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Nexus between digitalisation and institutional quality in Africa: Partial aggregation perspective

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Abstract

The advancement of the internet of things (IoT) and artificial intelligence (AI) has given rise to smart living, where digitalisation is prioritised as one of the socioeconomic progress factors. Among socioeconomic progress, state efficiency in the handling of governance and the justice system is key to institutional quality. The breakout of the pandemic has caused significant disruptions in daily endeavours across the globe, and that necessitated more use of the internet due to lockdown. It also allowed for the opportunity for the use of digital technologies to increase and facilitate economic activity as well as improve institutional quality and service delivery in the interest of addressing socio-economic dynamics across the globe. Thus, this study examines the nexus between digitalisation and the quality of economic and governance institutions in order to establish causal relationships. The study deploys panel data analysis from 2000 to 2022 for forty-eight African countries. The study employed principal component analysis (PCA) to construct the indices that measure digitalisation and institutional quality. The Dumitrescu-Hurlin (DH) causality test was deployed to examine the causal relations between digitalisation and institutional quality. The results from the stylised facts confirmed the presence

of a digital divide in Africa. In addition, the DH causality test revealed mutual feedback between digitalisation and institutional quality. The study recommends that African countries should prioritise efficient governance and administration that will foster the development of the telecommunications sector in order to ensure increased digital penetration in the African region.

Keywords: *Digitalisation, Institutional quality, Principal component analysis (PCA), and Africa*

1.0 Introduction

The digitalisation of economies is a topical concept in modern society, amid the advent of globalisation and the rapid advancement of digital technologies. The relevance of this concept could be attributed to the impact that digital technologies have on the structural transformation of economies because of their pervasive nature. The advancement of digital technologies offers a modern mechanism for achieving sustainable economic development. Pang, Jiao, and Zhang (2022) postulate that the emergence of rapid technological advancement accompanied by the emergence of the fourth industrial revolution are some of the core factors that encourage economies to embark on a quest for a digital economy. Afolabi (2023) argued that countries modernise their economies using digital technologies because they have a significant far-reaching impact across all human activities.

The African economies have, just as the global economies have, channelled the focus on harnessing innovation as a tool to attain sustainable development, economic growth, and reduce poverty levels (Odularu & Adekunle, 2020). The increase of digital technologies (commonly known as digitalisation) in African economies could be considered one of the outcomes of harnessing innovation. Banga and Velde (2018) further define the concept of digitalisation as “the transformation of the economy that is achieved through the interaction of digital technologies”. According to Denis (2021), the process of digitalising African economies commenced with gaining access to basic information and communication technology tools and services. Basic access to these tools and services paved the foundation for African economies to adopt emerging technological paradigms such as the Fourth Industrial Revolution (4IR), the Internet of Things (IoT), and artificial intelligence (AI). Despite the notable progress that African

economies have achieved in digitalising their economies, their economies continue to lag behind in terms of digitalisation speed and adjustment in comparison with global economies (Enaifoghe, 2021).

The existing literature has investigated the factors that impede the progress of the digitalisation of African economies (Banga & Velde, 2018; Melia, 2020; Yoon, 2020). These studies have identified various factors that delay the digitalisation of African economies. These factors include, lack of adequate digital infrastructure, a shortage of digital skills, and digital inequality. Despite this topic being explored by scholars, the existing literature has yet to establish a clear causal relationship between digitalisation and institutional quality in global south economies like Africa (Eger & Maggipinto, 2009; Anand et al., 2021; Behera et al., 2023). The focus of these regions is important, and studies in this context are warranted because economies in these regions are characterised by underdevelopment in comparison with their counterparts (Litonjua, 2012).

The existing evidence suggests that the quality of institutions could be used to explain the variation in Africa's underdevelopment in comparison with developed regions (Kumssa & Mbeche, 2004). The scholars argue further that the state is one of the most important institutions in society. In a similar context, Siba (2007) asserts that good quality institutions are those that are good for economic development. Alonso and Garcimaritn (2013) describe good institutions as institutions that stimulate the activities of economic agents with high social returns. Many African governments have been battling with constructing functional, efficient, and effective governance and institutional structures since the collapse of colonial states on the continent.

The weak institutional quality of African economies warrants institutional reform because weak institutions are characterised by corruption, a lack of transparency and accountability, and inefficiency in service delivery (Adam, 2020). Therefore, they contribute to the persistent underdevelopment of African economies. The existing literature suggests that the use of digital technologies could aid in enhancing institutional quality and promoting development (Singh et al., 2010; Mistry, 2012; Belanger & Carter, 2012; Tintin et al., 2018). These studies argue that digital technologies can promote transparency accountability, and efficiency in public administration. This paper focuses on the role that digitalisation has in improving the institutional quality of African economies. The centrality of this study lies in the detection of

the direction of links between digitalisation and institutional quality in Africa.

Literature Review

Theoretical Literature

The theory, known as the theory of creative destruction Schumpeter (1942) emphasises the reallocation of resources from obsolete industries into more productive and innovative ones, which will create the evolution of new industries over time and new products, services, and business models. The theory of digitalisation is grounded on the principle of the Schumpeterian (1942) neoclassical growth model. This theory (digitalisation) was first coined by Tapscott (1996) in the book *The Digital Economy: Promise and Peril in the Age of Networked Intelligence*. This theory posits that the era of network intelligence is about the networking or connecting humans through technology; this notion implies that technologies should be integrated into various social and economic streams (Tapscott, 1996; Zhang et al., 2022).

According to Carlsson (2004), the concept of the digital economy is described as a dynamic process rather than static efficiency. This is because the concept is centred on integrating digitally-oriented economic activities. The theory of technological revolution is further discussed by two other schools of thought, particularly the technophilic and technophobic perspectives. These two schools of thought differ in terms of their understanding of the impact of technology on society. The proponents of increased technology adoption are known as the ‘technophiles’; these are people who consider technology in a positive manner, and they advocate for the use of technology to combat social and economic issues (Amichai-Hambrurger, 2009). Technophiles strongly believe that human beings have no power to resist the power and influence of the evolution of technology (Osiceanu, 2015).

On the other hand, the antagonists of constant technological revolution are known as the ‘technophobes’. These are people who are against the negative side effects that technological advancement has on society and the environment (Osiceanu, 2015). According to David (2013), technophobes believe that the advancement in technology will have a negative impact on the economy, such as widening the digital inequality gap. In addition, technophobes argue that the impact that

technology has on the economy is greatly exaggerated and that technological advancement may destroy more jobs than it creates (David, 2013). Another study argues that the focus on digitalisation may induce governments and the private sector to invest in digital technologies and neglect investments to other economic sectors that could have better growth and development benefits (Mansell, 1999).

Zilber and Goodman (2021) argue that institutional theory is primarily concerned with the process of institutionalisation. The scholars conceptualise institutionalisation as the “spread of ideas, structures, understandings, and practices over time.” In the discipline of contemporary economics, scholars have made an attempt to distinguish the concepts of institutions and institutional quality. According to North (1990), institutions are boundaries that are created by humans to control social, political, and economic interaction. Similarly, Scheela and Van Dinh (2004) state that institutions are the collection of integrated rules and mechanisms for their application and the organisation that supports them.

On the other hand, institutional quality is understood as the efficiency and effectiveness and integrity of a nation’s institutions such as its legal and regulatory frameworks and governance structures (Afolabi, 2023b). Similarly, Kandil (2009) argues that the indicators of institutional quality consider a variety of determinants, including measures of economic freedom, the quality of policies, and a number of other macroeconomic determinants. The research work of Kaufmann et al. (2010) measures institutional quality using numerous components: quality of governance, government effectiveness, the extent of the rule of law, political stability, voice, and accountability. Despite the notable effort to define institutional quality, Quibria (2014) argues that the measures of institutional quality do not measure the quality in itself, but rather the perception of it. Grabowski and Self (2021) disagree and submit that perception plays a critical role in the functioning of institutions, formal or informal.

Empirical Literature

In the existing literature, the scholars have identified numerous factors that supports and facilitate the digital economy. For instance, the study by Ablyazou and Asaul (2021) identified digital infrastructures such as broadband internet and fixed telephones is critical tools that support,

facilitate, and promote the digital economy. Afolabi (2023b) identified human capital as one of the key components that promote the digital economy. The scholar argued that human capital equips individuals with the skills required to operate a digitalised economy. This notion is echoed by other studies such as Afolabi (2023a) and Khazheeva (2019) that have argued that developed digital economies are associated with developed human capital and intense investment in human capital development. This allows these economies to leverage digital technologies through a skilled and knowledgeable workforce.

In addition to these factors, scholars have reported that strong economic policy frameworks are one of the components that enhance a digital economy (Jiang, 2020; Afolabi, 2023a). The scholars further argued that strong economic policy frameworks influence the country's economic performance, encourage investment, and promote innovation, thereby advancing a digital economy. It is important to mention that these aforementioned components are the exact components that have been reported to be deficient in many African economies (Banga & Velde, 2018; Melia, 2020; Yoon, 2020).

The empirical literature has established the interaction between digitalisation and institutional quality. The research work of Labhard and Lehtimäki (2022) postulates that digitalisation, institutions, and governance offer a wide range of economic opportunities to economic agents by providing access to information and creating the framework for market transactions. In addition, the scholars argue that digitalisation enables an environment that facilitates accountability for stakeholders. A study by Sharma et al. (2022) argues that the role of institutions is to help economic agents reduce the uncertainties and externalities of their activities. Anand et al. (2021) consider innovation and technologies as tools to enhance the functioning of institutions, particularly the enforcement of rules that mediate social interactions among economic agents. Other studies, such as Adam (2020), examine the interaction between digitalisation and institutional quality. The study employed partial least squares structural equation modelling (PLS-SEM) to observe the interaction. The study considered institutions from the perspective of public governance and used ICT as a measure for digitalisation. Adam (2020) reported that digitalisation can be a cost-effective tool to enhance transparency in governance and reduce corruption in the public sector.

Similarly, Eger and Maggipinto (2009) argue that technology is a tool of transformation and can therefore be used to enhance transparency in

the government sector, particularly, in handling and managing information, and to restore citizens' confidence in the government. The scholars further argue that governments could use technology to give citizens easy access to information from public institutions. Thus, Eger and Maggipinto (2009) encourage governments to adopt technologies and embrace the idea of governance to enhance the quality of institutions. This notion is supported by Fuentelsaz et al. (2018). The study argues that countries with advanced technologies are associated with high-quality institutions characterised by strong regulatory frameworks, enforcement of regulations, and effective legal processes. The scholars further reported that quality institutions further encourage innovation, entrepreneurship, and firms' productivity. Their study was conducted on a sample of over 101 countries. Their study also indirectly uncovered the interaction between digitalisation, institutional quality, and economic performance.

Studies argues that the institutional quality framework should be measured using four dimensions, predictability, static and dynamic efficiency, and legitimacy (North, 2005; Alonso and Garcimartin, 2013; Alonso et al., 2020). The scholars argue that it is critical to identify variables that are associated with the abovementioned dimensions when conducting empirical analysis. In their study, Alonso et al. (2020) identified education, development level, inequality, tax revenue, and trade openness as the determinants associated with good quality institutional framework. The empirical findings of their study reported income per capita (inequality) and tax revenue to be sound determinants of institutional quality. The scholars' choice of the determinants of institutional quality is supported by other related studies. Furman et al. (2002) and Glaeser et al. (2004) reported human development (education) as a key determinant of institutional quality. These studies further argue that an educated and skilled society contributes to building transparent and dynamic institutions. Other studies, such as those by Alonso and Garcimartin (2013), identified income distribution (inequality) as a determinant of economic development. The scholars argue that institutional quality is in direct proportion to institutional quality.

A study by Nguyen et al. (2018) employed the system generalised s of moments (SGMM) to empirically analyse the impact of institutional quality on economic growth. However, the study conceptualised institutional quality from a governance perspective and thus used

governance indicators such as government effectiveness, regulatory quality, corruption control, and rule of law as the primary determinants of institutional quality. The existing empirical literature has established the connection between digitalisation and institutional quality; however, there is still a deficit of knowledge into the subject in the context of African economies. This warrants an investigation on the nexus, considering that African economies have used digital economic models to attain their macroeconomic objectives.

Methodology

The rationale for this study relied on establishing the direction of causation between digitalisation and institutional quality in Africa. The study first determines the measurement of the key terms of the study and conducts a causality test to ascertain the causal effect between digitalisation and institutional quality in Africa. The models for this study are stated below:

Measuring Digitalisation and institutional quality

To measure digitalisation and institutional quality in Africa, this study employed principal component analysis (P.C.A) to achieve two indices known to this study as digitalisation index. According to Aknabi (2015), the P.C.A technique is a process of transforming a high dimension of indicators and converting them into a single benchmark index that captures and presents the information on a different dimension and is mutually uncorrelated. Similarly, Coban and Topcu (2013) postulate that the P.C.A technique transforms a data series that consists of various indicators and transforms them into principal components that are not correlated. The rationale for employing principal component analysis is to avoid the potential problem of multicollinearity when modelling indicators that share similar characteristics. In addition, Pradhan et al. (2014) state that aggregating the indicators into a single index is considered a better approach than modelling each indicator separately. Other similar studies have employed the same technique to model a digital index (see Pradhan et al., 2019; David, 2019; Saba & David, 2020). According to David and Grobler (2020) and Saba and David (2020), the aggregate index is derived by using the first eigenvectors (known as the

loading matrix) from the P.C.A as the required weights. Therefore, the following linear combination is presented:

$$\text{P.C.A} = \emptyset_1 X_1 + \emptyset_2 X_2 + \emptyset_3 X_3 + \dots, \emptyset_k X_k \quad (1)$$

Where C.I. denotes the composite index and $\emptyset_1, \emptyset_2, \emptyset_3, \emptyset_k$ represent the eigenvectors derived from the P.C.A and X_1, X_2, X_3, X_k denotes the selected indicators that make up the composite index. To construct the digital index and institutional quality index, substitute the indicators into equation 1, hence:

$$\text{DigiIndex} = \emptyset_1 \text{mobile telephone} + \emptyset_2 \text{fixedline} + \emptyset_3 \text{internet access} \quad (2)$$

Equation 2 is used to construct the digital index; in the equation, DigiIndex denotes the composite index of digitalisation in Africa. Mobile telephones, fixed line; and internet access are the indicators used to measure digitalisation and are known as ICT indicators (ITU, 2018).

$$= \emptyset_1 \text{CorrpContr} + \emptyset_2 \text{Easeofbusi} + \emptyset_3 \text{Ruleoflaw} + \emptyset_3 \text{Voice\&Acc} \quad (3)$$

Equation 3 is used to construct the institutional quality index. In the equation, InstQualIndex denotes the composite index that measures institutional quality in Africa. CorrpContr denotes corruption control. Easeofbusi indicates ease of doing business, Ruleoflaw represents the rule of law, and Voice&Acc represent voice and accountability, and collectively they represent the indicators of institutional quality.

Examining the causal relationship between variables

To establish the nature of causality that exists between digitalisation and institutional quality, this study employs the Dumitrescu-Hurlin (2012) panel causality technique. According to Dumitrescu and Hurlin (2012), the DH test accounts for the heterogeneity across the cross-section units. Ndoricimpa (2014) argues that ignoring the heterogeneity across the cross-section units when testing for causality in a panel data series could compromise the validity of the findings and lead to faulty conclusions. According to Hsiao (2014), the DH test is built under the assumption that there is no causal link between two variables across all the cross-section units of the panel series. in the alternative hypothesis of the test, there are some cross-section units where there is no causality and also

cross-section units of the panel series where there is causality (Hsiao, 2014). To test for panel causality between two variables X and Y, the following model is proposed:

$$Y_{i,t} = \alpha_1 + \sum_{i=1}^n \beta_i x_{t-i} + \sum_{j=1}^m \gamma_j y_{t-j} + \varepsilon_{1i,t} \quad (4)$$

$$X_{i,t} = \alpha_2 + \sum_{i=1}^n \theta_i x_{t-i} + \sum_{j=1}^m \delta_j y_{t-j} + \varepsilon_{1i,t} \quad (5)$$

Where $X_{i,t}$ and $Y_{i,t}$ represent the observations of two stationary variables for individual cross-section at time t.

To test for causality, the null hypothesis is stated as:

$$H_0: \beta_{i1} = \dots \beta_{ik} = 0 \forall i = 1 \dots N \quad (6)$$

The alternative hypothesis is stated as follow:

$$H_1: \beta_{i1} = \dots \beta_{ik} = 0 \forall i = 1, \dots N_1 \quad (7)$$

$$H_1: \beta_{i1} \neq \dots \beta_{ik} = 0 \forall i = 1, \dots N_1 + 1, N_1 + 2, \dots N \quad (8)$$

The study will use the p-values associated with the global panel statistic W-Stat and the standardised Zbar-Stat to establish the nature and direction of causation that exist between the stated variables. The p-values are based on the N (0.1) limiting distribution principle (Dumitrescu & Hurlin, 2012). Thus, if the p-values associated with the W-Stat and Zbar-Stat are less than the 5% critical level, the study will reject the stated null hypothesis. This would imply that the variables have a causal link with each other.

Data series and variable description

The study relied on secondary data to fulfil the stated objectives. The data was gathered from reputable international databases such as the World Bank (WB) and the International Telecommunications Union (ITU). The period under observation spans from 2000 to 2022, and the selected sample size is 48 African countries. This was informed by the availability of data. The study employed sophisticated econometric

techniques such as interpolation and extrapolation to account for missing data without compromising the validity of the findings. Table 1 provides a summary of the variables and their sources, whereas the sample of countries is presented in Table 2.

Table 2: List of Countries

1. Algeria	11. Comoros	21. Gambia	31. Morocco	41. South Sudan
2. Angola	12. DRC	22. Ghana	32. Mozambique	42. Sudan
3. Benin	13. Congo Rep.	23. Guinea-Bissau	33. Namibia	43. Tanzania
4. Botswana	14. Ivory Coast	24. Kenya	34. Niger	44. Togo
5. Burkina Faso	15. Djibouti	25. Lesotho	35. Nigeria	45. Tunisia
6. Burundi	16. Egypt	26. Libya	36. Rwanda	46. Uganda
7. Cabo Verde	17. Equatorial Guinea	27. Madagascar	37. Senegal	47. Zambia
8. Cameroon	18. Eswatini	28. Mali	38. Seychelles	48. Zimbabwe
9. Central African Rep.	19. Ethiopia	29. Mauritania	39. Sierra Leone	
10. Chad	20. Gabon	30. Mauritius	40. South Africa	

Source: *Author's compilation (2023)*

4.0 Principal component analysis (PCA), summary statistics, and correlation results

Principal component analysis (PCA)

This study used the P.C.A. to construct two indices measuring the level of digitalisation and institutional quality in Africa. For the purpose of this study, the two indices are termed DigiIndex and InstiQualIndex, respectively. The DigiIndex measures digitalisation and the index includes three variables: mobile-cellular phone subscriptions per 100 inhabitants; the percentage of households using the internet; and fixed telephone line subscriptions per 100 inhabitants. The results of the P.C.A for the DigiIndex are presented in Table 1. The InstiQualIndex measures institutional quality in Africa. The index includes four variables: control of corruption, ease of doing business, rule of law, and voice and accountability for institutional quality indicators. The results of the P.C.A. for the InstiQualIndex are presented in Table 2, respectively.

Table 4.1: Principal component analysis for the Digital Index

Number	Value	Difference	Proportion	Cumulative Value	Cumulative Proportion
1	1.888302	1.078441	0.6294	1.888302	0.6294
2	0.809861	0.508023	0.2700	2.698163	0.8994
3	0.301837	---	0.1006	3.000000	1.0000
Eigenvectors (loadings):					
Variable	PC 1	PC 2	PC 3		
Mobile		0.881549	0.177908		
	0.437287				
Fixed_Line		-0.437583	0.655563		
	0.615434				
Internet		-0.177178	- 0.733884		
	0.655761				
Ordinary correlations:					
	Mobile	Fixed_Line	Internet		
Mobile	1.000000				
Fixed_Line	0.230980	1.000000			
Internet	0.375578	0.679648	1.000000		

Source: *Author's Computations (2023)*

The results in Table 4.1 revealed a considerable level of correlation between the three digitalisation indicators; this level of correlation aided in the construction of the digital index using the P.CA. In addition, Table 4.1 presents the eigenvalues of the three indicators; the study retained the eigenvectors associated with the variables whose loading values were greater than 0.4 in absolute value. Therefore, the factor scores to construct the P.C.A. were derived from the first principal component. This principle is also used in a study by Chen (2014).

Table 4.2: Principal component analysis for the Institutional Quality Index

Number	Value	Difference	Proportion	Cumulative Value	Cumulative Proportion
1	2.876546	2.176015	0.7191	2.876546	0.7191
2	0.700531	0.391217	0.1751	3.577077	0.8943
3	0.309314	0.195705	0.0773	3.886391	0.9716
4	0.113609	---	0.0284	4.000000	1.0000
Variable	PC 1	PC 2	PC 3	PC 4	
Corruption	0.537128	-	-0.529423	0.610389	
Control		0.242135			
Ease of	0.371439		-0.006809	0.035271	
Business		0.927762			
Rule of law	0.555649	-	-0.237790	-0.772495	
		0.194837			
Voice &	0.514569	-	0.814323	0.171557	
Accountability		0.206558			

Ordinary correlations:

	Corruption Control	Ease of Business	Rule of law	Voice & Accountability
Corruption Control	1.000000			
Ease of Business	0.420091	1.000000	1.000000	
Rule of law	0.876938	0.464464	1.000000	
Voice & Accountability	0.708629	0.414521	0.775702	1.000000

Source: *Author's computation (2023)*

Table 4.2 presents the PCA analysis for the InstiQualIndex. The results from the correlation uncovered a considerably high correlation between some of the institutional quality indexes; for instance, Control of Corruption and Rule of Law displayed a level of correlation greater than 0.87. Additionally, Rule of Law and Voice and Accountability displayed a correlation level greater than 0.77. This level of collinearity helped construct the InstiQualIndex using the P.C.A. while retaining some important characteristics of the indicators (Pradhan et al., 2019). Table 4.2 also presents the eigenvalues of the four institutional quality indicators. The study retained the eigen vectors associated with the values whose loadings were greater or closer to 0.4; this principle is used by Chen (2014).

Table 4.3: Summary Statistics

	DIGIN DEX	EDUCAT ION	GDPP C	INSTQUALI NDEX	INTER NET	LAND TEL	MOBILE TEL	TRAD E
Mean	47.3857		2475.8		15.2417	3.63457		79.33
	8	1213917.	32	29.29889	1	6	55.53267	870
Median	38.7523		1281.7		6.34442	0.99534		62.33
	7	478695.0	79	26.49632	2	1	47.56388	313
Maximum	164.612		17117.		92.1402	36.8847		980.1
	3	25769719	03	65.01368	8	0	206.7027	690
Minimum	-		178.27		-	0.00000		2.698
	3.729098	-6587309.	48	0.436335	4.440000	0	-5.878316	834
Std. Dev.	40.3159		2949.4		19.4746	6.17617		79.32
	4	2336648.	75	13.25562	9	7	45.94017	799
Skewness	0.69433		2.3402		1.59491	2.71453		6.829
	6	5.194342	14	0.681264	8	2	0.582657	429
Kurtosis	2.54096		8.6796		4.79971	10.7710		62.81
	5	42.96076	11	2.717365	8	8	2.445384	854
Jarque-Bera	100.449		2543.4		629.900	4219.88		17678
	6	80053.96	70	90.92847	8	2	78.21173	9.8
Probability	0.00000		0.0000		0.00000	0.00000		0.000
	0	0.000000	00	0.000000	0	0	0.000000	000

Sum	53403.7		27902		17177.4	4096.16		89414
	7	1.37E+09	63.	33019.85	1	7	62585.32	.72
SumSq.	1830172		9.80E		427050.	42951.4		70858
Dev.	.	6.15E+15	+09	197851.0	7	5	2376422.	39.
Observations	1127	1127	1127	1127	1127	1127	1127	1127

Source: Author's computation (2023)

Table 4.3 presents the summary statistics of the panel data series for this study. The descriptive statistics were measured in 46 African countries used in this study. The results revealed the average level of digitalisation or digital penetration to be at least 47.38 index points, as measured by the mean of the DigiIndex. This suggests that the average level of digitalisation in Africa is less than 50% for the period 2000-2022. The maximum level of DigiIndex was recorded at 164.61 index points. Observing this indication in conjunction with the average value of 47.38 index point suggests that there is a wide disparity in terms of the level of digitalisation in Africa. The standard deviation of the DigiIndex is 40.31594 with a Jaque-Bera statistic of 100.4496, which indicates that the residuals of the data series of the DigiIndex are not normally distributed.

The GDP per capita shows an average value of 2475.832, which indicates that the average real GDP per capita in Africa between 2000 and 2022 is U.S. \$2475.832 billion. The maximum real GDP per capita in Africa over the same period is \$17117.03 billion. This shows that level of economic growth in Africa varies by country. The Jaque-Bera statistic of GDPPC is

INSTQUALINDEX DIGINDEX INTERNET LANDTEL MOBILETEL EDUCATION GDPPC TRADE									
INSTQUALINDEX									
	1.000000								
	0.491205								
DIGINDEX	(0.0000)	1.000000							
	0.430578	0.820622							
INTERNET	(0.0000)	(0.0000)	1.000000						
	0.428603	0.416305	0.230980						
LANDTEL	(0.0000)	(0.0000)	(0.0000)	1.000000					
	0.447630	0.974452	0.679648	0.375578					
MOBILETEL	(0.0000)	(0.0000)	(0.0000)	(0.0000)	1.000000				
	0.048815	0.192363	0.235608	-0.027265	0.166140				
EDUCATION	(0.1014)	(0.0000)	(0.0000)	(0.3605)	(0.0000)	1.000000			
	0.259366	0.443263	0.237874	0.718099	0.434185	-0.024240			
GDPPC	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.4162)	1.000000		
	-0.048334	-0.003266	-0.011479	0.158272	-0.013992	-0.177220	0.210134		
TRADE	(0.1049)	(0.9128)	(0.7003)	(0.0000)	(0.6389)	(0.0000)	(0.0000)	1.000000	

2543.470, with a probability value that is statistically significant at the 1%, 5%, and 10% level of significance, indicating that the residuals of the data series are not normally distributed. The results in Table 3 show that

the average level of trade openness is 79.33870 for the periods 2000 and 2022. This suggests a considerable level of international trade competitiveness of African economies in the international trading community. The minimum trade openness is 2.698834, and the maximum is 980.1690. This indicates that the lowest trade openness as a percentage of the GDP is 2.69% and the highest is 980.17%. The two values indicate a wide disparity in terms of trade competitiveness among African economies, but they also reflect the social, economic, environmental, and geopolitical factors that have caused disruptions in the level of trade competitiveness in African economies.

Table 4.4: Pairwise Correlation Analysis

Source: Author's computation (2023)

The results from the pairwise correlation revealed a considerably strong level of correlation between the institutional quality index and the digital index (0.491205); in addition, the institutional quality index showed a considerably strong relationship between the determinants of digitalisation, mobile cellular, fixed telephone, and internet access. This correlation confirmed the relationship between digitalisation and institutional quality.

5.0 Stylised facts analysis

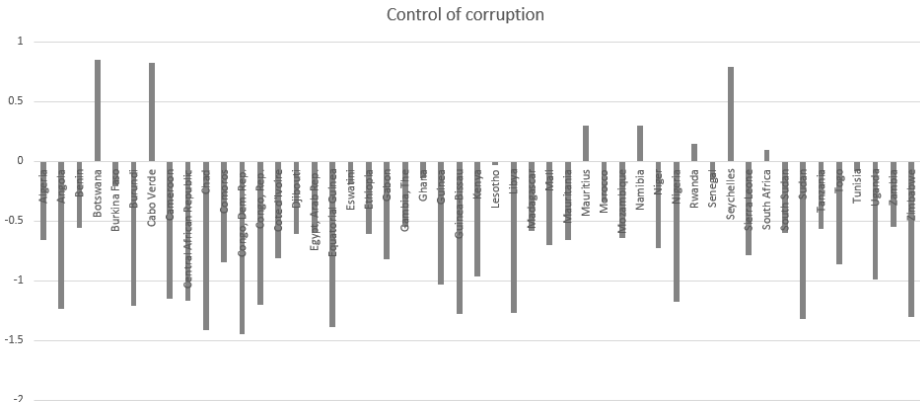
5.1. Institutional Quality trends in Africa

5.1.1 Control of co distributed.rruption

The study measures institutional quality using various indicators of good governance, informed by the empirical literature and theoretical underpinnings. One of the indicators chosen by this study is the control of corruption index; similar related studies have used the same indicator (see Asongu, 2013). Thus, Figure 1 presents the trend of controlling corruption in Africa between 2000 and 2022. The result depicts at least seven countries out of the entire sample with a positive level of corruption control in Africa. Countries such as the Seychelles, Botswana, and Cabo Verde have the highest level of corruption control in the region. On the other hand, countries such as the Congo, the Democratic

Republic, Equatorial Guinea, Chad, and Zimbabwe have the lowest level of corruption control on the continent.

Figure 1: Control of Corruption index in African countries

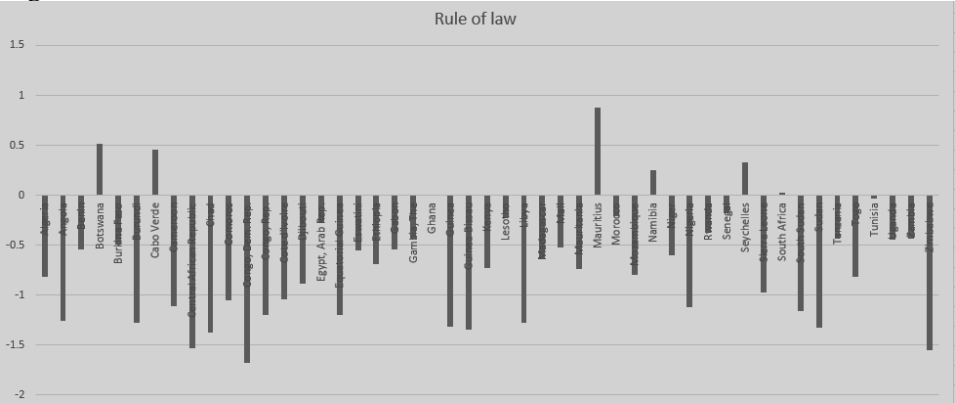


Source: Author's computation (2023)

5.1.2. Rule of law in Africa

Figure 2 shows the trends of the rule of law in Africa. The rule of law is considered not only a good indicator of institutional quality and modern democracy, but it is also a good indicator for sustainable economic development (Mutua, 2016). The results in Figure 2 enunciate the findings in Figure 1 of poor governance and institutional quality on the African continent. Figure 2 shows at least six countries with positive figures in terms of the rule of law on the continent, with countries such as Mauritius, the Seychelles, Botswana, and Cabo Verde scoring good positive values. On the other hand, Zimbabwe, the DRC, and Guinea-Bissau scored poorly on the indicator.

Figure 2: Rule of law in Africa

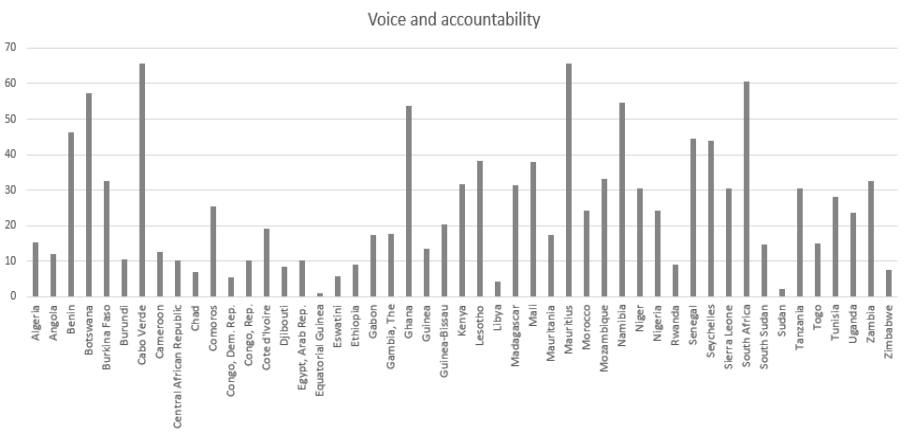


Source: Author's computation (2023)

5.1.3. Voice and Accountability in Africa

Figure 3 depicts the results of the voice and accountability indicator, which is another indicator of institutional quality and governance. The voice and accountability indicator is a good indicator that reflects the relationship between the government and its citizens (Sharma, 2008). This is because the citizens, just as the government, have a very important role in fostering good governance (Holland et al., 2009), which goes beyond the rule of law (O'Neil et al., 2007). The results in Figure 2 show a significant level of disparity among African countries in terms of freedom of expression and civil liberties on the continent. Countries such as the DRC, Equatorial Guinea, Libya, and Sudan scored less than 10 index points, while countries such as Cabo Verde, Mauritius, South Africa, and Botswana scored close to and above 60 index points.

Figure 3: Voice and Accountability in Africa

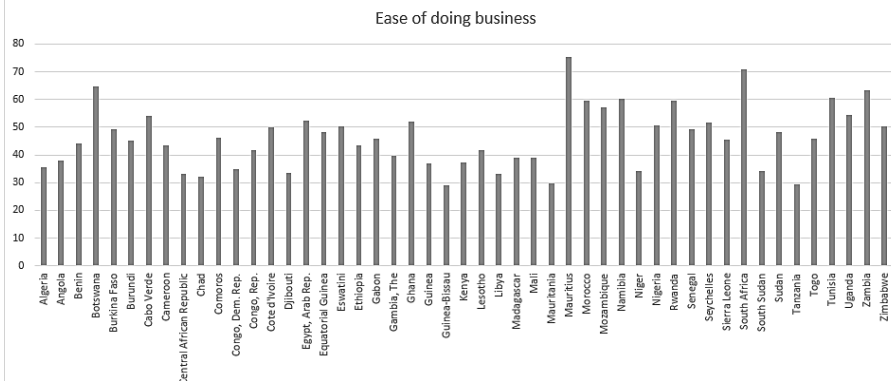


Source: Author's computation (2023)

5.1.4 Ease of doing business in Africa

The research work of Nyuur et al. (2014) argued that the inefficiency of African institutional quality impedes the process of doing business in Africa. The authors argue that this affects the sustainable development process on the continent. In 2013, almost all African countries except for South Africa and Tunisia were the worst-performing economies in terms of the ease of access index (Nyuur et al., 2014). Figure 4 shows the ease of doing business scores among African economies for the period 2000-2022. The results show Botswana, Mauritius, and South Africa as the economies with the most efficiency or ease of doing business in Africa. It is important to mention that these countries scored considerably better in other indicators of institutional quality, as depicted in Figures 1 to 3. On the other hand, the DRC, Equatorial Guinea, and Chad are some of the worst-performing countries, with scores less than 50 in terms of ease of doing business on the continent. It is also important to note that these countries scored poorly in other indicators of institutional quality. This suggests that institutional quality affects the cost of doing business in Africa, which enunciates the findings of Nyuur et al. (2014) that poor institutional quality impedes the sustainable development of the African continent.

Figure 4: Ease of Doing Business in Africa



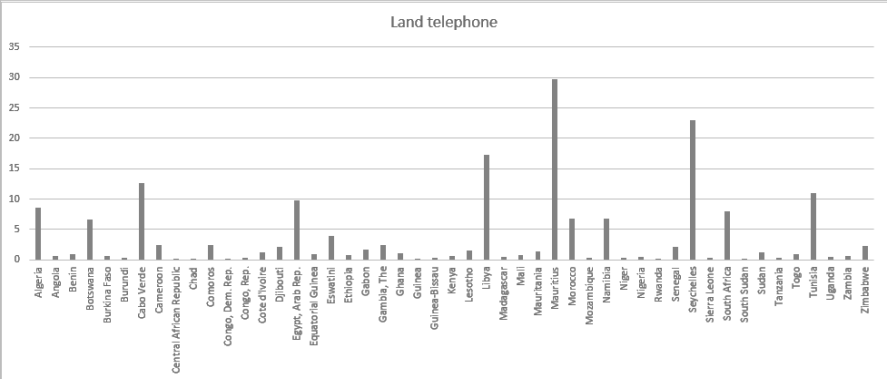
Source: Author's computation (2023)

5.2. Telecommunication trends in Africa

5.2.1. Fixed telephone line subscriptions

Table 5 presents the trend of the average fixed landline telephone subscriptions in African economies for the period spanning from 2000 to 2022. The results reveal a significant disparity in telephone line subscriptions across the continent. On a country level, Mauritius and the Seychelles have the highest level of fixed-line subscriptions in comparison with their African counterparts. It is also important to note that Mauritius exhibited good scores in terms of institutional quality as measured by the various institutional quality indicators in Figures 1 to 4. On the other hand, countries such as Angola, Niger, Rwanda, Chad, and the DRC are some of the countries with fewer of fixed-line telephone subscriptions in the continent. The low level of fixed telephone line subscriptions could also be attributed to the idea that mobile cellular subscriptions are a supplement to telephone fixed line subscriptions. Therefore, they are the most preferred indicator of digitalisation in Africa.

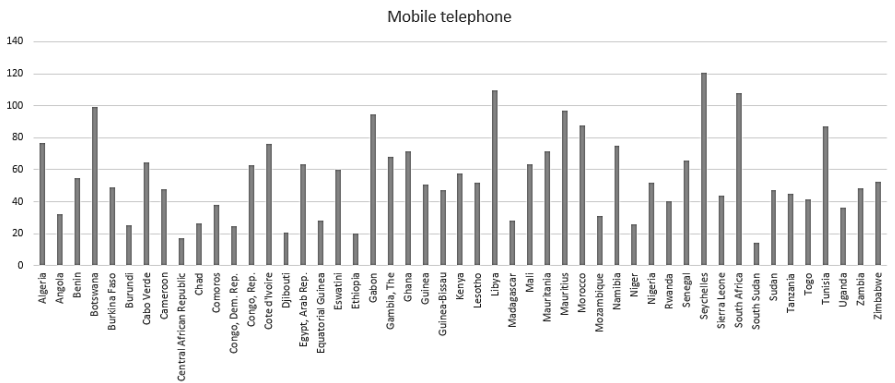
Figure 5: Landline telephone penetration in Africa



Source: Author's computation (2023)

5.2.1. Mobile cellular phone subscriptions in Africa

The empirical results in Figure 6 illustrate the level of digitalisation in Africa, measured by mobile cellular phone density. The results show that there is a considerable amount of mobile cellular phone density on the continent in comparison with fixed-line telephone subscriptions. This suggests that cellular phones are one of the most predominant tools that connect economic agents and facilitate economic activity in Africa. Countries such as Botswana, the Seychelles, South Africa, and Mauritius have close to 100 or over 100 mobile cellular phone subscriptions in Africa. The report of the African Development Bank (AFDB) (2022) attributes the significant growth of mobile cellular phone subscriptions to the increase in investment in the telecommunications sector. The research work of Bankole and Mimbi (2017) attributes the rapid transformation of the African telecommunications sector to the efforts of liberalisation and deregulation policies across the continent.

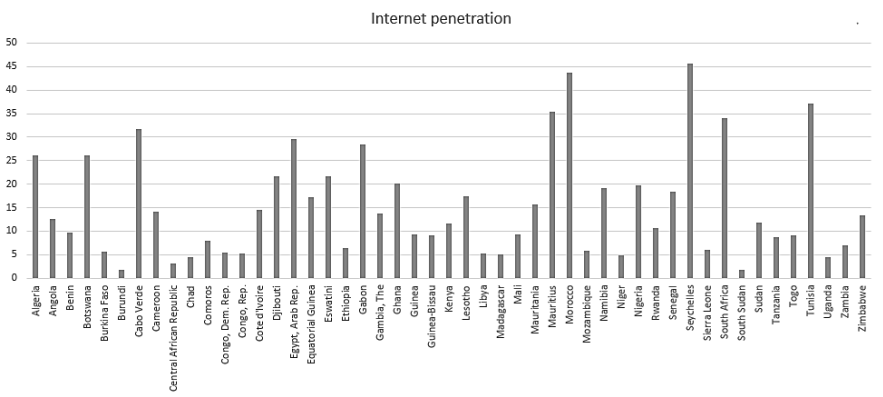
Figure 6: Mobile cellular phone density in Africa

Source: *Author's computation (2023)*

5.2.3 Internet access in Africa

This study used internet access as one of the indicators that measures digitalisation density in Africa. The results presented in Figure 7 show a considerable level of internet penetration in Africa, with over 10 countries having achieved an average internet access percentage of at least 20 per cent. Countries such as Mauritius, Botswana, Morocco, the Seychelles, and Tunisia have some of the highest internet access in the country, while Burundi, South Sudan, Niger, the DRC, and the Central African Republic are some of the countries with low internet access. It is important to note that countries such as Mauritius and Botswana have considerably good institutional quality scores according to the empirical findings in Figures 1 to 5. This suggests that countries with a high level of institutional quality are associated with a high level of digitalisation in the region. Studies attribute the level of digitalisation to the increase in investment in the telecommunications sectors as well as the liberalisation of the sector, which discouraged anti-competitive behaviour, improved access, and increased affordability of the digital tools (Jobodwana, 2009; GSMA, 2016; ITU, 2018). These studies strengthen the notion that institutional quality and digitalisation have a strong relationship.

Figure 7: Internet penetration in Africa



Source: Author's computation (2023)

5.3 Social and economic performance in Africa

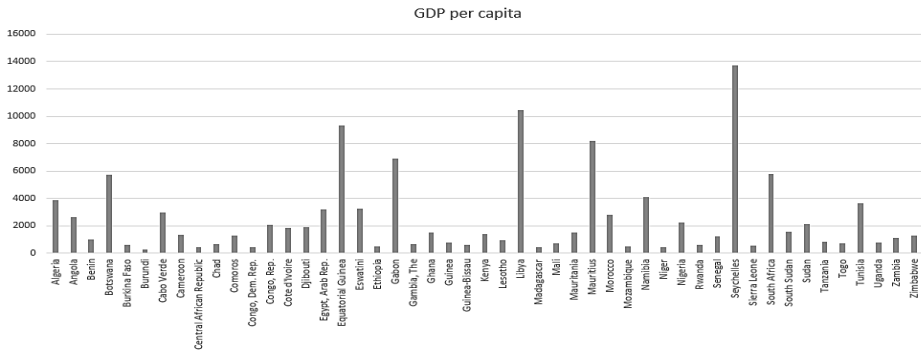
5.3.1 Economic performance in Africa

The empirical literature has established the connection between digitalisation and economic performance (Akram et al., 2021; Pradhan et al., 2019; David & Grobler, 2020; Olamide et al., 2022). The empirical literature has also established the nexus between institutional quality and economic performance (Nawaz et al., 2014; Jazul et al., 2022). Therefore, this study included economic growth and trade openness as some of the most important control variables. Figure 8 presents the average GDP per capita of African economies for the period spanning from 2000 to 2022. On the other hand, the average trade competitiveness of African economies is presented in Figure 9.

The results show that there's a wide disparity in economic growth across African countries. Figure 8 shows that the Seychelles, Libya, Equatorial Guinea, South Africa, Botswana, and Mauritius are some of the countries with high average GDP per capita for the period 2000-2022. The average GDP per capita for the Seychelles was recorded at almost U.S. \$14000 billion and the GDP per capita for Libya and Equatorial Guinea was recorded at over U.S. \$10000 billion and close to U.S. \$8000 billion. The interesting part of the results is that the Seychelles, South Africa, and Botswana are some of the countries with a considerable level of sophistication in digitalisation and institutional quality. On the other hand, Libya and Equatorial Guinea have poor

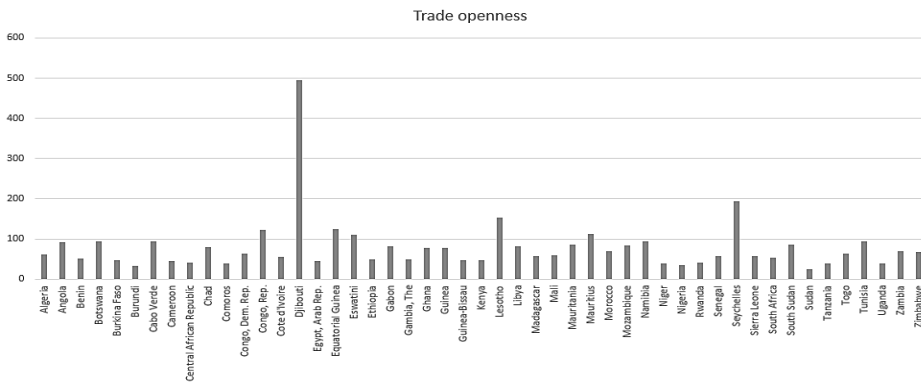
digitalisation and institutional quality, yet they have a high GDP per capita. This implies that for some African countries, economic growth is determined by other factors except for digitalisation and institutional quality; this warrants further empirical examination.

Figure 8: Average GDP per capita of African economies, 2000–2022



Source: Author's computation (2023)

Figure 9: Average Trade Openness of African economies, 2000–2022



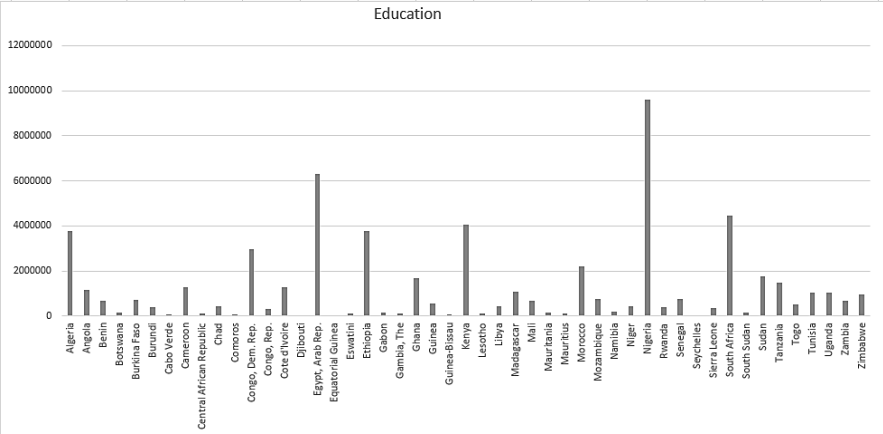
Source: Author's computation (2023)

The results in Figure 9 revealed that only Djibouti has the highest level of trade openness, trailing behind Djibouti are the Seychelles, Equatorial Guinea, and Lesotho. The results further show that many African economies are not competitive in the international trading community, which could be attributed to the quality of institutions, which discourages international economic activity. In addition, this also negatively impacts the economic growth and development prospects of many African

economies, hence the low figures in GDP per capita as reported in Figure 8.

5.3.2. Human Capital trends in Africa

Figure 10: Average education trends in Africa, 2000-2022



Source: Author's computation (2023)

6.0 Empirical Evidence

Dumitrescu-Hurlin's (DH) Causality

This study conducted the Dumitrescu-Hurlin (DH) causality study to empirically examine the causal link between digitalisation and institutional quality. The results revealed a bidirectional causal relationship between digitalisation and institutional quality; this was evident from the p-values that were less than 0.05. Therefore, the study failed to reject the hypotheses that DigiIndex does not homogenously cause InstQualIndex and that InstQualIndex does not homogenously cause DigiIndex. The implication of the mutual feedback observed in Table 5 indicates that the increase in digitalisation density could enhance institutional quality in Africa.

On the other hand, improved institutional quality could foster an economic climate that attracts domestic and foreign investment in the telecommunications sector, promotes innovation, and eventually enhances the level of digitalisation density within Africa. In addition, the findings suggest that increasing digitalisation or rather, adopting modern

economic models (the digital economy), would improve information access for citizens, promote efficient and transparent governance, and improve service delivery. These could also trickle down to promoting financial inclusion, reducing inequality gaps, and improving human capital levels. This means that digitalisation and institutional quality play a critical role in facilitating sustainable development.

Table 5: DH Causality Test

Null Hypothesis:	W-Stat.	Zbar-Stat.	Prob.
DIGINDEX does not homogeneously cause INSTQUALINDEX	5.95633	9.73521	0.0000
INSTQUALINDEX does not homogeneously cause DIGINDEX	3.31557	2.73139	0.0063
LANDTEL does not homogeneously cause INSTQUALINDEX	3.04203	2.00590	0.0449
INSTQUALINDEX does not homogeneously cause LANDTEL	3.41826	3.00375	0.0027
INTERNET does not homogeneously cause INSTQUALINDEX	4.59250	6.11806	0.0000
INSTQUALINDEX does not homogeneously cause INTERNET	2.96477	1.80098	0.0717
MOBILETEL does not homogeneously cause INSTQUALINDEX	5.25654	7.87922	0.0000
INSTQUALINDEX does not homogeneously cause MOBILETEL	2.67556	1.03396	0.3012
LANDTEL does not homogeneously cause DIGINDEX	3.14460	2.27793	0.0227
DIGINDEX does not homogeneously cause LANDTEL	5.00793	7.21987	0.0000
INTERNET does not homogeneously cause DIGINDEX	3.12722	2.23184	0.0256
DIGINDEX does not homogeneously cause INTERNET	4.39734	5.60046	0.0000
MOBILETEL does not homogeneously cause DIGINDEX	2.78899	1.33478	0.1819
DIGINDEX does not homogeneously cause MOBILETEL	2.55476	0.71355	0.4755
INTERNET does not homogeneously cause LANDTEL	6.13051	10.1972	0.0000
LANDTEL does not homogeneously cause INTERNET	2.73257	1.18516	0.2360
MOBILETEL does not homogeneously cause LANDTEL	5.15944	7.62172	0.0000
LANDTEL does not homogeneously cause MOBILETEL	3.52090	3.27595	0.0011
MOBILETEL does not homogeneously cause INTERNET	4.45210	5.74570	0.0000
INTERNET does not homogeneously cause MOBILETEL	2.85925	1.52112	0.1282

Source: Author's computation (2023)

7.0 Conclusion and Recommendation

The purpose of this study was to empirically examine the impact of digitalisation on institutional quality in Africa. The study was inspired by the advancement of technologies, the rapid digitalisation across the globe, and the adoption and modernisation of economies through the use of digital technologies for the purpose of social and economic development. The study employed a panel data series of 46 African countries for the period spanning from 2000 to 2022. To empirically examine the interconnection between digitalisation and institutional quality, the study employed the Dumitrescu-Hurlin (DH) causality technique. In addition, the study employed various statistical, applied, and analytical techniques to study the digital and institutional quality on the continent. The study employed the principal component analysis (P.C.A.) technique to construct two indices that measures digitalisation and institutional quality.

The empirical findings revealed a mutual feedback between digitalisation and institutional quality, which indicates that digitalisation can improve the quality of institutions in Africa and that improved institution could facilitates an environment that fosters rapid digitalisation on the continent. The results from applied analysis indicated that countries with high institutional quality, such as the Seychelles, Mauritius, South Africa, and Botswana, are associated with high levels of digitalisation. On the other hand, countries such as Equatorial Guinea, Libya, and Tunisia have poor institutional quality and digitalisation levels.

From the evidence presented in this study, it is recommended that the telecommunications sector and institutions need overhauling concurrently because mutual feedback exists between them. That means to improve institutional quality in Africa, increased digital proliferation is required, and vice versa. In addition, the study recommends that African economies prioritise or intensify the liberalisation of the telecommunications sector to ensure the spread of digital penetration, which will have a spillover effect on the efficiency of institutions in Africa. In essence, African economies require a holistic approach to policymaking, which means that policies associated with digitalisation and institutional quality should be integrated within other social and economic policies.

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