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A CAUSAL ANALYSIS OF INFRASTRUCTURE DEVELOPMENT AND ECONOMIC GROWTH IN DEVELOPING ECONOMIES – A CASE STUDY OF SUB-SAHARAN AFRICAN COUNTRIES

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ABSTRACT

Although there has been a major oil price drop in some months now which signals a renewed breezes in the overall world economy, the sub-Sahara Africa economy is forecast to grow at a combined rate of 5% over the next few years. To sustain this level of growth, huge investments into infrastructure and sustainable power supply should to be made. Small levels of infrastructure and power supply are a limiting factor for many who want to invest across various sectors in sub-Sahara Africa. This study revealed that there is a great need to improve on infrastructure development in the sub-Sahara African region, especially in the area of power supply, transportation and information communication and technology (ICTs), owing to the fact that there is a causality relationship between electricity consumption and economic growth in the region.

KEYWORDS: *Infrastructure development, economic growth, developing economies and sub-Sahara Africa*

1. INTRODUCTION

Infrastructure is one of the pillars of economic change in an economy. Justifiable economic growth normally happens in an environment where there is a significant infrastructure development. Nations that have developed their infrastructure will always record higher and better quality of economic growth and development than those that have failed to do so. When the economy is developed infrastructure wise, people tend to participate in and share the benefits of wider economic growth. The impact of infrastructure on growth in scientific literature is analysed from theoretical and empirical points of view and there is variety of concepts and models. Despite popular issue, there is dearth of researches about impact of infrastructure on the growth of sub-Sahara African countries.

Infrastructure plays a great role in both households and organization, which enhances investment decisions. It availability and readiness helps countries and regions of the world to integrate rapidly. For some decades now, sub-Saharan Africa suffers from a noticeable infrastructure dearth especially when they are compared with countries in other regions. These paucities have inhibited gains in domestic productivity and present a critical bottleneck to more regional economic growth and development. Estache and Vagliasindi (2007) argue that an insufficient power generation capacity limits growth in Ghana. Lumbila (2005) finds that deficient infrastructure may hinder the growth impact of foreign direct investment into Africa.

It is a known fact that inadequate infrastructure has contributed in high transaction costs of business in most sub-Saharan African economies. Today, African countries exhibit the lowest levels of productivity of all low-income countries and are among the least competitive economies in the world; it has been estimated to shave off at least 2 percent of Africa's annual growth (Calderon, 2008). If there is adequate infrastructure, African firms could achieve productivity gains of up to 40 percent (AfDB, 2010 - 2013). For there to be a sustainable growth in sub-Saharan Africa, there is every need that government of the region should make a conceited effort in developing feeder roads and transmission line that connect rural communities to national grids. This will enhance free flow of movement to enable individuals, households, rural communities and businesses alike to embark on income generating activities in the region.

Unreliable, insufficient and costly infrastructure across the African continent has arguably been the damaging weakness to higher and more inclusive growth and socio-economic development of the region. The level of Infrastructure stock have hampered rather than assisted growth and development. For Sub-Saharan Africa (SSA) to develop and industrialise in a viable manner, there is a need to address the challenge of infrastructure in the region. Therefore, this paper seeks to examine the relationship between infrastructure development and economic growth in sub-Saharan Africa. We will concentrate our work on these variables, energy, transportation, water and ICTs as they relate with economic growth which will be proxied by gross domestic product, GDP. Some statistical methods; ordinary least squares, unit root, cointegration and the granger causality test were used to test for correlation and direction of causality. Secondary data was sourced from World Bank development index, for a period covering 1990 to 2014. The paper has five sections, section one is our introduction; two, review of related literature; three, methodology; four, discussion of result; while section five concludes the work.

2. EMPIRICAL AND THEORETICAL REVIEW OF RELATED LITERATURE

The role of infrastructure for economic growth and development has been well documented in the literature (Aschauer, 1989; Munnell, 1990; World Bank, 1994; Calderon and Serven, 2003; Estache, 2006; Sahoo and Dash; 2008; 2009). Various reaserch on the role of infrastructure play in economic growth emanated after the seminal work by Aschauer (1989), he argued that public expenditure is quite productive, and the slowdown of the U.S productivity was related to the decrease in public infrastructure investment. Subsequently Munnell (1990), Garcia-Mila and McGuire (1992), Uchimura and Gao (1993), found high output elasticity of public infrastructure investment though comparatively lower than Aschauer.

Some other authors criticized this study, for example, Sturm et al. (1998), who showed that the literature review of the work contained a comparatively wide array of estimates of output elasticity of public investment in infrastructure viz., with a marginal product of public capital that is much higher than that of private capital (Aschauer, 1989; Khan and Reinhart 1990); roughly equal to that of private capital (Munnell, 1990); well below that of private capital (Eberts, 1986); and negative contribution of public investment (Hulten and Schwab 1991, Deverajan, Swaroop and Zou, 1996 and Prichett, 1996).

Additional focus in the literature is on optimal and efficient use of infrastructure for economic growth. Hulten (1997) and Canning and Pedroni (2004) stress that there is an optimal level of infrastructure maximizing the growth rate and anything above would sidetrack investment from a more productive resources, which result in total reduction in growth. The wide range of estimates make the results of these studies almost irrelevant from a policy perspective However, the study by Romp and De Haan (2007) which summarizes earlier studies and suggests that public capital may, under specific circumstances, raise income per capita in general. Although growth-enhancing impact of public capital differs across studies, there is more consensuses that public capital furthers economic growth. These authors, Easterly and Rebelo (1993), Canning and Fay, 1993, Canning (1999) applied a cross section-time series pooled data in their work and found that public infrastructure has positive effects on a country's productivity and performance which in turn leads to a positive impact on growth basically by the stock of infrastructure. Also, authors like, (Prud'homme, 2004, Agénor and Moreno-Dodson, 2006, Yeaple and Golub, 2007, Baldwin and Dixon, 2008, Seethepalli, Bramati, and Veredas, 2008, Straub, Vellutini and Warlters, 2008, Canning and Pedroni, 2008, de Haan, Romp and Sturm, 2007, Grubesic, 2009) looked at the work by using various economic theories, econometric models and analysing data at national or regional level. Banyte (2008) analyzes infrastructure as the factor that determines successful diffusion and adoption of innovation in the market.

Both Abedian and Van Seventer (1995) and Coetzee and Le Roux (1998) focus on financial measures public-sector infrastructure in analysing the relationship between infrastructure and growth. The former paper finds output elasticities between 0.17 and 0.33 and economic rates of return between 0.2 and 0.23 (depending on the definition of the infrastructure stock). The latter study obtains relatively similar results, calculating an output elasticity of 0.3 and an economic rate of return of 0.24. These results, however, like many international findings from the same time period, do not take into account the stochastic time trends in both infrastructure stock and output measures. The calculated elasticities are thus likely to be biased and so should be treated with a high degree of caution.

Infrastructure development has been in research studies lately, some refre to is as "Social Overhead Capital", "Economic Overheads", "Overhead Capital", "Basic Economic Facilities", etc. according to Nurkse (1955), he expanded the thought of overhead capital as an "overhead investment which is aimed at providing the services that are basic for any productive activity. Rostow (1960), a development economist, in his 'Theory of Stages of Growth' mentioned that social overhead cost is a pre-condition for take-off into self-sustained growth. He stated that they "create an atmosphere that breeds entrepreneurial capabilities and sustains a climate which is throbbing with economic activities and optimistic decision."

Another economist, Hirschman (1958), in his concept of social overhead Capital which is otherwise referred to as Infrastructure, encompasses rudimentary services which include thing like transportation, communication, power, health, water supply, irrigation and drainage system, this he said will impede primary, secondary and tertiary activities in the economy if they are not in place. In his theory of unbalanced growth, he mentioned that n less developed country has enough endowment of resources that will enable it to advance simultaneously in all sectors of the economy in order to achieve a full and balanced growth. He maintained that for development to take place in an economy, there is a need to adopt a deliberate strategy of unbalancing the economy.

Another author Hansen (1965), when taking a look on the role of public investment play in economic development, he divided public infrastructure into two categories; one is what he called Economic Overhead Capital (EOC) and he second is what he termed Social Overhead Capital (SOC). Economic Overhead Capital is meant to focus on provision of productive activities while Social Overhead Capital is intended to augment human capital and consists of social services such as education, public health facilities, fire and police protection, and homes for the aged.

A different perspective from Kindleberger and Herric (1973), defined infrastructure by introducing other two concepts of Economic Overhead Capital (EOC) and Strictly Social Overhead Capital (SSOC) which are two different components of Social Overhead Capital. From their own viewpoint, Economic Overhead Capital include public utilities while Strictly Social Overhead Capital includes the plants and machinery needed for providing services. Moreover, another development economist Todaro (1981), laid emphasis that capital accumulation which include new investments happens when a reasonable amount of income is invested which he believe will augment output and enhance income.

2.1 Defining Infrastructure

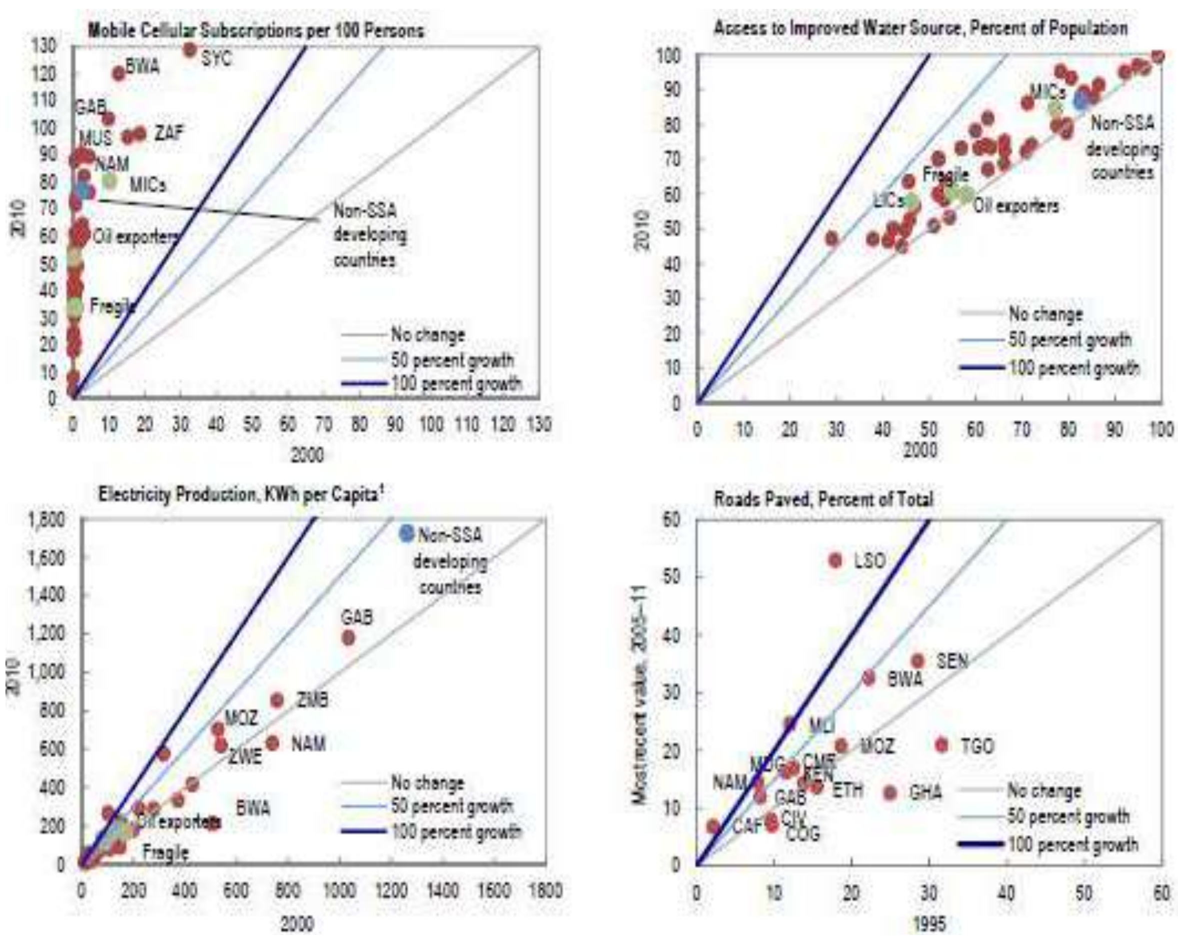
In a work like this, it will be very necessary to define what Infrastructure. Most author sees it as basic public infrastructure, which determines the footing for a social order. The World Bank report (2004) describes infrastructure as a term that encompasses many activities, it has a great role to plays especially for industrial and overall growth of the economy. Gradually, the importance of infrastructure has been ever-changing especially from that which focuses on physical assets to one that embodies notions of softer types of infrastructure such as information systems and knowledge bases (Button, 2002). In general, infrastructure can be categorized into 'hard' infrastructure (transport (ports, roads and railways); energy (electricity generation, electrical grids, gas and oil pipelines); telecommunications (telephone and internet); and, basic utilities (water supply, hospitals and health clinics, schools, irrigation, etc.) and 'soft' infrastructure (non-tangibles supporting the development and operation of hard infrastructure, such as policy, regulatory, and institutional frameworks; governance mechanisms; systems and procedures; social networks; and transparency and accountability of financing and procurement systems), Bhattacharyay, (2008).

Generally defined, infrastructure refers to all basic provisions and requirements that is needed for proper functioning of an economy. It can be categorized into two. First is the economic infrastructure which is the economy's capital stock that is employed in production, for example, electricity, roads and ports. Under it, we have utilities, public works and transport. Second is social infrastructure, which includes services such as health, education and recreation. This type of infrastructure directly enhances the level of output in economic activities, and on the other hand, indirectly restructures activities and outcomes of economic activities.

Social infrastructure also facilitates investment in human capital that ensures better utilization by some of the economy's physical capital stock and thereby raises the productivity of the workforce. The impact on growth is similar to an increase in the supply of capital – a higher capital to labour ratio which enables a given number of workers to produce more output per capita. It also enhances the quality of life of the populace by empowering them economically, politically and socially, with the attendant positive effects on efficient use of national resources and on poverty alleviation. Over the last fifteen years, many sub-Saharan African countries have made progress in improving their infrastructure, but results have been mixed across sectors and country groups. The African Infrastructure Development Index (AIDI) shows some overall progress between 2000 and 2010 (Figure 1), with the most rapid progress in sub-Saharan African low-income countries, and fragile countries lagging behind. Improvements in the overall index were mostly driven by enhancements in information communications technology (ICT), and to a lesser extent, better access to water and sanitation. By contrast, electricity production stagnated, and transport development has been limited. Three individual high performers are Ghana, Kenya, and Senegal; their noticeable score improvement was mainly driven by better performance in ICT. Some countries that lagged behind in the overall level of infrastructure development, such as Chad, Ethiopia, Madagascar, and Niger, have registered high percentage improvements, albeit from low levels (World Development Indicator, 2013).

Sub-Saharan Africa has experienced a revolution in access to ICT. ICT has seen an unprecedented expansion in the past decade, as indicated by the increase in mobile phone subscriptions. Cellular phone subscriptions grew at 40 percent per year in the past decade, and about half of the countries moved from under one phone per 100 people in 2000 to more than 50 phone subscriptions a decade later. The liberalization of markets and the emergence of competition, particularly in the mobile phone market, were the main drivers of this success. Regulatory reforms, including successful wholesale tariff setting, and reform of state-owned public enterprises were also instrumental in this transformation (World Bank, 2011).

Figure 1: African Infrastructure Development Index



Sources: African Development Bank, Africa Infrastructure Development Index, 2013; and World Bank, World Development Indicators. (1 Excludes South Africa.)

Access to water in Africa has also improved, but was uneven, with fragile states and oil exporters lagging behind. However, some low-income countries (Burkina Faso, Ethiopia, Guinea-Bissau, Malawi, Mali, Swaziland, and Uganda) have made substantial progress and increased their population's access to clean water by more than 20 percentage points since 2000. By contrast, progress in the electricity sector has been far more limited. Sub-Saharan Africa remains in the midst of a power crisis characterized by inadequate, unreliable, and costly electricity supply. While the rest of the world improved electricity supply in the last two decades, sub-Saharan Africa's per capita electricity production remained low and largely stagnant (Figure 1). The 48 sub-Saharan African countries, with a population of about 1.1 billion, generate roughly the same power as Spain with a population of 47.27 million (World Bank and African Development Bank, 2013). A few countries managed to double their per capita electricity production over the last decade, albeit mostly from extremely low initial levels (they are: Angola, Cabo Verde, Democratic Republic of the Congo (from 6 kWh per capita to 18 kWh), Ethiopia (from 25 kWh per capita to 57 kWh), Mozambique, and Rwanda (from 13 kWh per capita to 77 kWh). Overall, only about 32 percent of the population in sub-Saharan Africa has access to electricity, compared with more than half in South Asia, while sub-Saharan fragile states lag further behind. Most electricity sectors continue to be state dominated with electricity companies operating as monopolies, and highly regulated electricity markets (Alleyne, 2013).

Transport infrastructure development has also been limited. The most commonly used indicator to assess road infrastructure—percent of paved roads—suggests that African countries, with few exceptions, have made inadequate progress. Poor road conditions are still a critical issue, as less than one-fourth of total sub-Saharan Africa road network (excluding Mauritius and Seychelles) is paved (Figure 3). This results in very high costs, as road transport, the most dominant mode of transport in Africa, accounts for about 80 percent of freight and 90 percent of passenger traffic (other factors include institutional weaknesses, inadequate regulations, delays in border crossings, and cartelization.) Railway development has also been limited. Moreover, overall transport and insurance costs represent 30 percent of the value of exports, compared with about 9 percent for other developing countries (United Nations Economic Commission for Africa,

2009); in Africa's landlocked countries (Chad, Malawi, and Rwanda), these costs may reach about 50 percent of total export values.

3. METHODOLOGY

This is a quantitative study which also builds on other researches and methodologies. In this study, the researcher used some methods to test the hypothesis on the various relationships between infrastructure development and economic growth in sub-Saharan Africa. The statistical methods used are the Ordinary Least Squares Method (OLS), Unit root test, the cointegration test and the Granger causality test. These methods are used in order to avoid a number of challenges and issues that normally crop up when qualitative methods are used especially in econometric studies. These include the issue of subjectivity and bias of responses and the inability to incorporate such biases in econometric models.

The ordinary least squares method is one of the most popular and widely used methods for regression analysis. The method was developed by Carl Friedrich Gauss (1821) and has subsequently evolved to become the Classical Linear Regression Model (CLRM). It is mainly used to establish whether one variable is dependent on another or a combination of other variables. It entails establishing the coefficient(s) of regression for a sample and then making inferences on the population. The model for this study is:

$$InGDP = \gamma_0 + \sum_{i=1}^{k+d} \alpha_{1i} Inelcon_{t-1} + \sum_{i=1}^{k+d} \beta_{1i} Inimpwa_{t-1} + \sum_{i=1}^{k+d} \lambda_{1i} Ininter_{t-1} + \sum_{i=1}^{k+d} \delta_{1i} Inmob_{t-1} + \sum_{i=1}^{k+d} \delta_{1i} Intra_{t-1} + \varepsilon_{1t} \quad \ldots\ldots (1)$$

In the equation, lnGDP, lnelcon, Inimpwa, Ininter, Inmob and Intra are the natural logarithm of GDP growth (proxy for economic growth), electricity consumption, improved water source, internet users per 100 people, mobile subscription, and transportation. *k* is the optimal lag order, *d* is the maximal order of integration of the variables in the system and ε_1, ε_2, ε_3, ε_4 and ε_5 are error terms that are assumed to be white noise. Each variable is regressed on each other variable lagged from one (1) to the $k+d_{max}$ lags in the SUR system, and the restriction that the lagged variables of interest are equal to zero is tested.

Subsequently normal regression analysis entails that data series be stationary, it is evidently imperative that we first test for this condition to find out whether the series used in the regression process is a difference stationary or a trend stationary. The Augmented Dickey-Fuller (ADF) test is used. The ADF test simply runs a regression of the first-difference of the series against a first-lagged value, constant, and a time trend as the following:

Where there is no Intercept and Trend

$$\Delta Y_t = \delta Y_{t-1} + U_t \quad \ldots\ldots (2)$$

Where there is only Intercept

$$\Delta Y_t = \alpha + \delta Y_{t-1} + U_t \ldots\ldots (3)$$

Where there is both Intercept and Trend

$$\Delta Y_t = \alpha + \beta T + \delta Y_{t-1} + \ldots\ldots (4)$$

The hypothesis is as follows:
Ho: $\delta = 0$ (Unit Root) and H1: $\delta \neq 0$

The finding that many time series data may contain a unit root has spurred the development of the theory of non-stationary time series analysis. Engle and Granger (1987) pointed out that a linear combination of two or more non-stationary series may be stationary. If such a stationary linear combination exists, the non-stationary time series are said to be *cointegrated*. The stationary linear combination is called the *cointegrating equation* and may be interpreted as a long-run equilibrium relationship among the variables. The purpose of the cointegration test is to determine whether a group of non-stationary series are cointegrated or not. In other words, to examine whether or not there exists a long run relationship between variables (stable and non-spurious co-integrated relationship) (Miguel, 2000).

Johansen's methodology takes its starting point in the vector auto regression (VAR) of order *p* given by

$$y_t = \mu + A_1 y_{t-1} + \cdots + A_p y_{t-p} + \varepsilon_t \quad \text{…………………………} (5)$$

where y_t is an nx1 vector of variables that are integrated of order one – commonly denoted I(1) – and ε_t is an nx1 vector of innovations.

On the contrary, correlation does not certainly infer causation in any meaningful sense of that word. In other to ascertain the direction of causality between these variables, the granger causality test will be applied.

This Granger test is implemented by running the following regression:

$$\Delta y_t = \alpha + \sum_{i=1}^{p} \beta_i \Delta y_{t-i} + \sum_{i=1}^{p} \gamma_i \Delta x_{t-i} + \varepsilon_t \quad \text{………………………………………}(6)$$

and testing the joint hypothesis $H_0: \gamma_1 = \gamma_2 = \ldots \gamma_p = 0$ against $H_1: \gamma_1 \neq \gamma_2 \neq \ldots \gamma_p \neq 0$
Granger causality from the *y* variable to the coincident variable *x* is established if the null hypothesis of the asymptotic chi-square (χ^2) test is rejected. A significant test statistic indicates that the *x* variable has predictive value for forecasting movements in *y* over and above the information contained in the latter's past.

4. DISCUSSION OF RESULT

The Unit Root test was used to test for stationarity/nonstatonarity of the variable. This was done in other to avoid the danger of obtaining spurious regression. If this is not done, a significant result may be obtained from unrelated data. The unit root test for this work was done by using the Augumented Dickey-Fuller Test. The ADF tests allow one to specify how lagged difference terms are to be included in the ADF test equation. In this case, we have chosen to estimate an ADF test that includes a constant in the test regression and employs automatic lag length selection using a Schwarz Information Criterion (BIC) and a maximum lag length of 2. The unit root output provides information about the form of the test (the type of test, the exogenous variables, and lag length used), and contains the test output, associated critical values, and in this case, the p-value. Below is the summary of the unit root test:

Table i: ADF unit root test

Variable	Critical Values	Constant		Constant, Linear Trend		None	
D(LNGDP)	1%	-3.808546		-4.498307		-2.685718	
	5%	-3.020686		-3.658446		-1.959071	
	10%	-2.650413		-3.268973		-1.607456	
ADF		T-statistics	Probability	T-statistics	Probability	T-statistics	Probability
		-11.04872	0.0000	-10.03471	0.0000	-11.63487	0.0000
D(LNELCON)	1%	-3.737853		-4.416345		-2.664853	
	5%	-2.991878		-3.622033		-1.955681	
	10%	-2.635542		-3.248592		-1.608793	
ADF		T-statistics	Probability	T-statistics	Probability	T-statistics	Probability
		-2.623562	0.1022	-3.408367	0.0748	-3.408367	0.0748
D(IMPWA)	1%	-3.788030		-4.467895		-2.679735	
	5%	-3.012363		-3.644963		-1.958088	
	10%	-2.646119		-3.261452		-1.607830	
ADF		T-statistics	Probability	T-statistics	Probability	T-statistics	Probability
		-2.761539	0.0809	-2.939678	0.1710	0.681302	0.8551

D(LNINTER)	1%	-3.886751		-4.616209		-2.708094	
	5%	-3.052169		-3.710482		-1.962813	
	10%	-2.666593		-3.297799		-1.606129	
ADF		T-statistics	Probability	T-statistics	Probability	T-statistics	Probability
		-2.960456	0.0592	-3.183619	0.1203	-3.011112	0.0050
D(LNTRA)	1%	-3.752946		-4.440739		-2.669359	
	5%	-2.998064		-3.632896		-1.956406	
	10%	-2.638752		-3.254671		-1.608495	
ADF		T-statistics	Probability	T-statistics	Probability	T-statistics	Probability
		-4.611331	0.0014	-4.574368	0.0076	-4.254329	0.0002

Source: Author's calculation

From the result augmented dickey fuller unit root test, if the statistic t $_{\alpha}$ value is greater than the critical values, we do not reject the null at conventional test sizes and vice versa. The analysis started by the test of the statistical properties of the data series used. First, the order of integration in each of the GDP, ELCON, IMPWA, INTER AND TRA series were tested. The stationarity test, showed that the included variables were non-stationary at their level and first difference.

The test for non-stationarity was also done by calculating the auto correlation function ACF as seen below.

Table ii: Auto Correlation Function
Date: 12/25/15 Time: 20:53
Sample: 1990 2014
Included observations: 23

<table>
<tr><th>Autocorrelation</th><th>Partial Correlation</th><th></th><th>AC</th><th>PAC</th><th>Q-Stat</th><th>Prob</th></tr>
<tr><td>. |* . |</td><td>. |* . |</td><td>1</td><td>0.145</td><td>0.145</td><td>0.5497</td><td>0.458</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>2</td><td>0.037</td><td>0.017</td><td>0.5878</td><td>0.745</td></tr>
<tr><td>. |* . |</td><td>. |* . |</td><td>3</td><td>0.089</td><td>0.083</td><td>0.8157</td><td>0.846</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>4</td><td>0.037</td><td>0.012</td><td>0.8563</td><td>0.931</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>5</td><td>0.065</td><td>0.057</td><td>0.9933</td><td>0.963</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>6</td><td>0.069</td><td>0.045</td><td>1.1524</td><td>0.979</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>7</td><td>0.014</td><td>-0.008</td><td>1.1590</td><td>0.992</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>8</td><td>0.008</td><td>-0.005</td><td>1.1612</td><td>0.997</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>9</td><td>-0.003</td><td>-0.015</td><td>1.1616</td><td>0.999</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>10</td><td>-0.034</td><td>-0.039</td><td>1.2142</td><td>1.000</td></tr>
<tr><td>. *| . |</td><td>. *| . |</td><td>11</td><td>-0.161</td><td>-0.163</td><td>2.4547</td><td>0.996</td></tr>
<tr><td>. *| . |</td><td>. | . |</td><td>12</td><td>-0.102</td><td>-0.065</td><td>3.0015</td><td>0.996</td></tr>
</table>

From table above, it can be seen that the AC's are significantly positive and that AC(k) dies off geometrically with increasing lags k, it is a sign that the series obeys a low-order autoregressive (AR) process. In addition, since the partial autocorrelation (PAC) is significantly positive at lag 1 and close to zero thereafter, the pattern of autocorrelation can be captured by an auto regression of order one, that is, AR(1).

Having established that the various series are integrated of the first order, the second step in testing the relationship between GDP, ELCON, IMPWA, INTER AND TRA is to test for the cointegration relationship between the variables, in order to determine if there is a long-run relationship between the two variables. The test for the long-run relationship between both variables was done using Johansen cointegration test.

Table iii: Johansen cointegration test.
Date: 12/29/15 Time: 18:07
Sample (adjusted): 1997 2014
Included observations: 18 after adjustments
Trend assumption: Linear deterministic trend
Series: GDP ELCON IMPWA INTER TRA
Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.960534	108.6228	69.81889	0.0000
At most 1 *	0.740185	50.44130	47.85613	0.0280
At most 2	0.610983	26.18112	29.79707	0.1234
At most 3	0.363699	9.186723	15.49471	0.3484
At most 4	0.056623	1.049211	3.841466	0.3057

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.960534	58.18148	33.87687	0.0000
At most 1	0.740185	24.26017	27.58434	0.1259
At most 2	0.610983	16.99440	21.13162	0.1723
At most 3	0.363699	8.137512	14.26460	0.3649
At most 4	0.056623	1.049211	3.841466	0.3057

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

The relationship between the variables simply shows that in the long run the variables move together which connotes a long run relationship. This can be seen from the test statistics (trace statistics and maximum Eigenvalue) for all the five variable. When the p value is less than 5%, we reject the null hypothesis that there is no cointegration. We can see 2 cointegrating equations at the 0.05 level of significance, at a critical value of 69.81889; the p value is 0.0000 and at critical value of 47.85613; the p value is 0.0280. Also from the trace statistics which tests the null hypothesis of cointegrating relations against the alternative hypothesis (108.6228 and 50.44130 at none and at most 1 respectively) is greater than the critical value of 69.81889 and 47.45613 at 5% level of significance respectively. This denotes the rejection of the null hypothesis at 5% evel of significance, showing that there is a cointegrating relationship between the variables

Once we establish a cointegration relationship between all the variables, then we conclude that there exist a long-run relationship between them, even if they are individually non-stationary. If the trace statistics or the Likelihood ratio is greater than the critical value, then there is a cointegration.

From the granger causality test as applied in this work, the following results were obtained.

Table iv: Pair wise granger causality test

Pairwise Granger Causality Tests				
Date: 12/29/15 Time: 18:28				
Sample: 1990 2014				
Lags: 2				
Null Hypothesis:	Obs	F-Statistic	Prob.	Causality
ELCON does not Granger Cause GDP	23	4.93129	0.0196	Yes
GDP does not Granger Cause ELCON		0.64459	0.5366	No
IMPWA does not Granger Cause GDP	23	0.49454	0.6179	No
GDP does not Granger Cause IMPWA		2.43603	0.1158	No
INTER does not Granger Cause GDP	18	0.18210	0.8356	No
GDP does not Granger Cause INTER		1.34465	0.2946	No
TRA does not Granger Cause GDP	23	1.25338	0.3093	No
GDP does not Granger Cause TRA		2.15005	0.1454	No
IMPWA does not Granger Cause ELCON	23	0.62439	0.5468	No
ELCON does not Granger Cause IMPWA		1.07865	0.361	No
INTER does not Granger Cause ELCON	18	0.89548	0.4322	No
ELCON does not Granger Cause INTER		0.02832	0.9721	No
TRA does not Granger Cause ELCON	23	0.74860	0.4872	No
ELCON does not Granger Cause TRA		0.35267	0.7076	No
INTER does not Granger Cause IMPWA	18	1.06029	0.3745	No
IMPWA does not Granger Cause INTER		2.92370	0.0894	No
TRA does not Granger Cause IMPWA	23	0.23965	0.7894	No
IMPWA does not Granger Cause TRA		1.94630	0.1717	No
TRA does not Granger Cause INTER	18	5.23370	0.0215	Yes
INTER does not Granger Cause TRA		7.51654	0.0068	Yes

From the pairwise granger causality test, we found that we can reject the null hypotheses in these relationship. The F statistics and the probability values indicate if the null hypothesis should be accepted or rejected. In the first row, we have the F-statistics as 4.93129 with a probability value of 0.0196 which indicates a causality, which means that ELCON granger causes GDP; also we have in the last two rows a causality where TRA granger causes INTER and INTER granger cause TRA. We also found a bi-directional causality relationship which means a pair wise causality among internet and transportation (air transportation). For all other relationships, we accept the null hypothesis that there is no causality for other relationship in sub-Saharan African countries.

5. CONCLUSION

This study as one of the empirical studies on the analysis of infrastructure and growth in sub-Saharan Africa, this study has made an attempt to understand the relationship and interaction between them. The proxy for economic growth used in this study was gross domestic product. The result arising from this study shows that there is a long run relationship between the variable and that the direction of causality if only from internet users and transportation. Others variables indicate no causation, which implies that infrastructure has not impacted on growth for the period under review in sub-Sahara Africa. The study provided a proof that for the economies of sub-Saharan Africa to attain a certain level of growth, the government of the region need to invest more on infrastructure especially on the areas of power generation, transportation and ICT.

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