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Infrastructure, institutions and economic growth in Sub-Saharan Africa: New evidence using the CS-ARDL approach

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Abstract
This study examined the interactive effect of infrastructure and quality of institutions on economic growth in Sub-Saharan Africa over the period 1996 and 2020 using the Cross-Sectional-Autoregressive Distributed Lag estimator. This was with a view to providing additional macroeconomic evidence that is specific to the SSA region on the response of economic growth to infrastructure development contingent on the quality of the underlying institutions. Annual data on variables such as real Gross Domestic Product (GDP) per capita, fixed telephone subscriptions, mobile cellular subscriptions, electric power consumption, improved water source, improved sanitation facilities, gross capital formation per capita, labour force, urbanisation ratio, land area and population density were obtained from the World Bank Development Indicators (WDI) of the World Bank, 2021 edition. Also, data on institutional quality variables, namely, control of corruption, government effectiveness, political stability and absence of violence/terrorism, regulatory quality, rule of law, as well as voice and accountability were sourced from the World Governance Indicators (WDI) also of the World Bank, 2021 edition. Results showed that the per capita convergence holds true for countries in SSA in the long run, while it does not hold in the short run. The findings also revealed that infrastructure does not independently lead to economic growth in SSA when the role of institutions is not considered. This implies that any improvement in the stock of infrastructure will promote growth only when it is complemented with strong institutions. The study concluded that countries with weak institutions do not benefit maximally from infrastructure development policies as weak institutions constrain the efficient use of infrastructure assets.

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1. Introduction

In the last one and half decades, the literature on the nexus between infrastructure and growth in developing countries in general and in Sub-Saharan African (SSA) countries in particular has shifted to the investigation of the factors that moderate the nexus. This is because efforts at scaling up the stock of infrastructure in these economies have not really translated to the much desired growth. This experience of developing countries in terms of the growth effect of infrastructure, however, contradicts that of a country like China. The Chinese economy has been able to record significant growth in the last two decades due to massive investment in infrastructure, among other factors. This contradiction has, therefore, prompted scholars to search for factors which are responsible for the differences in the effects among countries. One of the factors that have been touted to be capable of causing the differences in the returns to infrastructure is institutional quality.

The fact that the infrastructure-growth link is moderated by the quality of institutions has been established in both the theoretical and empirical literature.

In the theoretical literature, scholars have argued that, based on their quality, institutional indicators will either limit or enhance the efficient use of infrastructure. For example, Hall, Sobel and Crowley (2010) [17] argued that countries with well-developed institutions, which do not encourage unproductive activities, tend to experience growth when they increase their capital stock. Conversely, investing in infrastructure in countries where corruption, rent seeking and other unproductive activities are prevalent may lead to zero if not negative growth rates. Also, Agénor and Montiel (2010) [1] posited that devoting resources to infrastructure development is a necessary but not sufficient condition for boosting economic growth. The authors underscored the importance of strong institutions which play the role of catalyst in the efficiency of capital. Furthermore, Wu, Tang and Lin (2010) [44] have attributed the efficacy of government spending on growth to the institutional quality of the country in question. They argued that in low-income countries, which are usually characterised by poor institutions, government expenditures have the tendency to retard growth or become ineffective. While also supporting this line of thought, Dabla-Norris *et al*. (2012) [8] argued that embarking on considerable infrastructure development in an environment characterised by weak institutions has the tendency of potentially undermining its growth benefits.

In SSA in particular, many countries are plagued by poor maintenance of existing facilities, coupled with wanton vandalisation and destruction of infrastructure facilities as a result of high rates of corruption and terrorism. The estimates arrived at by Gulati and Rao (2006) [16] on the cost of corruption in infrastructure suggest that between 5% and 20% of construction costs are being lost to bribe payments, while as much as between 20% and 30% of electric power is being stolen by consumers who collude with staff. Using investment and maintenance estimates from Fay and Yepes (2003) [13], Kenny (2009) [18] found that the financial burden may sum up to around US$18 billion annually in low-income countries if as much as 5% of expenditure and maintenance outlays in infrastructure are lost to institutional failure. What this suggests is that "better infrastructure (that is, infrastructure development embedded within a sound institutional framework), more growth" is a more accurate proposition than "more infrastructure, more growth". Hence, investigating the relationship between infrastructure and growth without paying attention to how institutional factors contribute to this relationship as a complementary factor may lead to seriously misleading inferences.

Although many studies acknowledge the high a priori probability that the linear relationship between infrastructure and economic growth is moderated by institutions, only a few have subjected this hypothesis to empirical testing in both the developed and developing countries. Studies that have been conducted to address this gap in SSA include Damijan and Padilla (2014) [9], Esfahani and Ramirez (2003) [11], Garlick (2008) [14], Kodongo and Ojah (2016) [19], as well as Okoh and Ebi (2013) [30]. These studies suffer two serious limitations, one of which is their inability to capture recent changes in the trend of infrastructure in particular, especially in the last decade. The other one concerns the methodology used by these studies, especially the few that employed panel data estimation techniques. For example, the System Generalised Method of Moments (GMM) adopted by Kodongo and Ojah (2016) [19] has been criticised on the ground of its inability to capture cross-section dependence and slope parameter homogeneity (Amin *et al*., 2022; Chudik & Pesaran, 2015; Sarafidis *et al*., 2008; Saygin & Iskenderoglu, 2022) [2, 6, 38]. To correct this second limitation, scholars have suggested the use of the Cross-Sectional-Autoregressive Distributed Lag (CS-ARDL) estimator. Another important advantage of CS-ARDL is its ability to yield robust estimates even when available dataset is relatively small (Amin *et al*., 2022) [2].

Hence, this study was conducted to investigate the role of institutions in the infrastructure-growth relationship in SSA over the period 1996 to 2020 using the CS-ARDL approach.

2. Literature Review

This section reviews the literature on the relationship between infrastructure and economic growth, while paying particular attention to the role of institutions, in line with the belief among economists and other stakeholders in recent years that "institutions matter".

2.1 Theoretical Review

Available theories regarding the economic impact of infrastructure can be reviewed from three fields based on the different analytical approaches: traditional approach, endogenous growth approach, and the new institutional economics.

A) Traditional Theory

The traditional neoclassical growth theory, which is largely due to the work of Solow (1956) [40], assumes that capital has diminishing returns. This leads to the condition that there is an inverse relationship between per capita income growths of countries and their initial income levels. If economies are similar in the sense of preferences and technology, countries that are poor in the level of capital grow faster than capital rich countries (Olson, Sarna & Swamy, 2000) [31]. In this model, technology is assumed to be exogenously given. Thus taking the saving and population growth rates as constant, the model predicts that countries would tend to converge into similar steady state level. Diminishing returns to physical capital is thus a force that allows countries to converge into income equability when they reach similar steady states level (Barro *et al*., 1991; Barro & Sala-i-Martin, 1992) [5, 4].

Despite its ability to explain international differences as a result of conditional convergence, the neoclassical model cannot however explain why the income gap between rich and poor countries is still widening (Mankiw, 1995) [21]. Beside this, there is no room for public decisions to have long-term effects on the economy since exogenous technical progress is the sole determinant of long-run growth in traditional neoclassical growth models (Getachew, 2009) [15]. A policy shock will have a transitory effect, influencing the level of (long-run) output only. Thus, an economy's institutions and infrastructure development, among others, will have no lasting effect on its output. By and large, economic agents are assumed to operate almost in a vacuum. However, the developments in post-independence Africa told a different story. Economic growth at that time was disappointing. Many of the economies were growing very slowly and some were even retrogressing. The problem then was not attributed to resource constraint but was linked to poor policies. Most countries had implemented a "government led" development paradigm that restricted

private sector development. Heavy intervention in the economy in the form of government production, control of prices and exchange rates, over-regulation of the economy and the adoption of import substitution strategies that included severe import controls and foreign exchange rationing inhibited economic growth.

B) Endogenous Growth Theory

Due to the less convincing empirical relevance of the neoclassical model, subsequent researches took a more radical approach to the study of economic growth. The goal of this approach, known as "endogenous growth theory", is to develop models of persistent growth that give up the assumption of exogenous technological change (Mankiw, 1995; Weil, 2005) [21, 42]. The approach embraces diverse body of theoretical and empirical works that emerged in the 1980s, following the path pioneered by Arrow (1962) [3]. Notable contributions include, among others, Romer (1986) [36], Lucas (1988) [20] and Robelo (1991) [36].

Instead of diminishing returns to capital, endogenous growth theory assumes constant returns to capital, i.e., doubling capital would double output. Technological change is assumed endogenous. As a result of the assumption of constant returns to capital, endogenous growth model predicts the gap between rich and poor countries remaining the same or even widening (Lucas, 1988; Mankiw, Romer & Weil, 1992) [20, 22]. The main contribution of the theory of endogenous growth as far as the advancement of economic growth is concerned, according to Fanta (2011) [12], is that it helps in explaining the existence of worldwide technological process, which is assumed to be exogenous by the neoclassical model. In this context, infrastructure is seen to affect productivity and aggregate output through direct and indirect channels.

This important contribution to knowledge notwithstanding, endogenous growth model has succeeded little in explaining cross-country income differences because growth is a complex phenomenon which cannot be explained by the theory of the creation of technology alone (Mankiw, 1995) [21]. Although policy reforms yielded some gains in terms of economic growth, these gains were small and far apart. Of particular concern was that for the majority of countries, the instituted reforms had serious adverse impacts on the wellbeing of the majority of the citizens. Poverty rates tended to increase and also the policies magnified inequalities in the distribution of income. As a result, there were frequent policy reversals resulting in stagnation. In some cases, dissatisfied citizens engaged in violent protests and in others, poor economic outcomes and the increasing inequality were used to justify military takeovers. Evidently, many of the policies instituted were not sustainable. Through the 1980s, most countries in SSA regressed in many of the dimensions of welfare.

C) New Institutional Economics

Following the seminal works of North and Thomas (1973) [27], Williamson (1985) [43], Matthews (1986) [23], and North (1990) [26], economists have emphasized the instrumentality of strong institutions to growth (Fanta, 2011) [12]. This is as a result of an expanding argument about the inability of markets alone to ensure economic efficiency. While earlier works on growth take the existence of institutions as given, more recent works showed the flaw in such approach. In particular, the failure of both the neoclassical and endogenous growth models to address the remarkable fact of the contemporary cross-country growth disparities led a large number of scholars to seek for other fundamental factors that are necessary in explaining economic growth and cross-country income disparities. Towards this end, economists incrementally advanced the notion that, in addition to government policies, high institutional quality is required to bring about higher economic growth.

The phrase "New Institutional Economics (NIE)" was coined by Williamson (1985) [43] in order to distinguish it from the "old institutional economics" which was pioneered by Veblen (1899) [41] and Commons (1934) [7]. Although the old institutional school regarded institutions as a key factor in defining and determining economic performance, but it had little analytical rigour and lacked theoretical framework as a school of thought. Its operation was outside of neoclassical economics and deriving reliable generalization or making sound policy choices was impossible because there was no quantitative theory for doing so. Unlike neoclassical economics, a striking feature of the theory is that the institutional framework is not assumed to be exogenous. Instead, it is clearly treated as an object of research such that the way and manner any given institutional arrangements affect economic behaviour is accorded due consideration (Richter, 2005) [35].

This new thinking in economics believes that the cost of transacting, which is determined by institutions and institutional arrangements, is critical to economic behaviour. It is therefore posited that a country's institutions, such as its legal, political, and social systems, define its economic performance. The proponents of NIE argue for the need to put in place regulatory mechanisms and other institutional frameworks in addition to substantive policies so that the efficient operation and functioning of the "hard" component can be facilitated. The bottom line of this argument is that it is the responsibility of the government to put in place appropriate institutions that allow the positive effects of infrastructure development to reflect on the country's economic performance. This emphasises the proposition that, while it is true that inputs and good policy are important components of the economic growth process, it is largely the quality of institutions that determines wealth accumulation.

2.2 Brief Empirical Review

The failure of the traditional economic analysis on the growth effect of infrastructure to capture the mediating role of institutions in the relationship led to the emergence of a new strand. This strand of the literature is preoccupied with the need to assess the extent to which institutions affect the relationship between the two variables. Studies in this category can be broadly divided into two based on their modelling of the relationship. The first category assumes a linear or symmetric relationship, while the second one assumes a non-linear or asymmetric relationship. The focus of this study is, however, limited to the first category of studies whose analysis is based on the use of a linear interaction model. The model is made up of a linear interaction term between infrastructure and institutions.

One of the studies in the first category in the context of countries in SSA is Esfahani and Ramirez (2003) [11]. The study examined the role of institutional factors in shaping the growth effects of infrastructure in 75 countries out of which 19 are from SSA between 1965 and 1995. Using instrumental variable (IV)/two stage least squares (2SLS) technique, the

results showed significant growth effects of infrastructure in the data set in which the contribution of infrastructure is affected by institutional factors. Also, Garlick (2008) [14] investigated the relationship among infrastructure, output and institutional quality in South Africa using time series data over the period 1960-2006. Results of their univariate cointegrating autoregressive distributed lag (ARDL) and multivariate cointegrating vector error correction model (VECM) estimations revealed that institutions are an important factor in the infrastructure-output nexus, although the exact form of this relationship is not clear.

In addition, Okoh and Ebi (2013) [30] examined the effect of the interaction of infrastructure investment and institutional quality in Nigeria using the pair-wise Granger causality approach. Findings revealed that the effects of the interaction between infrastructure investment and institutional quality on economic growth are insignificant. Furthermore, Damijan and Padilla (2014) [9] investigated the impact of various types of infrastructure investment on Gross Domestic Product (GDP) per capita growth conditional on institutional advancement and foreign co-financing. The study used panel data on Egypt, Morocco, Tunisia, Namibia and South Africa for the period 1990-2010 as well as the fixed effects approach. Results showed that infrastructure projects are long-term sustainable in a less corrupt environment. Finally, Kodongo and Ojah (2016) [19] assessed whether infrastructure availability and quality act through the mediating effects of institutions to impact economic growth for a panel of 45 SSA countries from 2000 to 2011. Using the system GMM, the study found that a largely insignificant effect of infrastructure access and quality on economic growth due to Africa's relatively low institutional quality which has made infrastructure less effective as a growth catalyst.

Some important points can be drawn from the brief empirical review above. One, existing empirical evidence on the role of institutions in mediating the effect of infrastructure on the growth of SSA countries is not conclusive. Two, the existing studies did not capture the recent changes in the trend of infrastructure in the selected countries. Finally, the system GMM technique employed by Kodongo and Ojah (2016) [19], whose analysis is close to the one done by this current study, has some limitations. The System GMM lacks the capacity to to capture cross-section dependence and slope parameter homogeneity (Amin *et al*., 2022; Chudik & Pesaran, 2015; Sarafidis *et al*., 2008; Saygin & Iskenderoglu, 2022) [2, 6, 38]. To correct this second limitation, scholars have suggested the use of the Cross-Sectional-Autoregressive Distributed Lag (CS-ARDL) estimator. Another important advantage of CS-ARDL is its ability to yield robust estimates even when available dataset is relatively small (Amin *et al*., 2022) [2]. This current study was therefore conducted to address the limitations in the existing empirical literature in the context of countries in SSA.

3. Methodology

This section presents the methodology that is employed to achieve the objectives of the study. Specifically, it presents the theoretical framework, estimating model, techniques of analysis, as well as measurements and sources of data.

3.1 Theoretical Framework

The theoretical basis for the analysis adopted in this study is the New Institutional Economics hypothesis. This view regards institutions as "soft" infrastructure, i.e., regulatory mechanisms and other institutional frameworks that must be put in place to facilitate the efficient operation and functioning of the "hard" component. In countries with good institutions, investments in infrastructure are both privately beneficial to individuals and also create a positive return for society as a whole. In countries with poor institutions, however, the higher returns to investments in rent-seeking activities that plunder the wealth of others, through lobbying and lawsuit abuse, for example—draw significant resources into these privately beneficial, but socially unproductive activities.

In the absence of strong institutions, the link between infrastructure spending and growth is weakened by evidence of low efficiency of public investment, and where a high degree of inefficiency and/or waste, often distorts the impact of infrastructure investment, leading to poorly executed and/or ineffective projects. The prevalence of corruption in such a setting reduces the quality of infrastructure investment and its economic benefits, in addition to raising the cost of infrastructure. Awarding public procurement contracts within the context of a corrupt system may lead to inferior public infrastructure and services. This is because when the government official saddled with the responsibility of monitoring infrastructure projects is corrupt, he or she may allow the use of substandard materials. In weak government quality conditions, therefore, new investment in infrastructure may respond more to political and individual interests than to economic and collective ones.

Weak institutions will not only reduce the rate of return to new investment in infrastructure, but will also affect the rate of return to existing stock. A common phenomenon in developing countries where governments are ineffective is the poor condition of existing infrastructure (roads with potholes, water and sanitation facilities in bad state, buildings in need of serious repairs, etc.). More often than not, new projects are undertaken while the existing ones are abandoned to deteriorate as a result of poor maintenance culture. Also, in cases of very high incidence of corruption, operation and maintenance on the physical infrastructure may be purposely reduced so that some infrastructures may deteriorate quickly to the point that they will need to be built again, thus affording some high-level officials the opportunity of collecting commission from the enterprise that will handle the project. By and large, we have a situation in which the deterioration in the existing infrastructure retards growth more than the rate at which the new ones add to it.

From the NIE perspective, therefore, modelling the growth effects of infrastructure without incorporating the quality of institutions will yield inconsistent results. Hence, the analysis in this study is based on the assumption that the quality of institutions affects output through the effect that institutions have on the productivity of infrastructure. This is opposed to the usual practice of implicitly assuming an underlying set of good institutions. The proposition that emanates from the position adopted is that countries with strong institutions benefit more from infrastructure development policies as strong institutions enhance the efficient use of infrastructure assets.

3.2 Model Specification

The linear interactive model that is adopted for the analysis carried out in this study is specified as follows:

$$\ln y_{it} = \delta_0 + \delta_1 \ln y_{it-1} + \delta_2 \ln k_{it} + \delta_3 (q * \ln k)_{it} + \delta_4 \ln x_{it} + \delta_5 (q * \ln x)_{it} + \delta_6 q_{it} + \varepsilon_{it} \quad (1)$$

where $\ln$ denotes natural logarithm, y is real GDP per worker, y_{t-1} is lagged real GDP per worker, k is physical capital per worker, x is infrastructure per worker, q is institutional quality, $(q * \ln k)$ is the interaction term between institutional quality and physical capital, $(q * \ln x)$ is the interaction term between institutional quality and physical capital, ε the disturbance term is assumed to have two orthogonal components: the fixed effects, μ_i, and the idiosyncratic shocks, v, i denotes country, while t is time series observation.

In equation (1), emphasis is on the statistical significance of the interaction coefficient δ_5. Depending on its sign, it can be inferred whether infrastructure and institutions are complements or substitutes in the growth process. A negative coefficient will indicate that infrastructure development is more effective in boosting economic growth in countries with weak institutions (Effiong, 2015) [10]. In other words, a negative interaction (i.e. $\delta_5 < 0$) provides evidence of substitutability between infrastructure and institutions. On the other hand, a positive interaction (i.e. $\delta_5 > 0$) would imply that the growth effects of infrastructure are enhanced in a strong institutional environment, thus supporting the complementarity of infrastructure and institutions.

3.3 Technique of Data Analysis

The main objective of this study is to examine the interactive influence of infrastructure and institutions on economic growth in SSA. This objective is achieved by estimating equation (1) using the CS-ARDL in view of its strength over other panel data estimators especially the System GMM. However, the validity of the CS-ARDL depends on the existence of cross-sectional dependence and slope parameter heterogeneity (Saygın & Iskenderoglu, 2022) [39]. In view of this, the study tested the two conditions to confirm the validity and reliability of the estimates obtained from the empirical analysis.

3.4 Definitions of Variables and Sources of Data

The data employed in this study is a panel of forty-one (41) SSA countries over the period 1996-2020. The list of the selected countries is presented in the appendix section. Details of the measurement of variables and sources of data used for analysis are shown in Table 1. The table shows that economic growth, which is the dependent variable, is measured using real GDP per capita. Gross capital formation is employed to measure investment in physical capital. Physical measures of infrastructure rather than monetary ones are used. Due to data availability, the study considered four out of the five infrastructure sub-sectors (telecommunications, electric power, clean water and improved sanitation). Using the Principal Component Analysis (PCA) method, the four sub-sectors are built into a synthetic index summarising different dimensions of infrastructure in line with Badalyan *et al* (2015), Calderón *et al*. (2015) as well as Chakamera and Alagidede (2017).

Following Kurul (2017), Helliwell, Huang, Grover, and Wang (2018), Seth (2018), as well as and Sondermann (2018), institutional quality was measured using the indicators developed by Kaufmann, Kraay and Mastruzzi (2010). The three authors have provided measures of national institutional environments through their work on the World Bank's Worldwide Governance Indicators (WGI). The WGI have lately become one of the most commonly used indicators of governance or institutional quality in empirical studies undertaken by academics as well as policymakers. The WGI dataset summarizes six dimensions of institutional quality or governance as follows: Voice and Accountability (VAC), Political Stability and Absence of Violence/Terrorism (PSV), Government Effectiveness (GEF), Regulatory Quality (RQL), Rule of Law (ROL), as well as Control of Corruption (COC). The scores range between −2.5 and +2.5. The classification by Omilola and Akanbi (2014) is adopted in order to categorise institutional quality at different levels. For the purpose of analysis, the study used an indicator of the overall quality of institutions by combining all six dimensions into a single index using the PCA method.

Table 1: Definition of Variables and Sources of Data

Variable	Identifier	Definition	Source
Gross Domestic Product (GDP)	y_{it}	Real GDP per capita (constant 2010 US$) and is expressed in logarithmic form	WDI, 2021
Initial real GDP	y_{it-1}	Real GDP per capita from previous period (constant 2010 US$) and is in logarithmic form	WDI, 2021
Index of Infrastructure Stock	x_{it}	Constructed as the principal component of fixed telephone subscriptions or main lines (per 100 inhabitants), mobile cellular subscriptions or mobile phones (per 100 people), electric power consumption (kWh per capita), improved water source (% of population with access) and improved sanitation facilities (% of population with access)	Author's Computation
Fixed Telephone Subscriptions	FTS	These refer to the sum of active number of analogue fixed telephone lines, voice-over-IP (VoIP) subscriptions, fixed wireless local loop (WLL) subscriptions, ISDN voice-channel equivalents and fixed public payphones. Measurement is per 100 inhabitants and is expressed in logarithmic form	WDI, 2021
Mobile Cellular Subscriptions	MCS	These measure subscriptions to a public mobile telephone service that provide access to the PSTN using cellular technology. Measurement is per 100 people and is expressed in logarithmic form	WDI, 2021
Electric Power Consumption	EPC	This measures the production of power plants and combined heat and power plants less transmission, distribution, and transformation losses and own use by heat and power plants. Measurement is in kWh per capita and is expressed in logarithmic form	WDI, 2021
Improved Water Source	IWS	Access to an improved water source refers to the percentage of the population using an improved drinking water source. Measurement is % of population with access and is	WDI, 2021

		expressed in logarithmic form	
Improved Sanitation Facilities	ISF	Access to improved sanitation facilities refers to the percentage of the population using improved sanitation facilities. Measurement is % of population with access and is expressed in logarithmic form	WDI, 2021
Index of Institutional Quality	q_{it}	Computed as the log of the principal component of control of corruption, government effectiveness, political stability and absence of violence/terrorism, regulatory quality, rule of law, and voice and accountability	Author's Computation
Control of Corruption	COC	This captures perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests	WGI, 2021
Government Effectiveness	GEF	This captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies	WGI, 2021
Political Stability and Absence of Violence/Terrorism	PSV	This measures perceptions of the likelihood of political instability and/or politically-motivated violence, including terrorism	WGI, 2021
Regulatory Quality	RQL	This indicator captures perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development	WGI, 2021
Rule of Law	ROL	This measure captures perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence	WGI, 2021
Voice and Accountability	VAC	This measure captures perceptions of the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media.	WGI, 2021
Physical Capital	PCP	Gross capital formation per capita (constant 2010 US$) and expressed in logarithmic form	WGI, 2021
Labour Force	LAB	Total Labour Force	WDI, 2021
Urbanization Ratio	UBR	Percentage of urban population in the total	WDI, 2021
Land Area	LAR	Land area in sq. km.	WDI, 2021
Population Density	POD	People per sq. km of land area	WDI, 2021

Notes: WDI denotes World Development Indicators, while WGI denotes World Governance Indicators.

4. Results and Discussion

This section presents empirical evidence, by means of statistical and econometric analysis, on the interactive influence of infrastructure and quality of institutions on growth.

4.1 Descriptive Statistics of Data

Before proceeding to the econometric analysis, this study examined the descriptive statistics of the main data used for analysis. This is necessary as it provides information on the characteristics of the variables used in the study and hence, the credibility and quality of the data. Table 2 displays the descriptive statistics of the main variables used in the analysis.

From the table, it is observed that all the mean and median values are positive except for the index of infrastructure stock. The table reports that while the average real GDP per capita is US$2,303.45, the median real GDP per capita is US$930.57. This means that half the countries recorded real GDP per capita less than US$945.82 and half recorded more. However, mean GDP is significantly higher than the median GDP and so, most of the countries recorded less than the average. The same also goes for each of initial real GDP per capita, physical capital as well as the index of infrastructure stock. The index of institutional quality is the only variable that has a mean value that is very close to the median value. This is a characteristic of right skewed distributions. The mean value of the infrastructure index (-0.335328) is similar to the ones obtained by Ogbaro (2019) [28] as well as Ogbaro and Oladeji (2021) [29].

The summary statistics of the index of institutional quality is very close to the one obtained by Ogbaro (2019) [28]. On a scale of 0 (lowest) to 100 (highest), the study reported weak institutional quality with an average score of 39. This study recorded a mean of 0.38 (38 on a scale of 0 to 100) which still suggests weak institutional quality across the region.

The results of the skewness statistic show that real GDP per capita, initial real GDP per capita, physical capital and index of institutional quality are positively skewed (their skewness values been greater than zero). On the other hand, the index of infrastructure stock is negatively skewed (its skewness value been greater than zero).

Results of the kurtosis statistic show that while real GDP per capita, initial real GDP per capita and physical capital are leptokurtic, the indices of infrastructure stock and institutional quality are platykurtic.

As for the Jarque-Bera test statistic, the results in Table 2 reveal that the calculated probability values of the statistic for all the variables except index of infrastructure stock are less than the 5% significance level which suggests the rejection of the null hypothesis of a normal distribution for the variables.

Table 2: Descriptive Statistics

	GDPPC	LAGGDPPC	PCP	INF	IIQ
Mean	2303.452	2175.885	797.9548	-0.335328	0.373395
Median	945.817	911.2192	173.9937	-0.280144	0.372747
Maximum	21443.98	21276.51	18123.49	2.942351	0.561594
Minimum	197.7725	170.5817	3.123834	-5.767763	0.154917
Standard Deviation	3262.968	3215.426	1831.973	1.632676	0.104179
Skewness	2.711868	2.668671	4.381622	-0.159120	0.352229
Kurtosis	11.59217	11.28744	25.79509	2.863532	2.6749489
Jarque-Bera (p-value)	0.000000	0.000000	0.000000	0.162752	0.000108
Observations	1025	1025	1025	1025	1025

***Source*:** Author's computations (2022) based on WDI and WGI of the World Bank (2021).
Notes: GDPPC represents real GDP per capita; LAGGDPPC represents real GDP per capita from previous period; PCP represents physical capital per capita; INF represents index of infrastructure stock; and IIQ represents index of institutional quality.

4.2 Cross-Sectional Dependence, Heterogeneity and Order of Integration

Prior to estimating equation (1) using the CS-ARDL estimator, this study carried out some important tests for the purpose of obtaining estimates that are reliable. The first among these tests is the cross-section dependence (CD) test, which also helps to choose the unit root test that is appropriate for determining the orders of integration of the series used for analysis. In lie with extant studies such as Nathaniel (2021), the CD tests proposed by Pesaran (2004) was employed for this purpose. The results of the test, which are reported in Table 3, show the existence of cross-sectional dependence in each series.

Table 3: Cross-Sectional Dependence Test Results

Variable	Breusch–Pagan LM	Pesaran scaled LM	Pesaran CD
lnGDPPC	559.8701***	50.4327***	20.5748***
lnLAGGDPPC	474.0912***	41.8361***	16.9754***
lnPCP	855.8923***	70.5290***	7.8934***
lnINF	1421.6267***	122.6984***	35.4512***
IIQ	505.6634***	67.9523***	24.9030***

***Source*:** Authors' computations (2022) based on WDI and WGI of the World Bank (2021).
Notes: ln denotes natural logarithm, GDPPC represents real GDP per capita; LAGGDPPC represents real GDP per capita from previous period; PCP represents physical capital per capita; INF represents index of infrastructure stock; and IIQ represents index of institutional quality. *** denotes statistical significance at 1%.

The second test is the homogeneity test which is required for determining the appropriate unit roots and cointegration estimator. Following Sanyin and Indes (2022), the Delta Test proposed by Pesaran and Yamagata (2008) was employed for this purpose. The results of the test, which are presented in Table 4, show that economic growth is homogenous among the selected countries.

Table 4: Delta Test for Slope Heterogeneity

	Coefficient	p -value
Δ	1.768	0.127
Δ adj.	1.8562	0.116
Δ (HAC)	-1.372	0.193
Δ adj.	-1.438	0.188

***Source*:** Authors' computations (2022)

The third test is the panel unit roots test which was conducted to investigate the stationarity of homogenous panel series under cross-sectional dependence. Based on the results in Table 3, the Cross-Sectional Augmented Im–Pesaran–Shin (CIPS) test proposed by Pesaran (2007) was employed for this purpose. The results of the test in Table 5 shows that the variables are of mixed orders, i.e., they are integrated of orders zero and one. Thus, these results as well as the findings of the presence of CD and homogeneity tests confirm that the CS-ARDL approach is the appropriate tool for estimating equation (1).

Table 5: Panel Unit Roots Test Results

Variable	CIPS (Level)	CIPS (1st Difference)
lnGDPPC	-1.489	-5.327***
lnLAGGDPPC	0.091	7.318***
lnPCP	1.539	5.184***
lnINF	2.103**	-
IIQ	1.047	10.824***

***Source*:** Authors' computations (2022) based on WDI and WGI of the World Bank (2021).
Notes: ln denotes natural logarithm, GDPPC represents real GDP per capita; LAGGDPPC represents real GDP per capita from previous period; PCP represents physical capital per capita; INF represents index of infrastructure stock; and IIQ represents index of institutional quality. *** and ** denote statistical significance at 1% and 5% levels, respectively.

4.3 Interactive Influence of Infrastructure and Institutions on Growth

Table 6 presents the results obtained from the estimation of equation (1) using the CS-ARDL estimator. The table shows that the error correction term (ECT) is negative and significant. This implies that the system returns to equilibrium in case of a shock that causes a disequilibrium. It also implies that a stable cointegrating relationship exists among the variables in the long-run. More specifically, the coefficient implies that the short-run speed of adjustment towards the long-run equilibrium is 67.2% per year, which is equivalent to about one and half years.

The coefficient of *LAGGDPPC* is negative and significant in the long run, implying that per capita convergence holds true in SSA. This finding is consistent with the prediction of Mankiw *et al*. (1992) [22] that the SSA region will form a homogenous set of countries in many respects particularly in the long run. In contrast, the coefficient of the series is positive and significant in the short run, implying that per capita convergence does not hold in SSA. This finding is not surprising because, contrary to the prediction of Mankiw *et al*. (1992) [22], the SSA does not form a homogenous set of countries in many respects. Countries in the region vary

strongly in terms of natural endowments, educational system, macroeconomic targets, population structure, political administration etc. All these factors tend to affect their per capita income growth. As a result, the convergence hypothesis as predicted by Mankiw *et al*. (1992) [22] may not apply to SSA in the short run. Overall, these findings indicate that, while countries in SSA can show individual differences in the short run, they tend to converge to form a bloc in the long run.

The coefficients of $\ln PCP$ and $IIQ*\ln PCP$ are positive and negative, respectively and significant in the long run. This implies that physical capital exerts a positive effect on growth, but institutional quality acts as a drag that leaks out the growth benefits of capital on growth. In contrast, the coefficients of the two series are both negative and weakly significant in the short run. This implies that physical capital constitutes a drag to the growth process, while institutional framework aggravates this negative effect. These results are not surprising given that only better institutions increase the contribution of physical capital to output. Hall *et al*. (2010) [17] explained that increases in capital retard growth in countries characterised by weak institutions because additions to the capital stock tend to be devoted to rent-seeking and other activities that are not socially productive. In countries where such behaviour is not constrained by institutional frameworks, there exists the possibility of rendering fixed capital formation an unreliable determinant of growth. For instance, the prevalence of corruption may bias commercial and public sector decision-making processes, leading to investment decisions that are relatively unproductive.

The coefficients of $\ln INF$ and $IIQ*\ln INF$ are both positive, but only the latter is significant in the long run. This implies that infrastructure has no significant effect on growth, and institutional quality lacks the necessary stimulus to make it significant. Similarly, the two series are positive, and only the latter is significant in the short run. This means that institutions and infrastructure are complements and any improvement in the stock of infrastructure will promote institutional quality and vice versa. As a result of this, one can say that infrastructure is as important in explaining per-capita and growth differentials as institutions.

The coefficient of institutional quality is positive in both the long and short run, and the effect is significant in the short run only. This implies that the variable does not affect growth in the long run. Rather, the effect of institutions on output in the long run is entirely captured by its effect on the productivity of infrastructure.

Table 6: CS-ARDL Estimation Results

Variable	Breusch–Pagan LM
Long-Run Result:	
lnLAGGDPPC	-0.995** (0.003)
lnPCP	0.023** (0.006)
IIQ*lnPCP	-0.063** (0.011)
lnINF	0.106 (0.026)
IIQ*lnINF	0.244** (0.055)
IIQ	0.004 (0.029)
Short-Run Results:	
lnLAGGDPPC	0.991** (0.005)
lnPCP	-0.082* (0.020)
IIQ*lnPCP	-0.182* (0.038)
lnINF	0.143 (0.061)
IIQ*lnINF	0.249** (0.124)
IIQ	0.286** (0.123)
Constant	0.148** (0.059)
ECT(-1)	-0.672***(-4.24)

***Source*:** Authors' computations (2022) based on WDI and WGI of the World Bank (2021)
Notes: ln denotes natural logarithm, GDPPC represents real GDP per capita; LAGGDPPC represents real GDP per capita from previous period; PCP represents physical capital per capita; INF represents index of infrastructure stock; and IIQ represents index of institutional quality. Figures in parenthesis represent robust standard errors. ***, ** and * denote statistical significance at 1%, 5% and 10% levels.

5. Conclusion

This study examined the interactive effect of infrastructure and quality of institutions on economic growth in SSA over the period 1996-2020. This was with a view to providing additional macroeconomic evidence that is specific to the SSA region on the response of economic growth to infrastructure contingent on the quality of the underlying institutions in the region. Results showed that infrastructure does not independently lead to economic growth in SSA when the role of institutions is not considered. The study therefore concludes that countries with weak institutions do not benefit maximally from infrastructure development policies as weak institutions constrain the efficient use of infrastructure assets.

The findings of this study show that achieving better outcomes in terms of the growth effect of infrastructure development requires institutional reforms that are more fundamental than simply designing infrastructure projects and spending money on them. Hence, this study recommends that strategies aimed at massive infrastructure development must be complemented by measures to improve the quality of institutions in the countries of the region. Specifically, governments in the region need to develop a set of policies that are focused on the improvement of institutional efficiency. This can be achieved by pursuing good governance through a more stable socio-economic and political environment, corrupt-free society, an effective public service, good regulatory environment, and a transparent leadership structure. Good governance should be allowed to rule over all other economic objectives.

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