and the rule of law. In *Information systems: People, organizations, institutions, and technologies* (pp. 23–30). Physica-Verlag HD.
- Eggertsson, T. (2009). Knowledge and the theory of institutional change. *Journal of Institutional Economics*, 5(2), 137–150.
- Gaskins, Leebrian Ernest (2013). "The Effect of Information and Communications Technology (ICT) Diffusion on Corruption and Transparency (A Global Study)" Theses and Dissertations. 19: <https://rio.tamui.edu/etds/19>
- Greif, A., & Laitin, D. D. (2004). A theory of endogenous institutional change. *American Political Science Review*, 98(4), 633–652.
- Guha, S., Kettinger, W. J., & Teng, J. T. (1993). Business process reengineering: Building a comprehensive methodology. *Information Systems Management*, 10(3), 13–22.
- Hammer, M., & Champy, J. (1993). *Business process reengineering*. London: Nicholas Brealey, 444(10), 730-755.
- Hayek, F. A. (1973). *Economic freedom and representative government* (p. 13). Wincott Foundation.
- Hollington, M. (2022). The potential of increased internet penetration to combat corruption in Africa. *Digital Policy Studies*, 1(1), 69–76.
- Imhonopi, D., & Urin, U. M. (2011). Information and communication technology (ICT) and governance in Nigeria: Challenges and prospect. *Journal of Humanities, Social Science and Creative Arts*, 6(2), 1–14.
- Ionescu, L. (2013). The positive effect of ICT infrastructure in reducing corruption and increasing transparency. *Economics, Management, and Financial Markets*, 8(2), 167–172.
- Kaufmann, D., Kraay, A., & Mastruzzi, M. (2011). The worldwide governance indicators: Methodology and analytical issues1. *Hague Journal on the Rule of Law*, 3(2), 220–246.
- Kennedy, R. (2016). E-regulation and the rule of law: Smart government, institutional information infrastructures, and fundamental values. *Information Polity*, 21(1), 77–98.
- Knight, J. (1997). Social institutions and human cognition: Thinking about old questions in new ways. *Journal of Institutional and Theoretical Economics (JITE)/Zeitschrift für die gesamte Staatswissenschaft*, 153(4), 693–699.
- Kohl, U. (2004). The rule of law, jurisdiction and the Internet. *International Journal of Law and Information Technology*, 12, 365.
- Koltay, T. (2016). Are you ready? Tasks and roles for academic libraries in supporting Research 2.0. *New Library World*.
- Kouladoum, J. C., Wirajing, M. A. K., & Nchofoung, T. N. (2022). Digital technologies and financial inclusion in Sub-Saharan Africa. *Telecommunications Policy*, 46(9), 102387.
- Libecap, G. D. (1989). Distributional issues in contracting for property rights. *Journal of Institutional and Theoretical Economics (JITE)/Zeitschrift für die gesamte Staatswissenschaft*, 6–24.
- Loukis, E., Janssen, M., Dawes, S., & Zheng, L. (2016). Evolving ICT and governance in organizational networks-Conceptual and theoretical foundations. *Electronic Markets*, 26(1), 7–14.
- Mallick, H. (2021). Do governance quality and ICT infrastructure influence the tax revenue mobilisation? An empirical analysis for India. *Economic Change and Restructuring*, 54(2), 371–415.
- Meyer, I. A., & Gent, P. R. (2016). The status of ICT in education in South Africa and the way forward. National Education Collaboration Trust.
- Mistry, J. J., & Jalal, A. (2012). An empirical analysis of the relationship between e-government and corruption. *International Journal of Digital Accounting Research*, 12.
- Misuraca, G., & Viscusi, G. (2015). Shaping public sector innovation theory: An interpretative framework for ICT-enabled governance innovation. *Electronic Commerce Research*, 15(3), 303–322.
- Misuraca, G., Broster, D., & Centeno, C. (2012). Digital Europe 2030: Designing scenarios for ICT in future governance and policy making. *Government Information Quarterly*, 29, S121–S131.
- Murray, A. D. (2017). Mapping the rule of law for the internet. In *The legal challenges of social media* (pp. 13–34). Edward Elgar Publishing.
- Myerson, R. B. (2004). Justice, institutions, and multiple equilibria. *Chicago Journal of International Law*, 5, 91.
- Nchofoung, T. N., & Asongu, S. A. (2022a). ICT for sustainable development: Global comparative evidence of globalisation thresholds. *Telecommunications Policy*, 46(5), 102296.
- Nchofoung, T. N., & Asongu, S. A. (2022b). Effects of infrastructures on environmental quality contingent on trade openness and governance dynamics in Africa. *Renewable Energy*, 189, 152–163.
- Nchofoung, T. N., Achuo, E. D., & Asongu, S. A. (2021). Resource rents and inclusive human development in developing countries. *Resources Policy*, 74, 102382.

- Nchofoung, T. N., Asongu, S. A., Njamen Kengdo, A. A., & Achuo, E. D. (2022). Linear and non-linear effects of infrastructures on inclusive human development in Africa. *African Development Review*, 34(1), 81–96.
- Ngouhouo, I., Nchofoung, T., & Njamen Kengdo, A. A. (2021). Determinants of trade openness in sub-Saharan Africa: Do institutions matter? *International Economic Journal*, 35(1), 96–119.
- Noor-Ul-Amin, S. (2013). An effective use of ICT for education and learning by drawing on worldwide knowledge, research, and experience. ICT as a Change Agent for Education. India: Department of Education, University of Kashmir, 1, 13.
- North, D. C. (1990). *Institutions, institutional change and economic performance*. Cambridge University Press.
- Oliveira, T. A., Oliver, M., & Ramalinho, H. (2020). Challenges for connecting citizens and smart cities: ICT, e-governance and blockchain. *Sustainability*, 12(7), 2926.
- Orji, U. J. (2015). *Multilateral legal responses to cyber security in Africa: Any hope for effective international cooperation?*. In 2015 7th International Conference on Cyber Conflict: Architectures in Cyberspace (pp. 105–118). IEEE.
- Pagallo, U. (2021). *On the principle of privacy by design and its limits: Technology, ethics and the rule of law*. In Italian Philosophy of Technology (pp. 111–127). Springer, Cham.
- Ponelis, S. R., & Holmner, M. A. (2015). ICT in Africa: Building a better life for all. *Information Technology for Development*, 21(2), 163–177.
- Quarshie, H. O. (2014). Using ICT to fight crime-A case of Africa. *Journal of Emerging Trends in Computing and Information Sciences*, 5(1), 21–24.
- Roodman, D. (2009a). A Note on the Theme of Too Many Instruments. *Oxford Bulletin of Economics and Statistics*, 71(1), 135–158.
- Roodman, D. (2009b). How to do xtabond2: An introduction to difference and system GMM in Stata. *Stata Journal*, 9(1), 86–136.
- Sabani, A., Deng, H., & Thai, V. (2019, January). *Evaluating the development of E-government in Indonesia*. In Proceedings of the 2nd International Conference on Software Engineering and Information Management (pp. 254–258).
- Samarakoon, S., Christiansen, A., & Munro, P. G. (2017). Equitable and quality education for all of Africa? The challenges of using ICT in education. *Perspectives on Global Development and Technology*, 16(6), 645–665.
- Santiago, R., Carvalho, T., & Cardoso, S. (2015). Portuguese academics' perceptions of higher education institutions' governance and management: A generational perspective. *Studies in Higher Education*, 40(8), 1471–1484.
- Sayılır, Ö., Doğan, M., & Soud, N. S. (2018). Financial development and governance relationships. *Applied Economics Letters*, 25(20), 1466–1470.
- Soper, D. S., & Demirkan, H. (2012). How ICTs affect democracy and corruption in emerging societies. *IT Professional*, 14(4), 18–23.
- Tchamyou, V. S., Erreygers, G., & Cassimon, D. (2019). Inequality, ICT and financial access in Africa. *Technological Forecasting and Social Change*, 139, 169–184.
- Toader, E., Firtescu, B. N., Roman, A., & Anton, S. G. (2018). Impact of information and communication technology infrastructure on economic growth: An empirical assessment for the EU countries. *Sustainability*, 10(10), 3750.
- Tucker, C. M., & Ostrom, E. (2005). Multidisciplinary research relating institutions and forest transformations. Seeing the forest and the trees: Human-environment interactions in forest ecosystems, 81–103.
- Varghese, N. V. (2013). Government and Governance Reforms in Africa. *International Higher Education*, (73), 13–14.
- Weicher, M., Chu, W. W., Lin, W. C., Le, V., & Yu, D. (1995). *Business process reengineering analysis and recommendations*. City University of New York.
- Williamson, B. (2016). Digital education governance: An introduction. *European Educational Research Journal*, 15(1), 3–13.
- World Bank. (2021). *World Development Indicators. April 2021*. World Bank.
- World Bank. (2022). *Worldwide governance indicators April 2022*. World Bank.
- World Bank (2022a). *World Bank digital development plan. Too-many-africans-cannot-access-technology-they-need-world-bank-initiative-aims*.
- World Bank (2022b) *World Bank. : Governance Global Practice supports client*.

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