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RESEARCH ARTICLE

Qualitative and Quantitative Effects of Infrastructure on Economic Growth and Productivity in Africa

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Abstract: Productivity and economic growth in Africa are constantly stalled by the inadequate and poor quality of infrastructure. Despite the current efforts to understand the economic growth effects of infrastructure, little is documented in the literature concerning the implications of infrastructure quality on productivity and economic growth. We sought to address this issue by investigating the impacts of the quantities and qualities of infrastructure (electricity, telecommunication, roads and airports) on growth and productivity in Africa. It was established that the quantities of electricity, telecom and airport can boost economic growth. Sadly, road infrastructure quantities exerted negative pressure on growth and productivity. While electricity and airport quantities could trigger productivity, we did not find sufficient evidence that increased telecommunication subscriptions may influence productivity. As for the qualitative effects, the quality of airports showed no significant effect on growth while the qualities of electricity, telecommunication and roads imply negative growth impacts. Across all the four infrastructure types, none of their quality attributes tended to influence productivity. We believe that the current shortage and poor (or deteriorating) infrastructures are the fundamental reasons behind the infrastructures' weaker and, in other instances, negative impacts. An equal proportion of funding is required for both additional infrastructures and improving the quality of the existing infrastructure. Resolving the infrastructure problems in Africa will be challenging in the presence of weak institutions and governments that breed and incubate corruption. Weaker governments cannot run stronger institutions.

JEL classification: H54, O40, J24, O55

Keywords: Infrastructure Quality; Economic Growth; Productivity; Africa

1 Introduction

The shortage and poor state of infrastructure remain a hindrance to Africa's economic development. For instance, an erratic electricity supply causes businesses to suffer, while a lack of improved sanitation and water threatens millions of lives (International Finance Corporation, 2017). Consequently, poor infrastructure is believed to be among the critical factors for sluggish and even negative growth rates in countries such as Zimbabwe, whose growth deteriorated from 3.8% in 2014 to 1.5% in 2015 (AfDB, 2017). As in most developing countries, financing infrastructure ventures in Africa is held back by a lack of policy focus and the artificial shortage of innovative funding mechanisms.

While public infrastructure is universally acknowledged as a necessity for the wellbeing of every economy, the question that remains unanswered is whether an increased supply of these infrastructures would guarantee economic growth. Theoretical models (for instance, Arrow and Kurz, 1970; Barro, 1990) have analysed the impact of infrastructure on growth. Policymakers are much interested in the empirical performance of infrastructure investments. Aschauer's (1989) seminal paper revealed the importance of infrastructure investment for the United States (US) in the 1970s even though the estimates were challenged by Gramlich (1994), whose view was that certain infrastructure classes should not have significant output contributions. Since then, several studies have attempted to investigate the relationships between the various sources of infrastructure (mainly electricity, telecommunication & transportation) and economic growth, yet empirical gaps still exist in the literature.

Failure to consider both the stock and quality features of each infrastructure when quantifying the growth and productivity impacts of the various infrastructure types is a crucial research problem. A handful of studies (for example, Calderon, 2009; Loayza and Odawara, 2010; Chakamera and Alagidede, 2018) accounted for infrastructure quality. More precisely, Calderon and Serven (2010), who examined the effect of infrastructure on growth and inequality in Sub Saharan Africa, concluded that, given the shortages and poor state of infrastructure within the region, infrastructure development affords a double potential to speed up poverty alleviation through increased growth and equality. Calderon (2009) showed that the gains are largest for electricity-generating capacity, telephone density, road quality and road network length. Moreover, greater payoffs emerged from large infrastructure quantities than from quality developments. Loayza and Odawara (2010) observed that a permanent rise in infrastructure spending has a progressively rising impact on economic growth. While these studies accounted for infrastructure quality, examining the effect of infrastructure quantity and quality on productivity remains a major gap. Moreover, the effects of the quantitative and qualitative features of the individual infrastructures have not been properly interrogated. Likewise, evidence in the extant studies remains inconclusive regarding the relationships between the different infrastructure types and economic growth, a vital empirical gap for policymaking. According to Deng (2013), the mixed results could be attributed to (i) various ways of measuring a similar phenomenon (like those applied to describe covariates, dependent variables, estimation approach and functional specification), and (ii) different contexts (for instance, period of study, capability of the economy in facilitating economic development, geographical scale), among other factors. Our results help to untangle the issues related to functional specification, underscoring the importance of incorporating infrastructure quality in the infrastructure-growth models.

This study attempts to narrow these empirical gaps. We use both infrastructure stock and quality data of the main infrastructure sectors (electricity, telecommunication, roads and airports) for 27 SSA countries over the 2000-2014 period[1]. Unlike the time series approach that focuses on individual countries and is often hindered by small sample sizes, this paper can exploit additional power from a combination of time series and cross-sectional data. This essay contributes to the existing infrastructure-growth literature in several ways: We take a step further from the earlier studies such as Calderon (2009), Calderon and Serven (2010), and Loayza and Odawara (2010) that focussed on Africa by considering both the growth and productivity effects of the individual infrastructure sectors. These earlier studies mainly focused on aggregate infrastructure indices that combine transportation, telecommunication and electricity sectors. The rest of the study is structured as follows: Section 2 provides brief literature regarding the growth effects of the various infrastructure sectors. Section 3 describes the econometric model and analytical method of the study. The discussion of the results and key implications is done in section 4, while section 5 concludes and suggests possible areas for further research.

2 Literature Review

Theoretically, each public infrastructure supports economic growth in different ways. The development of roads affords knowledge spillovers, emanating from an entire agglomerated area via dynamic network externalities (Tripathi and Gautam, 2010). Roadways can open unconnected areas to trade, investment and employment opportunities. The benefits of roads are measured in terms of time saved, tyre wear, fuel consumption, car repairs and reduced accident risk (Larsen, 1968). Telecommunication facilitates trade and production by allowing the dissemination of information among economic agents (Ismail and Mahyideen, 2015). Telecommunication is believed to be associated with a rise in total factor productivity (TFP) and providing the whole economic system with vital technological externalities (Antonelli, 1996). The collaboration between telecommunication network providers and telecommunication equipment producers shapes technological change that is necessary for TFP. Electricity is an indispensable factor that assumes a vital role in the production processes and lightning (Abbas and Choudhury, 2013). Each infrastructure type is therefore imperative to economic growth. It is essential to present some evidence from the previous empirical studies. In terms of transportation, Murakami et al.'s (2016) models for metropolitan output per capita suggest that cities with airport-rail links experience higher productivity than those without such infrastructures. Moreover, Ismail and Mahyideen (2015) demonstrate that a 10% rise in paved roadways increases economic growth by at least 5%. Interestingly, Ozbay et al. (2007) observe a positive time lag effect between the time of highway investment and the effect on growth. Focusing on SSA, Boopen's (2006) results suggest a growth contribution from transport infrastructure. Furthermore, Peter et al. (2015) show a positive effect (0.21) of roads on economic growth in Nigeria.

In other studies, economic growth contributions are doubtful. Concerning the US, Turner (2013) maintains that roads require scrutiny if not absolute scepticism in terms of

[1]Angola, Benini, Botswana, Burkina Faso, Burundi, Cameroon, Chad, Gabon, Gambia, Ghana, Guinea, Kenya, Madagascar, Malawi, Mali, Mauritius, Mozambique, Namibia, Nigeria, Rwanda, Senegal, Sierra Leone, South Africa, Swaziland, Tanzania, Uganda and Zimbabwe.

their role in development. He claims that highways seem to display far lesser definite returns than probable investment alternatives such as education and healthcare. Tripathi and Gautam (2010) find that growth in the length of highways crowd out gross private capital formation and show no effect on output in India. Furthermore, Yu et al. (2012) demonstrate that the impact of transport infrastructure on output tends to be more noticeable in intermediate Chinese regions than the congested ones while benefiting the lagging regions is not likely. Meng and Han's (2016) findings suggest that improvement in road infrastructure does not contribute to economic growth but raises CO_2 emissions in Shanghai.

In telecommunication, Cronin et al. (1991) discovered a two-way causal relationship between the size of the US telecom investment and economic activity. In the same century, Crandall (1997) found evidence that the economic growth influence of new telecommunications infrastructure was weak to finalise that it had already produced enormous externalities. A study by Roller and Waverman (2001) is among those that demonstrate significant growth contributions of telecommunication. Correa (2006) also presents evidence that telecommunication productivity surpassed other sectoral productivity and economy-wide productivity in the UK. Moreover, Dvornik and Sabolic (2007) demonstrate causality from telecommunication to GDP in Europe. Other studies (Pradhan et al., 2014; Lam and Shiu, 2010) show a bi-directional relationship between telecommunication and growth. Moreover, Maiorano and Stern (2007) show the positive contribution of mobile penetration to growth in middle and low-income economies. Rohman and Bohlin (2014) discovered that the telecom sector's coefficient multiplier declined to approximately 1.3 by the end of 2008 from roughly 1.8 in the 1980s. They believe it could be due to the uses of mobile that are not linked to business activities. Closely related, Ward and Zheng (2016) show that mobile services contribute greatly to economic growth but deteriorate as the province develops further. Kumar et al.'s (2015) results suggest that telecommunication services contribute 0.43% in the long run and 0.33% in the short run.

As far as electricity infrastructure is concerned, several studies have shown evidence supporting a positive impact of electricity on growth. Ciarreta and Zarraga's (2010) results suggest that a 1% rise in electricity consumption could lead to a 0.05% increase in growth in European countries. Tang and Tan's (2013) paper shows the positive income contribution of electricity consumption. Hamdi et al. (2014) also find that a percentage increase in electricity consumption could increase long-run growth by 0.46% in the Kingdom of Bahrain. Apergis and Payne (2011) show mixed results for the electricity-growth causality, which depend on income levels and whether short-run or long-run. Recently, Kantar et al. (2016) found a robust association between electricity consumption and economic growth in the low, middle and high-income economies. Moreover, several studies (Belaid and Abderrahmani, 2013; Osman et al., 2016; Gurgul and Lach, 2012; Yoo, 2005) reveal evidence for a feedback hypothesis. Interestingly, Al-mulali et al. (2014) find renewable energy consumption more significant than non-renewable energy in Latin America.

Focusing on 17 African economies, Wolde-Rufael (2006) find causality running from both directions in three economies, from electricity to growth in other three economies, from growth to electricity in six economies, and no causality for the rest. Akinlo's (2009) results show a unidirectional causality from electricity consumption to GDP in Nigeria. Kouakou (2011) in Cote d'Ivoire also discover a bi-directional causality between electricity and growth. Additionally, Ibrahiem's (2015) findings suggest a cointegrating relationship between growth, electricity consumption and foreign direct investment in Egypt and bi-directional causality between electricity consumption and growth. Lately, Adams et al.'

(2016) results suggested a feedback hypothesis between energy consumption and growth in 16 SSA states. Generally, it is possible to find evidence for both bi-directional and uni-directional causal relationships when applying data for different countries (see Yoo, 2006; Yoo and Kwak, 2010).

On the other hand, Ozturk and Acaravci's (2011) results imply no electricity-growth relationship in most Middle East and North Africa (MENA) countries. Furthermore, Wolde-Rufael (2014), who examined 15 economies, documented limited evidence of the electricity-led growth hypothesis. Lack of consensus necessitates further research.

3 Methodology and Data

3.1 Data Description

This empirical study considers 27 SSA countries (see footnote 1). Annual data for 2000-2014 was obtained from numerous sources as displayed in the Appendix, Table A2. Change in Gross Domestic Product (GDP) per capita is the proxy for economic growth, while output per worker represents productivity. The infrastructure variables are the quantity and quality measures of electricity, telecommunication (fixed lines plus mobile), roads and airports. Figures 1 shows the qualities of infrastructures.

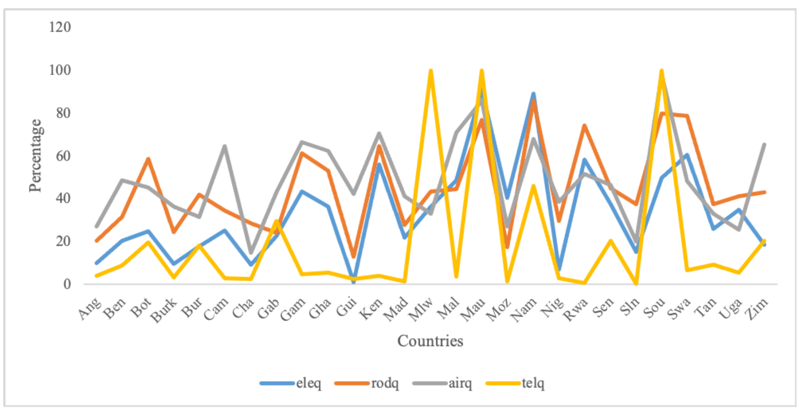

Figure 1: **Infrastructure Quality Levels**
Note: Average values for the infrastructure qualities for the period 2000-2014: average quality score of electricity = 33,7%, average quality of roads = 45,2%, average quality of airports = 48,4% and average quality of telecommunication = 19,4%.

Based on the average values, most countries in the sample have lower infrastructure quality levels, as illustrated in Figure 1. Comparisons can be made in terms of the quality infrastructure developments among the African countries. Mauritius, Namibia, Swaziland (now Eswatini), Rwanda and Kenya were the top 5 with respect to electricity quality performance, which means they experienced relatively low distribution losses, on average. As for road quality attributes, Namibia, South Africa, Swaziland, Mauritius, and Rwanda were better. In terms of air transport quality, South Africa, Mauritius, Mali, Kenya and Namibia were on top five in the sample.

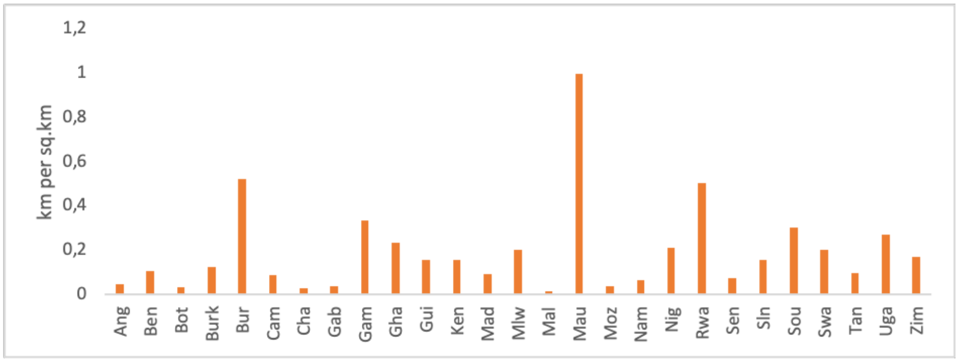

Figure 2: **Quantity of road infrastructure**
Note: Average values of road quantities for the period 2000-2014.

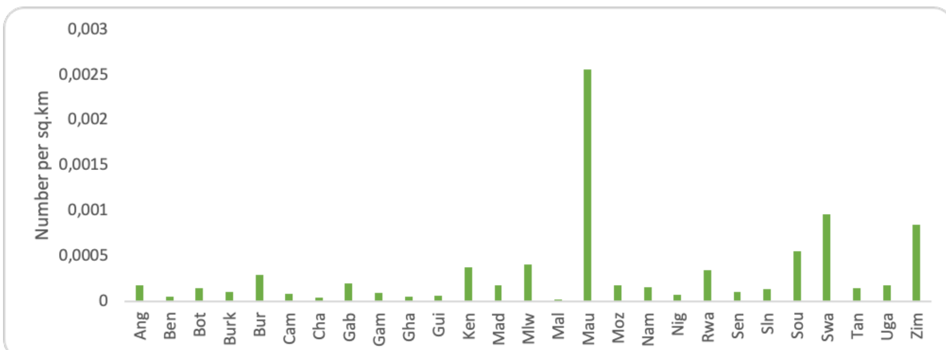

Figure 3: **Quantity of airports**
Note: Average values of airport quantities for the period 2000-2014.

On the other hand, Malawi, Mauritius, South Africa, Namibia and Gabon performed better in terms of telecommunication quality. Internet connections and subscriptions revolutionised communication and its effectiveness. The major problem is that data charges are higher in many African countries, excluding many people from reaping the benefits of Information Communication Technology (ICT). For example, according to Oluwole (2021), "…Sub Saharan Africa ranking as the region with the most expensive data prices in the world." An overall conclusion derived from Figure 1 is that infrastructure in many regional countries is very poor, compounded with high electricity distribution losses, lower internet subscribers, a greater proportion of unpaved roads and airport runways. Poor infrastructure quality may hinder the growth effects of the existing infrastructures. Having presented the qualities of the different infrastructures, Figures 2 -4 compare the average infrastructure quantities.

The quantities of the various infrastructure sectors could not be displayed in a single figure because of different units of measurements. Figure 2 shows that Mauritius, Burundi and Rwanda had relatively large quantities of roads. In other words, these countries have better road networks as measured by road length per square kilometre. Figure 3 indicates that Mauritius is the only country in the sample with a better number of airports per square kilometre. This is also because Mauritius is a very small country. Generally, all the countries are still facing a shortage of roads (poor road network) and airports, which may delay economic growth. However, as argued by Calderon and Serven (2010), these shortages may also allow the respective countries to have larger payoffs from additional infrastructures.

In terms of electricity quantity, Figure 4 shows that South Africa had a much better net electricity generation capacity (Blns kWh). The country is endowed with huge coal reserves, although the recent push is towards renewable sources of energy. It also exports electricity to the neighbouring countries. Regardless, South Africa has been facing load shedding, with Eskom marred with several challenges. Some of the challenges are linked to corruption. Sadly, electricity generation capacity in many African countries is very low, which may continue to threaten economic progress in the region.

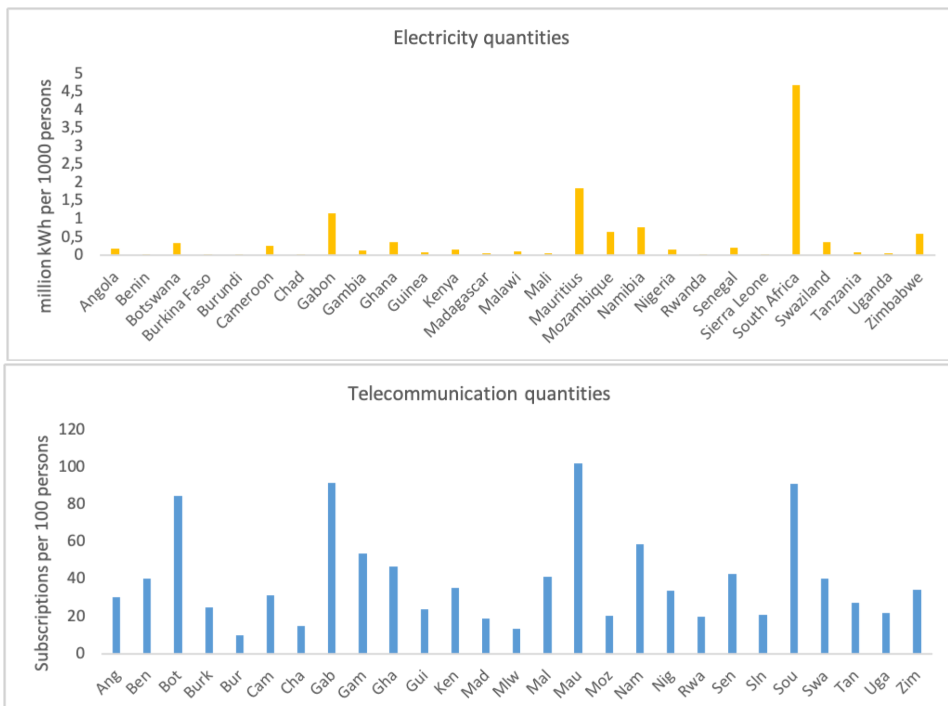

Figure 4: **Quantities of electricity telecommunication infrastructures**
Note: Average values of electricity and telecommunication quantities for the period 2000-2014

A reasonable number of countries (Mauritius, South Africa, Gabon, Botswana, Namibia, Gambia, Senegal, Ghana, Malawi, Benin and Swaziland) had at least 40 internet subscribers per 100 persons (Figure 4). An increase in subscriptions has been facilitated by a fall in the prices of mobile phones. The control variables include capital, labour, terms of trade and inflation. Each variable is standardised for uniformity across the countries.

3.2 Models

To examine the infrastructure-growth effects, this essay considers the following model:

$$\ln g_{it} = \alpha_0 + \beta_1 \ln ele_{it} + \beta_2 \ln tel_{it} + \beta_3 \ln air_{it} + \beta_4 \ln rod_{it} + \delta'_{it} \ln Z_{it} + \varepsilon_{it} \quad (1)$$

where g_{it} is change GDP per capita; ele_{it}, tel_{it}, rod_{it}, air_{it}, represent electricity, telecommunication, roads and airports infrastructure variables, respectively; Z is a vector of control variables, which include capital, labour, terms of trade and inflation; α_0 is an intercept; β_1, β_2, β_3 and δ_{it} are the key parameters to be estimated; ε_{it} is the error term; and $\ln$ shows the logarithm transformation of the variables. This study uses equation 1 to estimate two models, one for quantity infrastructure effects and another for quality infrastructure effects. The study also estimates the following equation for the effects of infrastructure on productivity.

$$\ln p_{it} = \theta_0 + \gamma_1 \ln ele_{it} + \gamma_2 \ln tel_{it} + \gamma_3 \ln air_{it} + \lambda_4 \ln rod_{it} + \eta'_{it} \ln Z_{it} + \varepsilon_{it} \quad (2)$$

where $\ln p_{it}$ represents productivity; θ_0 an intercept; γ_1, γ_2 , γ_3, and γ_4 are the parameters to be estimated; the other variables are as described in equation 1. Equation 2 is also used to estimate wo empirical models, one for the quantitative infrastructure effects and another for the qualitative infrastructure effects.

Identification is often problematic, especially in the presence of endogenous variables and correlation between the covariates and the error terms. A bi-directional causality may exist between infrastructure and growth. While, in theory, a full structural model can handle bi-directional causality, its practical implementation poses stringent data requirements (Calderon and Serven, 2010). Consequently, the use of an instrumental variable approach is an alternative. Certain demographic indicators that often correlate with infrastructure could work as external instruments (Calderon, 2009). These can be used together with internal instruments (lags) in a GMM framework. Nevertheless, finding reasonable external instruments that can represent each infrastructure sector is a challenge. Thus, we only rely on internal instruments in a dynamic GMM framework to overcome the identification problem.

3.3 Econometric Approach

We apply techniques that are best suited for panel data. Panel tests are generally robust than time series tests given additional information to exploit that emerges from cross-sectional dimensions (Burret et al., 2014). Panel techniques allow us to control for unobserved heterogeneity among cross-sections that would remain unexploited (see Khan and Abbas, 2016). This study applies the system Generalised Method Moments (system-GMM).

3.3.1 Generalised Method Moments

The GMM technique offers numerous advantages. It sanctions us to account for unobserved time effects, country-specific effects, and most importantly, it handles the endogeneity of regressors (see Calderon, 2009). Hansen (1982) indicated that the variables can also be serially correlated and conditionally heteroscedasticity. Moreover, GMM does not make a strong distributional assumption like other techniques (Hansen and West, 2002). GMM is also robust and efficient than other estimators (e.g. OLS) when auxiliary assumptions such as homoscedasticity are violated (Woodridge, 2001). By relying on instrumental variables, GMM overcomes an identification problem that often arises in the presence of endogeneity and non-linear regressions. Consider the following model:

$$\ln \Delta y_{it} = (1+\phi)\Delta_{i,t-1} + \delta_i \Delta x_{it} + \Delta\varepsilon_{it} \tag{3}$$

where y_{it} is a dependent variable; x_{it} is a set of regressors (infrastructure plus control variables), δ_i is a vector of parameters, and Δ denotes first differences. In equation 3, instrumental variables are used to eliminate the problem of endogeneity whereby the endogenous and predetermined variables in first differences are instrumented with suitable lags of the variables in levels (see Liang, 2006). With appropriate lags of y_{it} and x_{it}, the moment conditions for the difference-GMM are:

$$E\left[\begin{bmatrix} x_{i,t-1} \\ \downarrow \\ x_{i,t-p} \\ y_{i,t-1} \\ \downarrow \\ y_{i,t-p} \end{bmatrix} (\varepsilon_{it} - \varepsilon_{i,t-1})\right] = 0; t \geq 3; p \geq 2; \tag{4}$$

(Condition for all valid instruments in the differenced equation)

Note that in equation 4 estimation, instrumental variables are used to eliminate the problem of endogeneity of regressors whereby the endogenous and predetermined variables in first differences are instrumented with suitable lags of the variables in levels (see also Liang, 2006). Nevertheless, at times the lagged levels of the independent variables cannot be strong instruments when the variables are persistent over a period of time (Blundell and Bond, 1998). Consequently, a system-GMM can be used, which allows for a combination of regressions in differences and levels to develop a more efficient system estimator (Arellano and Bover, 1995; Blundell and Bond, 1998). Given the moment conditions for the difference-GMM (Equation 4), additional moment conditions based on the system-GMM are as follows:

$$\begin{gathered} E\left[\begin{pmatrix} \Delta x_{i,t-1} \\ \Delta y_{i,t-1} \end{pmatrix} (\phi_i + \varepsilon_{it})\right] = 0 \\ \Delta x_{i,t-1} = x_{i,t-1} - x_{i,t-2}; \Delta y_{i,t-1} = y_{i,t-1} - y_{i,t-2} \end{gathered} \tag{5}$$

where the moment conditions in Equation 5 assume a zero correlation between the differences of the variables and the country-specific effects. We use the system-GMM by Blundell and Bond (1998) to estimate the impact of various infrastructure stocks and qualities on economic growth.

4 Results and Discussion

4.1 Summary statistics

Table 1 shows the summary statistics of the variables. All variables are normalised using the natural logarithm transformation. Our variables of interest are log Gross Domestic

Product per capita (LGDP), log productivity (LPROD), log stocks of electricity (LELES), telecommunication (LTEL), roads (LRODS) and airports (LAIRS), and their log qualities (i.e. LELEQ, LTELQ, LRODQ and LAIRS). The control variables are capital (LCAP), labour (LLAB), terms of trade (LTOT) and inflation (LINF), all in logs. Evidence in the table shows that LELES, LAIRS, LELEQ, LAIRQ, LRODQ, LCAP, LTOT and LINF are fat-tailed as represented by excess kurtosis (i.e. above the threshold of 3). Some variables are positively skewed, whereas others are negatively skewed. Excess kurtosis and skewness are undesirable features that potentially threaten the identification of parameters, particularly when the standard OLS is used. These concerns are not expected to plague our estimations by applying the GMM estimator, which does not require any distribution assumptions (see Hansen and West, 2002). The total number of observations (Obs) for each variable should be 405, but other variables have less, hence having an unbalanced panel. The standard deviation, minimum and maximum values for each variable are presented in the table.

Table 1: Summary Statistics

Variable	Obs	Mean	SD	Min	Max	Skew	Kurt
LELES	405	0.393	1.820	-3.244	5.504	0.514	3.320
LTELS	405	2.838	1.600	-1.640	5.375	-0.663	2.388
LAIRS	404	-8.699	1.048	-11.019	-5.824	0.491	3.323
LRODS	405	-2.133	1.040	-5.858	0.105	-0.141	2.662
LELEQ	404	3.237	0.930	-0.097	4.557	-1.128	4.279
LTELQ	405	1.388	1.625	-3.936	4.605	0.237	2.626
LAIRQ	405	3.744	0.479	2.078	4.605	-1.028	4.757
LRODQ	398	3.529	0.568	0.872	4.605	-0.405	3.579
LGDP	405	6.825	1.098	4.691	9.392	0.649	2.372
LPROD	405	7.669	1.217	5.758	10.314	0.709	2.292
LCAP	405	21.259	1.439	15.758	25.175	0.079	4.060
LLAB	405	4.137	0.238	3.563	4.464	-0.655	2.498
LTOT	405	4.715	0.287	4.052	5.564	0.974	3.720
LINF	390	1.081	2.624	-9.210	5.784	-2.383	7.832

Note: Estimated using Stata. Number of panels=27, Number of periods=15.

4.2 Correlation Analysis

Our correlation analysis is based on the Spearman rank-order. Table A1 in the Appendix presents the correlation coefficients for the infrastructure variables versus economic growth and productivity. Below each coefficient and in brackets are the probability values. All the correlation coefficients of the infrastructure variables and GDP and productivity are statistically significant except for the correlation coefficient of LPROD vs LAIRS. This suggests that there is no linear relationship between the number of airports and productivity.

The correlation coefficients show the strength of either a positive or negative linear relationship between a pair of variables in question. For instance, we regard the values between -0.3 and -0 (0 and 0.3) as a sign of a weak negative (positive) linear relationship; -0.4 and -7 (0.4 and 7) as a moderate negative (positive) linear relationship; -0.8 and -1 (0.8 and 1) as a strong negative (positive) linear relationship. The correlation analysis has been used to have an initial picture of the possible relationships. However, a correlation coefficient demands that the underlying relationship between variables is linear; otherwise, the coefficient will be questionable. Expecting some of the relationships to be non-linear, we make further regression analyses using the GMM technique that does well in estimating non-linear relationships.

4.3 Unit root test

Before running a regression, it is vital to determine the variables' stationarity (or unit root) properties. We employ a unit root test by Im, Pesaran and Shin (2003), in short IPS. Unlike the Levin, Lin and Chu (LLC) unit root test, one of the advantages of this test is that it assumes an individual unit root process. The unit root results are presented in Table 2. All estimations consider automatic lag selection based on the Akaike Information Criterion (AIC). The results indicate that LELES, LTELS, LRODS, LTELQ, LLAB and LINF are stationary in level while the rest of the variables are non-stationary in level. All variables are significant in the first difference and hence stationary. We apply variables in their first difference. It is important to employ stationary variables to avoid spurious results.

Table 2: Im, Pesaran and Shin (IPS) unit root test

	Level	1st Difference
Variable	W-t-bar	W-t-bar
LELES	-2.991***	-10.291***
LTELS	-4.764***	-2.878***
LAIRS	2.878	-11.183***
LRODS	-59.589***	-27.118***
LELEQ	1.934	-6.847***
LTELQ	-7.838***	-8.301***
LAIRQ	1.375	-4.302***
LRODQ	4.450	-2.992***
LGDP	-1.188	-9.305***
LPROD	0.697	-9.362***
LCAP	1.308	-11.414***
LLAB	-1.931**	-4.512***
LTOT	0.622	-11.410***
LINF	-10.926***	-14.400***

Note: Estimated using Eviews.
The IPS has a Null Hypothesis of a unit root (individual unit root process).

4.4 Quantitative infrastructure effects

We estimate the growth and productivity effects of infrastructure using the system-GMM approach. Table 3 shows the impacts of the various infrastructure quantities on growth and productivity. Our results suggest that a 1% increase in electricity generation capacity will increase GDP per capita and productivity by 0.07% and 0.02%, respectively. This shows the importance of electricity in production and other economic activities. However, the impacts on growth per capita and productivity are minor, probably reflecting the substantial unmet demand for electricity in SSA. The International Energy Agency's (2014) report indicated that since 2000, demand for electricity in SSA rose by 35% to reach 352 TWh in

2012. In the same period, SSA's grid-based power generation capacity increased from 68 gigawatts (GW) to 90 GW with generation from coal accounting for 45% of the total, hydrogeneration (22%), oil (17%), gas (14%), nuclear (2%) and other renewables (below 1%). The increase in electricity generation has not been adequate. The deficiency of electricity leads to less consumption than required and ultimately shows less impact on growth and productivity.

The power outages that are common in Africa are alarming. Andersen and Dalgaard (2013) demonstrate how power outages could substantially slow economic growth in SSA. Cook et al. (2015) mention several ways in which electricity gaps can frustrate regional economic growth. These include an ability to lower production and commerce, undermining human resource development, and elevating the use of polluting biomass energy such as charcoal and wool. Unproductive use of the available energy may also lead to weak economic growth. We believe these factors may hinder the effective contribution of electricity quantity in SSA.

Our results also suggest that a 1% increase in telecommunication stock (i.e. telephone plus mobile phone subscriptions) leads to a 0.06% rise in economic growth. To further explain the estimated telecommunication stock impact, our telecom quantity growth impact is the same as the one estimated by Canning and Pedroni (2008) in the case of 25 African countries. A positive growth effect is plausible given that telecommunication is one of the critical solutions to the distance barrier. On its own, the telecommunication industry contributes to economic growth through income generation and employment creation. It also facilitates trade and tourism. The role of private involvement in the African telecommunication sector has been remarkable over the past years, accompanied by increased mobile subscriptions. The growth impact of the telecommunication sector should improve following the growing use of mobile phones and technology.

Moreover, public fixed-line providers have raised their focus on mobile and data facilities. Tributes may go to the telecommunication policies that seek to enhance competition in telecommunication sectors of SSA countries. Generally, market structures have transformed from state-ownership to joint ventures (or private-ownership) and from monopoly to competition (see Minges, 1999). The telecom contribution is weak, just like the other infrastructures. This might be connected to the unproductive use of telephones and mobile phones. For instance, Rohman and Bohlin's (2014) results showed a greater coefficient multiplier of telecommunication in the 1980s as compared to the 21st century (particularly, 2008), with technological coefficient weakens as the epicentre of telecommunication output. They pinpointed the utilisation of cellular in much fewer business activities than that of the telephone era in the past as a possible explanation. Furthermore, power interruptions that are common in SSA can adversely affect the performance of telecommunication (see Malakata, 2015; Ewusi-Mensah, 2012). It could be that some of the reasons above are responsible for the adverse effect (-0.004) of telecommunication on productivity. If most people use telecommunication devices to stay on social media instead of doing business, productivity will fall. Most importantly, there is an issue of the high phone call and data charges. Due to high telecommunication tariffs, low-income households and businesses could find it difficult to harness all of its potentials as access is restricted, adversely affecting productivity and limiting economic growth. Our view could be linked to Mačiulytė-Šniukienė and Gaile-Sarkane (2014:1272), who mentioned that "the ICT can influence productivity when higher levels of financial investment in ICT bring about new products and falling prices." Prices in most African countries have not been failing irrespective of an

Table 3: Quantitative Infrastructure Effects

	Growth model	Productivity model
Variable	Coefficient	Coefficient
LGDP(-1)	0.166***	—-
	[0.044]	—-
LPRODV(-1)	—-	0.049**
	—-	[0.028]
LELES	0.072***	0.020***
	[0.026]	[0.005]
LTELS	0.057***	-0.004
	[0.006]	[0.006]
LAIRS	0.222***	0.034***
	[0.043]	[0.007]
LRODS	-0.057***	-0.014***
	[0.008]	[0.003]
LCAP	0.169***	0.010*
	[0.017]	[0.006]
LLAB	-0.437***	-0.998***
	[0.136]	[0.020]
LTOT	0.302***	0.043***
	[0.037]	[0.005]
LINFL	-0.001	0.000**
	[0.001]	[0.000]
Constant	0.024***	0.019***
	[0.003]	[0.001]
Observations	336	336
2nd Order	-1.349	-1.547
(P-value)	(0.178)	(0.122)
Sargan	22.482	18.372
(P-value)	(0.935)	(0.987)

Note: Arellano-Bond test for zero autocorrelation in first-differenced errors has the Null hypothesis of no autocorrelation. Sargan test of overidentifying restrictions has the Null hypothesis that overidentifying restrictions are valid. In parathesis [ ] are standard errors. ***, ** denote statistically significant at 1% and 5%, respectively.

increased number of subscriptions. Roads and airports represent transportation infrastructure. Amazingly, road infrastructure suggests negative growth and productivity effects. A percentage increase in the stock of roads lessens GDP per capita and productivity by 0.06% and 0.01%, respectively. This outcome clashes with our theoretical expectation that an economy can benefit from its stock of roads. Empirically, it is not surprising; Tripathi and Gautam (2010) found similar evidence in the case of India. Most relevantly, our negative coefficient of roads infrastructure is in line with the findings of Canning and Pedroni (2008). They reported pervasively negative long-run effects of transport infrastructure (kilometres of paved roads) on economic growth among African countries. They pointed out that African economies as a group may tend to over-invest in roads such that additional construction could drain resources from other investments and overwhelm the positive impact of road networks, thus leading to negative effects.

Despite the possibility of Canning and Pedroni's explanation, we believe the term "over-invest" requires caution in this analysis. It does not suggest the SSA countries have invested immensely in road infrastructure. Reasonably, given their level of development and excessive reliance on foreign technology, when these countries invest in the construction of roads, there will be a huge drain of public funds and significant sacrifices of other investments while the economic benefits from such constructions will not surpass the costs.

We believe that the key problem in most SSA countries is the lack of a conducive environment (which promotes vibrant economic activity and creates jobs) that ensures the most productive utilisation of the road infrastructure system. It is only in favourable environments that road infrastructure can create economic benefits above their construction costs, including any potential growth "curse" from carbon dioxide (CO_2) emissions. This is most probable when modelling short-run effects. It is also vital to contemplate Canning and Pedroni's (2004:19) observation that "there is a growth maximising level of infrastructure above which the diversion of resources from other productive uses outweighs the gain from having more infrastructure." It is below such a level that the construction of additional infrastructure increases growth while investment above the maximisation level diminishes growth. High transportation costs in SSA are another issue, which is critical, especially in rural areas. Africans face the problem of lack of cheap transport (Mission, 2014). Rural people walk long distances to access transport (e.g. buses, taxis), thus, hindering their ability to visit marketplaces frequently.

The negative growth effects implied by roads may not entirely imply that no countries in SSA are reaping the benefits of their road networks. These elasticities may vary across different states. Lee (2010) shows evidence of this variability and argue that the negative elasticities in other states suggest that the benefits of extra mile road construction do not cover the cost of maintenance.

Besides their unproductive use, we also recognise the idea that road construction may take valuable resources away from other competing production inputs such as land, private capital and human capital (see also Lee, 2010). As a result, this might reduce a country's potential output growth. For instance, valuable resources can be taken away from agriculture (in the form of loss of land, less investment in fertilisers, tractors, irrigation equipment), which has been one of Africa's key sectors, leading to a poor harvest and output growth. Taking away resources from education can lower potential output growth, especially in the long run. Nevertheless, we are mindful that education, agriculture, mining, and other vital activities require a good road network. Consequently, the interpretation of transportation growth elasticities should go beyond the statistical coefficients. Rather, it could be best also to consider the contribution of transportation in the context of "agglomeration economies."[2] Unlike the quantity of roads, the airports' quantity exhibits positive effects on economic growth and productivity, as indicated in Table 3. Airports are crucial for the transportation of both passengers and freight from and to overseas. Airports can also attract other economic activities in the surrounding area.

4.5 Qualitative Infrastructure Effects

Table 4 presents the effects of infrastructure quality. Like the quantitative effects of roads, our results suggest a negative growth effect (-0.08%) coming from the quality of roads. The

[2]However, the key challenge is to measure the externalities from road infrastructure in the entire agglomerated area.

coefficient for the impact of road quality on productivity is just zero with a negative sign (-0.00%). Consequently, we cannot argue that the qualities of roads have impacted output per worker in SSA. One of the possible explanations is the lower proportion of paved roadways in most SSA economies. Most roads have remained unpaved (dust). As demonstrated in Figure 1, the average road quality for the 27 SSA countries in 2014 was about 45%.

Table 4: Qualitative Infrastructure Effects

	Growth model	Productivity model
Covariates	Coefficient	Coefficient
LGDP(-1)	0.232***	—-
	[0,046]	—-
LPRODV(-1)	—-	0.000
	—-	[0.016]
LELEQ	-0.030*	0.000
	[0.018]	[0.003]
LTELQ	-0.018***	0.003
	[0.006]	[0.003]
LAIRQ	0.023	-0.000
	[0.014]	[0.004]
LRODQ	-0.080**	-0.000
	[0.039]	[0.006]
LCAP	0.200***	0.022***
	[0.014]	[0.006]
LLAB	-0.303*	-0.985***
	[0.159]	[0.016]
LTOT	0.303***	0.028***
	[0.045]	[0.005]
LINFL	-0,001	0.000
	[0.002]	[0.000]
Constant	0.033***	0.017***
	[0.003]	[0.002]
Observations	331	331
2nd Order	-0.635	-0.884
(P-value)	(0.525)	(0.377)
Sargan	22.075	21.214
(P-value)	(0.943)	(0.957)

Note: See Table 3 footnotes. ***, **, * denote statistically significant at 1%, 5% and 10%, respectively.

This indicator assesses the quality of roads, ranging from extremely underdeveloped to extensive and efficient (Mo Ibrahim, 2016). Thus, in this case, the roads in SSA are underdeveloped, on average. Few individual countries (such as Namibia, South Africa, Mauritius, Swaziland and Rwanda) have better quality roads, with scores above 70%. SSA needs to invest more in the improvement of roads quality. The potholes that are prevalent in most SSA countries are problematic. For example, in February 2017, the former Zimbabwean President, Robert Mugabe, declared the Harare road network a state of disaster given potholes in combination with rains making some of them essentially impassable (Muzulu, 2017). The coefficient for the effects of airport quality on growth and productivity are not statistically significant. Accordingly, it is a suggestion that these coefficients cannot be emphasised. We believe the poor quality of airports in most African countries might explain why there are no significant benefits derived from the existing qualitative features of the airports.

Our results also suggested a negative effect of telecommunication quality on growth, whereas the impact on productivity is not statistically significant. This tends to reflect the poor quality of the telecom services, as represented by lower scores in most SSA countries (see Figure 1). More specifically, the average telecom quality in 2014 for the 27 countries is about 19% and is the lowest compared to other infrastructure sectors. Except for a handful of economies such as South Africa, Mauritius, Malawi (with scores of 100% each) and Namibia with a telecom quality score of 46%, the quality scores for the rest of the economics are below 30%. This shows the high risk that the information technology infrastructure will prove inadequate to business needs, having applied IT infrastructure quality scores as a proxy. The insignificant contribution of the telecommunication quality on productivity might somewhat be attributed to unproductive use of the emerging mobile advances. Despite several people having access to mobile internet or data services and using these for vital purposes such as marketing and education, the majority may use their devices mainly for social interaction (e.g. via Whatsapp, Facebook, Instagram, Twitter), which barely make any economic input.

Same as the qualities of roads and telecommunication, the quality of the electricity supply in SSA has hurt economic growth and showed no effect on productivity. This result is not startling given the poor electricity quality in the region. We believe the unreliable electricity supply in SSA, which considers interruptions and voltage fluctuations, exert negative pressure on GDP per capita. Over the years 2000-2014, while few countries such as Mauritius, Namibia, Rwanda and South Africa showed average electricity scores of 86%, 85%, 62% and 61%, respectively, the remaining countries have had lower scores. Consequently, the average quality scores of electricity for the 27 SSA countries between 2000 and 2014 had been about 34%, as indicated in Figure 1. Insufficient and ageing power plants that are poorly maintained are problematic. The International Energy Agency (2014) states that the stock of electricity available to users is significantly less than the level suggested by installed capacity, of which poor maintenance is one of the reasons. Transmission and distribution losses lessen the final electricity supply by 20% in other SSA states (International Energy Agency, 2014).

Finally, this study discusses the results of the control variables. Our results suggest that a percentage increase in capital stock stimulates economic growth roughly by 0.2%, whereas productivity increases in the range between 0.01% and 0.02%. These outcomes are in line with our expectations as capital plays a significant role in production processes. Capital, including increased machinery and equipment, can boost workers' productivity, ultimately raising economic growth. An increase in labour supply as indicated by a rise in employment to population ratio, on the contrary, indicates negative growth and productivity effects. As a possible explanation, it could be that labour has been slightly rising in SSA while the stock of capital has generally declined in the region. In the view of the classical school of thought, it may symbolise a scenario whereby increased labour on fixed capital will result in reduced output.

Our results imply that improving the TOT by 1% in SSA can promote economic growth by approximately 0.3% and productivity in the range between 0.03% and 0.04%. Despite this positive impact, the growth contribution of the TOT could be higher when the region improves TOT, possibly by lessening its reliance on exports of raw or primary commodities. While some of the individual countries (e.g. Angola, Cameroon, Chad, Gabon, Nigeria, Mali) may somewhat have experienced improved TOT over the period 2000 and 2014, the TOT for the 27 sampled countries somewhat declined. The IMF (2016) argues that the sharp fall in commodity prices causes serious strains on several SSA countries, with oil-exporting economies (e.g. Nigeria, Angola) encountering challenging economic conditions, so do non-energy commodity-exporting countries such as South Africa, Ghana and Zambia. Also, countries such as Zimbabwe, Malawi and Ethiopia are facing a serious drought. Due to the smaller value of primary products, commodity shocks and fluctuating prices, SSA countries could not realise the full potential growth contribution of TOT.

The effect of inflation on economic growth has the expected sign (i.e. negative). However, the effect is not significant. On the other hand, the effect of inflation on productivity is just zero. It generally implies that changes in the average price level between 2000 and 2014 did not adversely affect economic growth and productivity in most SSA countries. Annual average inflation for the 27 countries slightly decreases. In practice, we cannot dispute that inflation has once affected countries such as Zimbabwe during the period in question. Weak monetary and financial policies were among the reasons for high inflation in Zimbabwe that experienced world-record hyperinflation in 2008. The country was consequently forced into de facto dollarisation and abandoning its local currency.

4.6 Key Policy Implications

It is imperative to consider infrastructure quality when making infrastructure-growth predictions. Infrastructure quality can improve with innovation or deteriorate over time, both with a bearing on economic performance. While the respective governments in SSA still need to invest more in infrastructure quantities, they also need to spend substantial amounts in repairing and upgrading the existing infrastructures. The quality levels of the various infrastructure sectors are not impressive, and as such, it should be a matter of concern.

The negative impact of road quantity on growth and productivity may infer that the roadways in most SSA countries are not networked enough to foster productivity and growth per capita. In this case, the respective governments need to invest more in additional roads. This is the first step in levelling the field for effective movement of goods and services from the hinterland to cities and vice versa. The cost of road construction is driven by existing technology and institutional setups. The materials used for road construction is one-sided. In the abundance of raw materials such as wood, grass, sand and stone, it is quite surprising that African countries have still not found a way out of making way for the proper functioning of cities and countryside. The prevailing technology of relying on asphalt and stones is obsolete. The tendering and procurement processes in the infrastructure business is stinking, with each public infrastructure over-budgeted, over delayed and over-inflated for its good. Weaker governments cannot run stronger institutions. This is law. This is where the turning of the wheel towards sanity must begin. Corrupt systems of government will increasingly give way to cleaner ones. New and alternative sources of construction materials now have a platform to exhibit with the dawn of the Meta Engineering and Construction Corporation. Introducing alternative means of transport, over and above what is known, is key to the next stage of our evolution, and we argue that teleportation, transference among other psychic and non-physical means of transport which are already here, would ease the enormous burden imposed by one-sidedness.

The implication of our findings for the power sector points to prioritising energy and refocusing it to specific productive sectors. This means that all leakages must be closed so that the existing production can be concentrated and distributed efficiently. We believe the electricity sector is not fully benefiting most African economies due to the over externalisation of the sector. It is typically driven by technology and funding that is outside its purview of control. Even though it is clear that electricity preservation strategies such as load shedding do hurt economic growth, they persist nonetheless. It is important to diversify electricity sources rather than relying on the traditional sources of coal and hydro. Chakamera and Alagidede (2018) illustrated the extent to which SSA relies on non-renewable power sources. Universal electrification may require increased attention on solar systems and bioenergy. Renewable energy is fundamental for long-term sustainability. The International Energy Agency (2014) notes that the African continent is endowed with abundant renewable power potential, which entails a greater opportunity. Other scholars (e.g. Al-mulali et al., 2014) indicate that renewable energy could have a greater contribution to growth than non-renewable.

The respective governments should also aim to enhance the quality or effectiveness of the electricity supply. The average electricity quality levels in SSA (refer to Figure 1) are very low. The possible explanations include aged and ineffective power plants in most SSA countries and a rise in electricity transmission and distribution losses. Minimising electricity transmission and distribution losses is central to ensuring efficiency and enhancing electricity output available to the end-users.

Policymakers should also pay attention to the minor growth contribution from the quantities of telecommunication (i.e. increased subscriptions). Despite a colossal escalation of telecommunication subscriptions, mostly from mobile phones, the fragile growth impact may entail that the current growing mobile services are not productively utilised while advancing unrelated-business mobile uses, primarily via social media. Most importantly, when it comes to quantity versus quality of telecom infrastructure in SSA, we recommend that there be much attention on the advancement of telecom quality. Over the past two years, it has become easier for many African people to own a functional mobile phone (at least one subscription). Yet, network connection remains a major obstacle to effective communication in most countries. Increased private participation in the telecommunication sector may improve performance. Among other factors, poor legal framework, the degree of state intervention and weak regulations obstruct the measures that are set to enhance competition and attract investments in the telecommunication sector of developing economies (Paleologos and Polemis, 2013). Consequently, it is crucial to improve the legislation concerning telecom operations in the continent. This should include breaking up the monopoly of the huge telecom companies to allow for competition and better pricing, dealing with corruption and ineptitude in the global telecommunication architecture and injecting proper management and control at the top echelons of the telecommunication industry. Anything short of these requires that the existing telecommunication system cracks up, and with the crevices all over the place, new and more efficient telcos will fill the gaps and offer great customer services and better connectivity. Increasingly, humans will become aware of their own bodies as the ultimate communication device, and with this, the disappearance of the smart devices.

5 Conclusion

The insufficient and poor state of infrastructure in Africa persistently obstructs the continent's productivity and economic growth trajectory. Most African economies are marred with poor road networks, road potholes, unreliable telecom connections and frequent power outages. Few countries have domestic airlines (e.g. South African Airways, Royal Air Maroc, Ethiopian Airlines, Kenya Airways, Air Algerie and Air Mauritius), while most rely on foreign airlines for air services. Although efforts have been made to ascertain the growth impacts of infrastructure, less is still known concerning the implications of infrastructure quality on productivity and economic growth. Misallocation of infrastructure budgets occurs without proper research and understanding of the role that infrastructure quality attributes entail in the development of economies. Given Africa's poor quality of infrastructure, harnessing the full benefits of the existing infrastructure stocks remains a challenge. This study sought to investigate the effects of infrastructure quantity and quality on productivity and economic growth in Africa.

It was established that the quantities of electricity, telecom and airport can boost economic growth. Sadly, road infrastructure quantities exerted negative pressure on growth and productivity. While electricity and airport quantities could trigger productivity, we did not find sufficient evidence that increased telecom subscriptions may influence productivity. As for the qualitative effects, the quality of airports showed no significant effect on growth while the qualities of electricity, telecommunication and roads imply negative growth impacts. Across all the four infrastructure types, none of their quality attributes tended to influence productivity.

The weaker productive and growth effects, and at times negative effects, imply the stress that the inadequate and poor state of infrastructure has on the development of the African economies. The road network is very poor, failing to connect the urban and remote areas effectively. In rural areas, many farmers are still struggling to transport their agricultural inputs and outputs. Africa has stayed for a long, relying on foreign-based solutions, technologies and institutional setup. The light at the end of the tunnel cannot be seen without revolutionising our thinking and considering new and alternative sources of construction materials.

The electricity sector must focus more on improving efficiency and eradicating persistent generation and distribution leakages. The 4th Industrial Revolution technologies like the Internet of Things (IoT), artificial intelligence (AI), advanced drones, machine learning and so on must be incorporated to monitor and account for every kWh closely. Detection of electricity leakages due to a fault, illegal connections and other factors will be prompt.

In terms of telecommunication, it is fundamental to eradicate monopolies of the sector to permit competition and better pricing, injecting proper management and control at the top echelons of the telecommunication industry. This is the only way to achieve better connectivity and affordable services. A few years ago, there was a time when a very simple mobile phone was exchanged with at least one cow in countries such as Zimbabwe. But due to increased competition and supply of phones, those days are history. Ordinary people can now afford even a smartphone.

One fundamental problem that applies to all the infrastructure types is that the charges (transport tariffs, electricity charges, data and phone call charges) are high, and affordability becomes an issue that inhibits people from capturing the potential infrastructure benefits. Most importantly, we conclude that resolving infrastructure challenges in Africa requires establishing robust institutions and governments that do not breed and incubate corruption. The existing corrupt systems must vanish first. Hope is not lost; the critical infrastructure gaps may translate into opportunities when additional infrastructure development leads to greater payoffs.

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Appendix

A1

Table 5: A1: Correlation Analysis

GDP, Productivity and Infrastructure Quantity variables		
	LGDP	LPROD
LELES	0.377	0.292
	(0.000)	(0.000)
LTELS	0.746	0.543
	(0.000)	(0.000)
LAIRS	0.150	0.062
	(0.003)	(0.217)
LRODS	-0,115	-0.225
	(0.022)	(0.000)
LELEQ	0.305	0.330
	(0.000)	(0.000)
LTELQ	0.686	0.597
	(0.000)	(0.000)
LAIRQ	0.422	0.450
	(0.000)	(0.000)
LRODQ	0.465	0.379
	(0.000)	(0.000)

Notes: Particularly for these estimates, the Eviews has been used as it is easy to get the probability values in addition to the correlation coefficients.

A2

Table A2: Data information

Variable	Source
Infrastructure stocks	
❖ Net electricity generation capacity (Blns kWh)	❖ Analyse Africa - below is the primary source: ❖ US Energy Information: International Energy Statistics
❖ Telephones (subscriptions per 100 persons)	❖ Analyse Africa; World Bank Group: WDI
❖ Mobile (subscription per 100 persons)	❖ Analyse Africa; World Bank Group: WDI
❖ Roadways (km)	❖ CIA Factbooks; Photius Coutsoukis
❖ Airports (Total Number)	❖ CIA Factbooks; Photius Coutsoukis
Infrastructure quality	
❖ Quality of electricity supply (Score / 100; 100=best): This indicator assesses the reliability of the electricity supply, taking into account interruptions and voltage fluctuations	❖ Mo Ibrahim Foundation (2016)
❖ Telecommunication quality (Score / 100; 100=best) – proxy Internet Subscribers (ITU): This sub-indicator assesses the risk that the information technology infrastructure will prove inadequate to business needs	❖ Mo Ibrahim Foundation (2016)
❖ Quality of roads (Score / 100; 100=best): This indicator assesses the quality of roads, ranging from extremely underdeveloped to extensive and efficient	❖ Mo Ibrahim Foundation (2016)
❖ Quality of air transport infrastructure (Score / 100; 100=best): This indicator captures the quality of air transport infrastructure and aviation safety	❖ Mo Ibrahim Foundation (2016)
Independent and Control Variables	
❖ GDP per capita ($US)	❖ Africa Analysis - *primary source:* IMF
❖ Productivity -Output per worker (GDP constant 2005 USD)	❖ International Labour Organization
❖ Capital – proxy Gross fixed capital formation (current US$)	❖ World Bank Group: World Development Indicators
❖ Labour – proxy Employment to population ratio, 15+, total (%)	❖ International Labour Organization
❖ Inflation (Consumer prices: Annual Percentage)	❖ World Bank Group: World Development Indicators
❖ Terms of Trade	❖ World Bank Group: World Development Indicators

Notes: Telephone and Mobile subscriptions were summed up to develop a single variable that represents the quantity of telecommunication infrastructure.