INFRASTRUCTURE, INSTITUTIONAL QUALITY AND INFRASTRUCTURE FINANCING GAPS: THE CASEE OF SELECTED AFREICAN COUNTRIES

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By: Blondel Nyamkure

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Supervisor: Dr Nyasha Mahonye

DECLARATION OF AUTHENTICITY

I declare that the research project: Essays on Infrastructure development, institutions and Economic Growth in Sub Saharan Africa (SSA), is my own original work. Each source in the study was acknowledged by a complete reference. Moreover, the Thesis has never been submitted before for any other research purposes other than at University of Witwatersrand.

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Johannesburg, South Africa

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ABBREVIATIONS

AICD	African Infrastructure Country Diagonistic
GR	Government Revenue
IMF	International Monetary Fund
OECD	Organisation for Economic Co-operation and Development
WB	World Bank

ABSTRACT

The aim of this thesis is to examine three related issues around institutions, infrastructure and economic growth of Sub-Saharan Africa (SSA) economies. The first essay (Chapter Two) chronicles the evolution of the SSA region's gaps in infrastructure needs and financing. We observed that the SSA region's infrastructure investment and financing gaps are widening and ballooning over time across the four infrastructure types. We also found evidence of positive and significant correlation between infrastructure quality and institutional quality among a sub-sample of former British colonies in the SSA region, which turn to be weak and insignificant in case of other former colonies. This is also influenced by the influence of the legal origins on the infrastructure development in the SSA region. Also, of interest is the observation that the SSA region's debt is approaching unsustainable level, in which 40% of this debt burden is as a result of leakages through bureaucrats' rent-seeking and managerial inefficiency tendencies necessitated by porous, opaque and weak institutions. This serves as a possible reason why the infrastructure investment and financing gaps for SSA economies is continuously widening over time despite funds; more of their funding requirements are lying idle under mutual management funds' custody, which the region is failing to tape into. Therefore, to close its infrastructure investment and financing gaps, relevant authorities of SSA countries must develop great strong institutions, implement radical structural reforms which crowd-in and promote private sector participation in infrastructure projects. Also, given the complementarity between infrastructure stock and human capital, there is need to massively invest in soft infrastructure such as education and health care.

Due to the conspicuous antecedent literature dearth on the institution-infrastructure nexus, the main thrust of the second essay (Chapter Three) is to estimate the static and dynamic threshold level of institutional quality that will ensure stimulation of infrastructure development through efficient use of public debt (PD), government (GR) financial sector funds (FMD) and services as well as crowd in foreign direct investment (FDI) inflows in a panel of 46 Sub-Saharan African region between 2000 and 2017. For robustness of results, we employed a Hansen fixed effects threshold approach, Fully Modified Ordinary Least Squares (FMOLS) static models and Seo and Shin (2016) and Seo et al. (2019) recent theorized dynamic panel threshold regression approaches as informed by the New Institutional Economics theory. For our estimation approach, we adopted non-linear

asymmetric static and dynamic modeling which gained prominence in recent econometric literature. The dynamic panel data threshold model was estimated using the Seo and Shin (2016) theoretical first differenced Generalized Method of Moments (FD-GMM) estimation technique as operationalized by Seo et al. (2019). Though it varies with the aspect of economic and political institutional quality measure and whether entangled or disaggregated, overall, the results revealed that the effect of institutional quality on infrastructure development is nonlinear, with thresholds ranging between 45 – 90% in the static case and 56 – 82% in the dynamic case. This provides support for the use of a threshold regression model, with institutional quality serving as the threshold variable.

Further probing was done using PD, FMD, GR and FDI as additional transition variables. In terms of the threshold level, the findings show that the index of institutional quality that will ensure the efficient use of infrastructure in stimulating growth is 0.61. The study also found that, on average, most countries in the region are operating below this threshold level, hence their huge infrastructural investment and financing gaps as well as underdevelopment observed in Chapter Two. The conclusion that is drawn from the analysis is that poor institutional quality is one of the factors hampering development of infrastructure of SSA regional countries. Coupled with a huge debt burden, low institutional quality also hinders efficient allocation of funds by financial institutions towards infrastructure development and reduction of FDI inflow to SSA regional economies. Legal origin has also been found to play a pivotal role in shaping the SSA region's state of infrastructure development. The major strength of this study is that the methodology employed for the threshold analysis is exhaustive since it encompasses both static and dynamic panel data models developed for single and multiple threshold(s) value(s). Weak political institutions have been found to be a major drag to SSA's infrastructure development. Thus, it is recommended that governments in the region need to formulate and implement policies targeted at improving the level of economic and political institutional quality in their countries, which can crowd-in both domestic (public and private) and foreign infrastructure investors.

Essay three (Chapter four) examines the non-linear threshold effect of infrastructure, quantity, quality and access on economic growth using a rich and robust sample of 46 SSA countries. The study was provoked by the observation that despite its largest infrastructure investment and financing gaps, the SSA region also scored the least on all infrastructure aspects across the globe. Furthermore, economy growth of SSA economies stalled post the global financial crisis and inequality and poverty trends were on an upward trajectory. From antecedent literature, we identified the following drawbacks: (a) The literature did not determine the minimum amount of infrastructure quality or quantity which is needed to boost growth; (b). Lack of ascertainment on whether infrastructure quality and quantity has a U or inverted U-shaped effect on growth; (c). Though infrastructure access is directly and indirectly linked to welfare issues, inclusive growth and SDGs, it was conspicuously omitted and(d). at the literature did not explore whether infrastructure quantity, quality and access has complementarity or substitutability effect on growth. These issues form the basis and contribution of this study to the body of existing knowledge. Thus, this study strived to close these gaps by employing a static model (Hansen fixed effects) and dynamic model (System Generalized Methods of Moments (SGMM). We found that, firstly, the infrastructure quantity, quality and access have positive effect on growth of the SSA region, with quantity on the top followed by access and lastly quality. Secondly, the three infrastructure dimensions act as complements as opposed to substitutability since combining the three infrastructure aspects yield more growth benefits than their individual effect.

Thirdly, infrastructure quantity and quality have a non-linear U-shaped effect on economic growth of SSA with optimum minima thresholds levels of 60% and 71%, respectively while that of infrastructure quality is linear. Best growth benefits will accrue to the SSA region when the quantity dimension of infrastructure is combining or interacting with both quality and accessibility, followed by quantity and quality and lastly quantity and access. Fourth, relative to the world average benchmark (excluding SSA), the growth benefit of 14.25% per annum accrues to the SSA region if it closes its overall infrastructure gap. In a more granular form, closing the quantity infrastructure gap would deliver higher growth benefit of 8.67% per year, followed by increasing infrastructure accessibility of 3.92% per annum and lastly catching up in terms of quality will raise growth by 1.66% per year. We observed that major contributors were electricity power, road network and improved drinking water. We recommend that SSA governments, development financial institutions (DFIs) and the private sector across the globe, like sovereign wealth funds, pension funds, and insurance companies devote financial resources towards infrastructure investment in the SSA region for it to reach

CONTENTS

List of Tables

List of Figures

Appendices

CHAPTER 1:SSA INFRASTRUCTURE DEVELOPMENT, FINANCING, INSTITUTIONS AND ECONOMIC GROWTH

1.1 Introduction

A good infrastructure is viewed as of paramount importance in fostering growth (Boarnet, 1998), increasing productivity (Aschauer, 1989), lowering firm costs (Nadiri and Mamuneas, 1994), raising international trade flows (Limao and Venables, 2001), opening space for employment creation and reducing inequality and poverty by enabling industrialisation, particularly of developing economies (OECD, 2006; AfDB, 2013, 2018; Calderon et al., 2018). Adequate proportions of infrastructure services in the antecedent academic extant literature dating back to the work of Aschauer (1989) as well as policy debates by World Bank (1994) and IMF (2014) have long been regarded as a pinnacle for economic development. But there is dearth of literature related to evolution of infrastructure gap, financing, and relationship between infrastructural, institutional quality and economic growth of emerging and developing economies (EMDEs), especially in Africa where the problem seems to be more prominent. Recognizing the fact that Africa's weak physical infrastructure base holds back the region's progress towards improved living standards, poverty reduction, domestic and international trade and investment, and socially inclusive GDP growth, in 2005 at the G8 summit leading to the formation of African Country Infrastructure Diagnostic (ACID) program, the international community pledged significant support towards African infrastructure sector (AfDB, 2013). Furthermore, to buttress the value of infrastructure to African economies, the Africa Progress Panel, composed of distinguished members like Kofi Annan, Michel Camdessus and Peter Eigen, has ranked infrastructure development as a key priority for the advancement of the region, and has urged the G20 leadership to continue to give it their highest support.

The financial and technical support was to be directed towards infrastructural financing and harnessing the ever ballooning infrastructure gap across African economies, with the aim of strengthening their institutions and capacity building programmes. ACID (2009) and AfDB (2013) cited inadequate infrastructure as the third most serious constraint of doing business in the African region, after access to finance and corruption. According to Yepes et al. (2008)

and AfDB (2013), despite abundant mineral and other natural resource endowments, Africa, particularly the Sub-Saharan region has the least productivity, which is attributed to serious infrastructure deficiencies across the main four subsectors, namely; communication technology, transportation, energy, water and sanitation. Moreover, the 2009 ACID found that investment in infrastructure accounts for more than 50 percent of the recent improvement in economic growth in Africa, and that it has the potential to achieve even more. These facts made analysing the evolution of African infrastructure gap and financing, the effect of instructional factors on infrastructure and infrastructure-growth nexus, more pertinent.

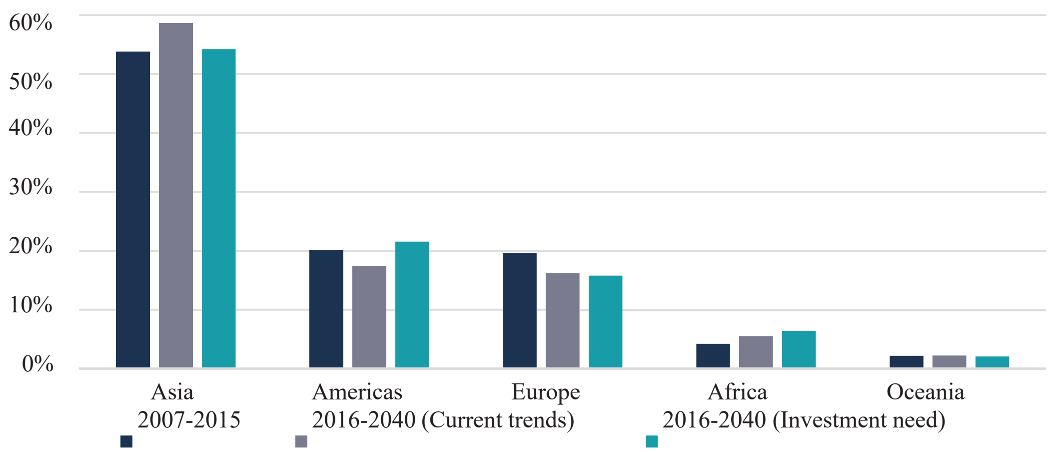
Over the past quarter century, academic research has devoted considerable effort to theoretical and empirical analysis of the contribution of infrastructure development to growth and productivity (Calderón et al., 2018). More recently, increased attention has also been paid to the impact of infrastructure on human development, poverty reduction, inequality, attainment of millennium and sustainable development goals (Estache et al., 2002; World Bank, 2003, 2006; Calderon and Serven, 2004, 2010; AfDB, 2013; Lindy et al., 2016). According to Calderon et al. (2018), an emerging consensus from the literature is that infrastructure development can play a major role in promoting growth and equity — and, through both channels, help reduce poverty under the right macroeconomic and institutional frameworks.

In light of the crucial roles played by infrastructure, this study sought to look at three related issues. The first issue, discussed in Chapter Two, assesses the evolution of infrastructure financing across a select of Sub-Saharan African countries. The second issue, covered in Chapter Three, examines the role of institutional framework on infrastructure investment of SSA economies. The last issue, which is covered in Chapter Four, examines the nexus between infrastructure investment and economic growth of selected countries in the SSA region. Chapter Five provides policy recommendations/implications from the findings on each of the three issues covered in this study. Since no study is exhaustive, Chapter Five also covers suggested areas for further studies.

1.2 Study Background

The estimated global infrastructure investment needs according to the Oxford Economics (2017, 2018) report for the period 2016 – 2040 is approximately $94 trillion, a figure that is 19% higher than what the current trends of investment can deliver, which translates to an annual average of $3.7 trillion. To meet this investment need, against the 3% growth in infrastructure investment as a ratio of the GDP expected under the current trends, the world must raise it to 3.5%. However, the infrastructure investment need requirements are skewed. For example, as per the current status quo shown in Figure 1.1, Asian emerging markets are expected to dominate the global infrastructure market in the future up to year 2040, since compared to the second ranked Americas' 22%, it will account for 54% of global infrastructure needs. Also, only four countries accounting for the larger chunk of the expected infrastructure needs to 2040 will dominate, namely, China, USA, India and Japan, with China accounting for preponderance 30%.

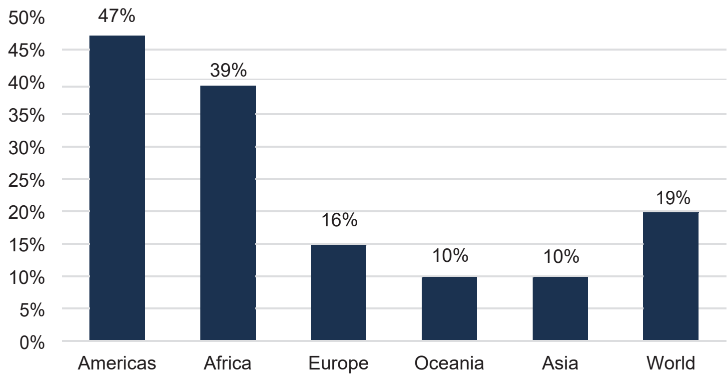
Figure 1.1: Regional Share of Global Infrastructure Investment (2007-2040)



Source: Oxford Economics (2017)

The infrastructure gap, which is a measure of the extent to which the expected investment under the current trends is exceeded by forecasted investment needs, derived from Figure 1.1 is reported in Figure 1.2. As presented in Figure 1.2, the infrastructure gap is largest in the Americas where estimated investment requirement under the current trends is 47% less than Oxford Economics' forecasted investment needs, followed by Africa's 39% over the period 2016-2040. Though with considerable growth potential, having a regional proportion of 6% of the global infrastructure investment needs, irrespective of being the second-largest and second-populous continent, after Asia, African infrastructure market in absolute terms, remains small (Oxford Economics, 2017). Furthermore, if the infrastructure investment gap is expressed as a percentage of GDP, paying attention to figures reported in Table 1.1, Africa with 1.7%, has the highest gap globally.

Figure 1.2: Infrastructure Investment Gap by Region (2016-2040)



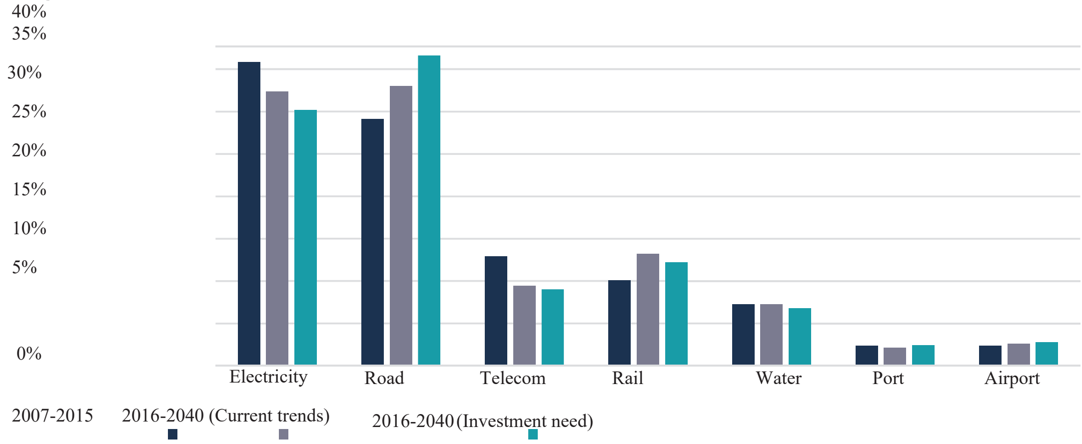
Source: Oxford Economics (2017)

Disaggregating the composite infrastructure investment needs into specific sectors, altogether accounting for more than two-thirds of global needs, Figure 1.3 indicates that roads and electricity are the most crucial sectors. The investment gap is greatest in case of the roads sector, where the investment needs are 31% greater than what would be delivered following the current investment trends. Despite constituting the smallest proportion of the infrastructure investment needs globally, ports and airports, with investment needs of 32% and 26% above current trends forecasts, respectively, also have relatively huge gaps.

Relaxing of the assumption of constant forecasted global GDP growth, the scenario analysis by Oxford Economics' Global Infrastructure Outlook (GIO) in 2018 shows that the infrastructure needs will still be on the higher side. In their report, for example, they explored a scenario where global GDP was to grow by 0.4% points higher for the 2016–2040 duration of forecast and found that for the same period, the total global spending requirements would be approximately 11% or \$9 – \$10 billion more.

The global infrastructure investment needs estimated by the Oxford Economics (2017) report are exacerbated by the need to meet United Nation (UN) sustainable development goals (SDGs) for universal access to drinking water, sanitation and electricity by 2030. These goals mean an additional \$3.5 trillion (0.3% of the world GDP) required leading to 2030. To meet the safe drinking water and waste disposal SDG, \$1.9 trillion investment is required, whereas provision of universal access to reliable electricity, in case of the world's poorest economies, an investment of 3.9 trillion by 2030 will be a daunting task. In reference to Table 1.1, when SDGs requirements are excluded, infrastructure investment deficit as a ratio of the world GP is observed to be only high in the case of roads. When SDGs requirement in included, however, both roads and electricity have an equal gap of 0.3% of the global GDP.

Figure 1.3: Sectoral Share of Global Infrastructure Investment (2007-2040)



Source: Oxford Economics (2017)

At a more specific disaggregated regional level Africa has the biggest deficit of 1.7% of the GDP, coupled with a far much larger SDGs requirement of 3.4% of the GDP needed to meet the UN set goals. Africa's total infrastructure investment gap as a percentage of the GDP of 5.1% is extremely higher than the global infrastructure requirement averaging 0.9%. Thus, to meet their economies underpinning productivity and citizens' needs, countries across the length and breadth of the world, particularly in Africa, need to massively invest in infrastructure.

Table 1.1: Global Investment Needs as a Percentage of GDP (2016-2040)

	CURRENT TRENDS (CT)	INVESTMENT NEED (IN)	GAP (IN - CT)	SDG (REQUIREMENT OVER AND ABOVE IN)*
By Infrastructure Sector				
ROAD	1.0%	1.3%	0.3%	
ELECTRICITY	1.0%	1.1%	0.1%	0.2%
RAIL	0.4%	0.4%	0.0%	
TELECOMS	0.3%	0.3%	0.0%	
WATER	0.2%	0.2%	0.0%	0.1%
AIRPORTS	0.1%	0.1%	0.0%	
PORTS	0.1%	0.1%	0.0%	
By World Regions				
ASIA	4.0%	4.4%	0.4%	0.3%
AMERICAS	1.7%	2.5%	0.8%	0.1%
EUROPE	2.3%	2.6%	0.4%	0.0%
AFRICA	4.3%	5.9%	1.7%	3.4%
OCEANIA	3.5%	3.8%	0.4%	0.0%
WORLD	3.0%	3.5%	0.6%	0.3%

Note: *represent Sustainable Development Goal requirement over the period 2016 – 2030
Source: Adapted from Oxford Economics' Global Infrastructure Outlook (GIO) (2017, https://doi.org/10.1002/pa.2562 2018)

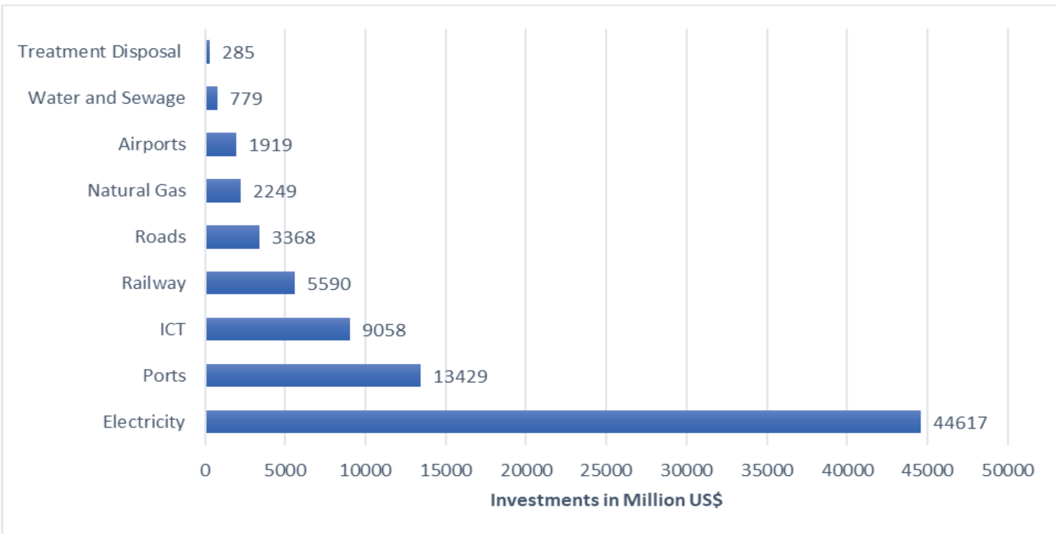
In light of the above background, this study therefore, sought to address three related issues namely, 1) to assess the evolution of infrastructure financing across a select of Sub-Saharan African countries, 2) to examine the role of institutional framework on infrastructure investment of SSA economies and 3) to determine the nexus between infrastructure and economic growth of selected countries in the SSA region.

1.2.1 An Overview on Infrastructure Investment Needs, Institutions and Growth of Africa

The United Nation Development Programme (UNDP) (2014) report indicates that there are 1.2 billion people under abject poverty in the world (consuming below $1.25 per day). Out of this huge number, one in every three resides in Africa. The African Development Bank (AfDB) (2018), in its African Economic outlook report, stated that to fight extreme poverty, inequality and lack of job opportunities for approximately 12 million youths who annually join the labour market, Africa must industrialise. This support academia and policy makers with the same view such as Sachs et al. (2004), Collier (2006), IMF (2014) who advocate for a 'big push' for the region to escape poverty and close the per capita gap with the rest of the emerging and developed world. The AfDB (2018) further argues that the main factor holding Africa back from reaping and enjoying fruits of industrialisation is insufficient stock of productive and quality infrastructure like water, power and transport services, which allow firms to survive in industries with strong comparative and competitive advantages.

In addition, Georgieva (2019) stated that despite strides made in relation to eradication of extreme poverty, improved standards of living, raising life expectancy and economic growth, Sub-Saharan Africa is halfway in meeting Sustainable Development Goals (SDGs), whose focus on infrastructure includes reliable electricity, access to clean water and sanitation. The AfDB (2018) approximated the continent's infrastructure needs to be around \$130 – 170 billion per year, with a financing gap ranging between \$68 and \$108 billion. In the report, it further argued that the new figures were way above the annual infrastructure investment needs and financing gap of \$93 and \$31 billion, respectively, reported by the World Bank and Agence Française de Développement. The AfDB (2018) estimates support the 2018 African projections in Global Infrastructure outlook (GIO) report by Oxford Economics of total actual infrastructure investment of \$4.3 trillion by 2040 (\$170 billion per year). If Africa operates at its full potential capacity or at par with other continents, its infrastructure needs skyrocket to \$6 trillion (\$240 billion per year) (Oxford Economics, 2017), which translates to a difference of \$1.7 trillion (almost 40%). The average infrastructure investment and projects reaching financial closure for the SSA region by sector for the period 1990 to 2019 are presented in Figures 1.4 and 1.5, respectively.

Figure 1.4: Average Infrastructure Investment in Different Sectors within the SSA Region (1990-2019)



Source: Own Computations from Wold Bank – Private Participation in infrastructure (PPI) Database (2017)

The 2015 Infrascope report for Africa by the Economist Inteligent Unit highlighted that to address the ever balloning African infrastructure investment gap, there must be sustainable public-private partnerships (PPPs) in infrastructure, with the private sector playing a leading role due to its monitoring and management efficiency advantage. However, suprisingly, regional infrastructure and projects reaching financial closure since 1990 to date potrayed by Figures 1.4 and 1.5, respectively, fall far below the projections needed to close the SSA infrastructure gap. Public capital spending on instrastructure is much lower compared to the infrastructure needs. This observation is also supported by statistics reported by Mastruzzi (2017) in the case of 24 SSA countries (constituting 70% of the regional GDP) who found sectoral capital spending to be 67%, 15%, 15%, 2% and 2% for road, electricity, water and sanitation, water transport and air transport, respectively. It was further noted that between 2009 and 2015, only a meagre 1.8% of the GDP of the 24 countries was allocated towards building, rehabilitation and improvement of existing infractructre across main sub-sectors. As evidence of possible weak institutional quality and abundance of rent-seeking tendencies rampant across SSA economies hindering project excution, Mastruzzi (2017) observed that overall actual infrastructure spending of 1.8% of the GDP was far less than the amount allocated, which was 3.4% of GDP. This corroborates Calderon et al. (2018)'s observation that across all developing regions, SSA is at the bottom in all dimensions of infrastructure development and performance.

On the infrastructure catergory of the 2012-2013 World Economics Forum's (WEF's) Global Competitive Report, the SSA region scored 2.91 out of an expected highest competitive score of 7. Calderon and Serven (2010) have stated that many SSA countries are landlocked and 40% of region's population resides in the landlocked counries, and due to remoteness, most of the region's economies are detached from global market centers[1]. All these pointers lead to a single conclusion that, irrespective of many countries in the SSA region being landlocked and housing one-seventh of wold's population, there is a severe infrastructure gap holding back its growth prospects, which urgently need to be addressed. The geographic disadvantages of the region emanating from 37% of our select sample of 46 SSA countries not having cheap marine mode of transport result in high transport costs that hinder intra-and-inter-regional trade (Limao and

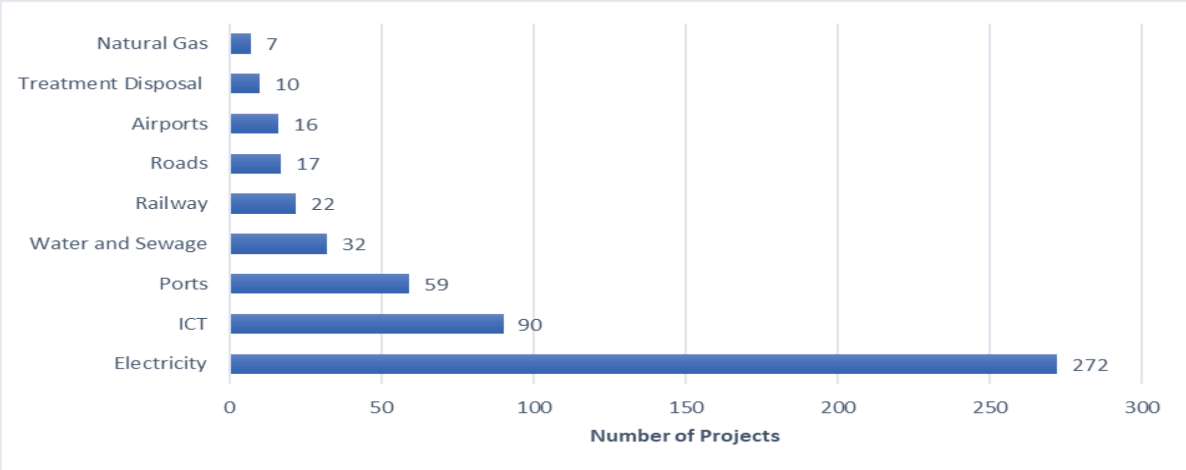
[1] Sixteen (16) of the 46 SSA countries as per United Nation Development program categorized standards are landlocked. These landlocked economies constitute 35% of our sample of SSA countries which are Botswana, Burkina Faso, Burundi, Central African Republic, Chad, Ethiopia, Lesotho, Malawi, Mali, Niger, South Sudan, Eswatini, Uganda, Zambia and Zimbabwe.

Venables 2001; Elbadawi et al., 2006; Behar and Manners 2008). Limited openness to trade due to inability to enjoy cheap marine transport economies of scale and scope is the main factor behind the stylized fact that, ceteris paribus, landlocked countries tend to grow slower than others. However, according to Calderon et al. (2018), adequate transportation and communication facilities can help overcome these geographic disadvantages. The region's problem of poor infrastructure coupled with weak institutions acts as a drag and adds to its geographic disadvantage, which ultimately hinders attainment of its growth potential prospects.

Complementing Figures 1.4 and 1.5, highlights from World Bank's 2019 Public Private Infrastructure (PPI) database for the SSA region indicated that 44 countries have private participation in infrastructure investment out of which 524 projects worth $80 967 million reached their financial closure over the period 1990-2019. Moreover, for the same period, projects canceled or under distress were 51 of the 524, which constitutes approximately 10% of the SSA region's total investment. Interestingly, with 69.8% for ICT and 67.55% for Energy, the Greenfield project was the type of PPI with both the largest share in investment and projects, respectively, compared to other three types of financial or contractural closures namely; Browfield, Divestures, and management and lease contracts.[2]

[2] The definition of financial or contractual closure varies among types of private participation as a result of availability of public information: (a) For management and lease contracts, a contract authorizing the commencement of management or lease service must be signed with the private consortium assuming the operation of the services. (b) For brownfield concession projects, contractual closure is reached when the concession agreement is signed, and the date for taking over the operations is set. (c) For greenfield projects, financial closure is the date that whereby a) there is the existence of a legally binding commitment of equity holders and/or debt financiers to provide or mobilize funding for the full cost of the project; and b) the conditions for funding have been met and the first tranche of funding is mobilized. If this information is not available, the construction start date is used as an estimated financial closure date. (d) For divestitures, the equity holders must have a legally binding commitment to acquire the assets of the facility. Such commitment usually occurs at the signing of the share purchase contract.

Figure 1.5: Infrastructure Projects Reaching Financial Closure in SSA Region by Sector (1990-2019)



Source: Own Computations from Wold Bank – Private Participation in infrastructure (PPI) Database

Table 1.2 presents the ranking of 15 African countries in relation to conduciveness and preparedness of their operating environment for PPPs based on scores on six indicators[3] and overall[4] scores using the 2015 Economist Intelligent Unit's (EIU) Infrascope indices. The range of the conduciveness and preparedness of their operating environment for PPPs is 0 – 100, with a score of 100 representing the best rating. EIU (2015) further categorized the countries' indicators of environment conduciveness and preparedness for PPP arrangements into four broad sub-groups which are: Mature (80 – 100), developing (60 – 79.9), emerging (30 – 59.9) and nascent (0 – 29.9). Surprisingly, based on the overall score, no African country has a developed operating environment which can fully support PPP arrangement. Only South Africa and DRC qualify to have a mature and nascent environment, respectively, while the environment of the

[3] Infrascope Index is a benchmarking tool for 15 African countries which evaluates their capacity and readiness to implement sustainable and efficient concession projects in key infrastructure sectors, principally electricity, transport and water by dividing the PPP project lifecycle into 6 components (The Economist Intelligent Unit (EIU), 2015). The first index, legal and regulatory framework (RF) is composed of four item which are: i) Consistency and quality of PPP regulations ii) dispute-resolution mechanisms iii) fairness/openness of bids, contract changes and iv) effective PPP selection and decision-making. The second one, institutional framework (IF) has only two, i) PPP contract, hold-up and expropriation risk and ii) quality of institutional design. The third indicator, operational maturity (OM) has five items; i) public capacity to plan and oversee PPPs, ii) Regulators' risk-allocation record, iii) criteria and methods of awarding projects, iv) quality of electricity, water and transport concessions and v) experience in electricity, water and transport concessions. The fourth composite index, investment climate (IC) is constituted by three items, i) political distortion, ii) political will and iii) business environment. The fifth measure, financial facilities (FF) is derived from four items, i) government payment risk, ii) debt marketability iii) capital market: private infrastructure finance and iv) government support and affordability for low-income users. Lastly, sub-national adjustment factors (SAF) measures adjustment ability and willingness of sub-national arms of government to the PPP arrangements.

[4] The overall score is calculated by assigning weights on the 6 indicators, namely, RF, IF, OM, IC, FF and SAF of 25%, 20%, 15%, 15%, 15% and 10%, respectively.

other 13 rated countries are categorized as emerging ones. In case of the other six indicators, the categories in which individual countries fall varies much, but generally operating environments of African economies' where PPP specific legislatures are already in place can be categorized as emerging ones. Great care must be taken when generally viewing African economies' operating environment as emerging in supporting PPP arrangements since almost half of 55 Africa countries either do not have specific laws regulating PPPs or have them in place, but they are not yet ratified/operationalized (EIU, 2015; World Bank, 2019). This institutional weakness poses a serious challenge on private participation in infrastructure investment projects, a possible reason why the African growth lags and its infrastructure investment gap continues to widen above other continents of the world and the global average score.

Table 1.2: Indicators for Environment Conduciveness and Preparedness of African Economies for PPPs

Country	RF[5]	IF[6]	OM[7]	IC[8]	FF[9]	SAF[10]	Overall	Std Dev
South Africa	75 (1)	75 (1)	75 (1)	46.4 (14)	91.7 (1)	50 (1)	70.7 (1)	17.3 (15)
Morocco	56.3 (4)	50 (2)	56.3 (2)	59.3 (3)	52.8 (3)	25 (8)	51.8 (2)	12.6 (9)
Kenya	65.6 (2)	50 (2)	40.6 (6)	53.6 (9)	55.6 (2)	25 (8)	51.4 (3)	14 (13)
Egypt	59.4 (3)	50 (2)	53.1 (3)	54.6 (8)	33.3 (10)	50 (1)	51 (4)	8.9 (3)
Tanzania	50 (6)	50 (2)	43.8 (5)	58.1 (5)	38.9 (6)	50 (1)	48.6 (5)	6.5 (2)
Côte d'Ivoire	53.1 (1)	50 (2)	34.4 (9)	58.3 (4)	38.9 (6)	25 (8)	45.5 (6)	12.6 (9)
Tunisia	50 (6)	50 (2)	31.3 (11)	60.1 (2)	44.4 (4)	25 (8)	45.4 (7)	13.1 (12)
Uganda	37.5 (12)	50 (2)	46.9 (4)	52.3 (12)	38.9 (6)	50 (1)	45.1 (8)	6.2 (1)
Rwanda	46.9 (10)	33.3 (10)	31.3 (11)	61.3 (1)	41.7 (5)	50 (1)	43.5 (9)	11.2 (6)
Ghana	50 (6)	41.7 (9)	34.4 (9)	58.1 (5)	38.9 (6)	25 (8)	43 (10)	11.6 (7)
Cameroon	43.8 (11)	25 (11)	31.3 (11)	55.8 (7)	27.8 (14)	50 (1)	38.2 (11)	12.7 (11)
Nigeria	31.3 (13)	25 (11)	40.6 (6)	52.8 (10)	33.3 (10)	50 (1)	36.8 (12)	11 (5)
Zambia	50 (6)	25 (11)	25 (14)	39.2 (15)	30.6 (13)	25 (8)	34.2 (13)	10.2 (4)
Angola	28.1 (14)	16.7 (14)	37.5 (8)	52.6 (11)	33.3 (10)	25 (8)	31.4 (14)	12.3 (8)
DRC	21.9 (15)	16.7 (14)	6.3 (15)	50.1 (13)	5.6 (15)	25 (8)	20.6 (15)	16.6 (14)
Overall	48.9 (2)	40.8 (3)	39.4 (5)	54.4 (1)	40.6 (4)	37.9 (6)	43.8	
Std Dev	14.1 (3)	16.3 (5)	15.5 (4)	5.8 (1)	18.2 (6)	12.9 (2)	11.3	**15.2**[11]

Source: Own Compilation from Infrascope (2015) report by The Economist Intelligent Unit (EIU)

Furthermore, high public debt now reaching unsustainable levels for most SSA region economies, chokes the most expected form of infrastructure investment in this region, namely, public infrastructure investment (Georgieva, 2019). Such costly debt is largely composed of

[5] Regulatory framework (RF) indicator measures the effectiveness of a country's legal and regulatory framework for private participation in infrastructure.

[6] Institutional framework (IF) evaluates the design and responsibilities of institutions that prepare awards and oversee projects.

[7] Operational maturity (OM) measures the government's ability to uphold laws and regulations for concessions, as well as the number and success rate of past projects

[8] Investment climate (IC) indicator assesses the business, social and political environment for investment.

[9] Financial facilities indicator evaluates the ability of financial facilities for funding infrastructure

[10] Sub-national ability factor (SAF) indicator assesses the quality of Sub-national frameworks and experiences in PPPs

[11] The overall standard deviation measures the variations of the six indicators across all the fifteen countries.

domestic and international financial markets commercial borrowing accounting for more than 70% of the region's debt stock increase in the past decade. The study further stated that most public investment spending in the SSA region is unproductive and inefficient. For example, 60% of the region's infrastructure spending translates into public capital stock, which implies that for every \$1 spend, the asset value to be realized will be a meagre \$0.60. The remaining 40% of accumulated debt burden, budgets deficits and unsustainable debts of SSA economies are leakages, possibly through rent-seeking tendencies and inefficiencies in public finance management by bureaucrats. Therefore, the only way of speeding up infrastructure investment and closing the ever-skyrocketing infrastructure gap is through PPPs, which seem to be hindered by weak and porous institutions.

According to EIU (2015), a growing body of international evidence points to the importance of a favourable regulatory environment and robust institutional framework in developing sustainable and efficient PPP infrastructure projects. PPPs benefit much from the leveraging effect strengths of both the public and private sectors such as management and technical know-how from the private sector, and the public sector's abilities to guarantee private investment security and provision of legal and regulatory certainties that private investors require. Following Georgieva (2019)'s observation that most SSA government are financially constrained due to unsustainable debt accumulation levels, to close the infrastructure gap, they can take advantage of financing arrangements that the private sector can provide (EIU, 2015; AfDB, 2018). For example, the AfDB (2018) showed that globally, institutional investors such as sovereign wealth funds, pension funds, and insurance companies have more than \$100 trillion in assets under their management. A small fraction of these excess global savings and low-yield resources would be enough to plug Africa's financing gap and finance productive and profitable infrastructure. But borrowing from the law and finance theory (La Porta et al., 1997, 1998, 2000; Beck and Levine, 2008), to crowd-in the private sector to participate and tape into these excess funds towards infrastructure investment, there is need for a conducive environment, with well-designed policies, laws and regulations that facilitate PPPs. With proper cost recovery, appropriate risk allocation and investor protection through upholding and respecting property rights, PPPs can drive essential infrastructure in constrained government budgets like in the case of the SSA region. As a result, this justifies the need to examine the effect of institutional quality and regulatory framework on infrastructure investment in the SSA region. The International monetary fund (IMF) (2019) report indicated that the SSA region has incurred economic slowdown for quite a long time for almost a decade due to a plethora of factors, which broadly revolve around inadequate infrastructure and lack of required structural reforms.

1.2.2 Institutional Challenges Facing SSA Infrastructure Development and Economic Growth

Sub-Saharan Africa ranked as the lowest scoring region on transparency international's corruption perception index for 2021 as evidenced by the figure 1.6 below.

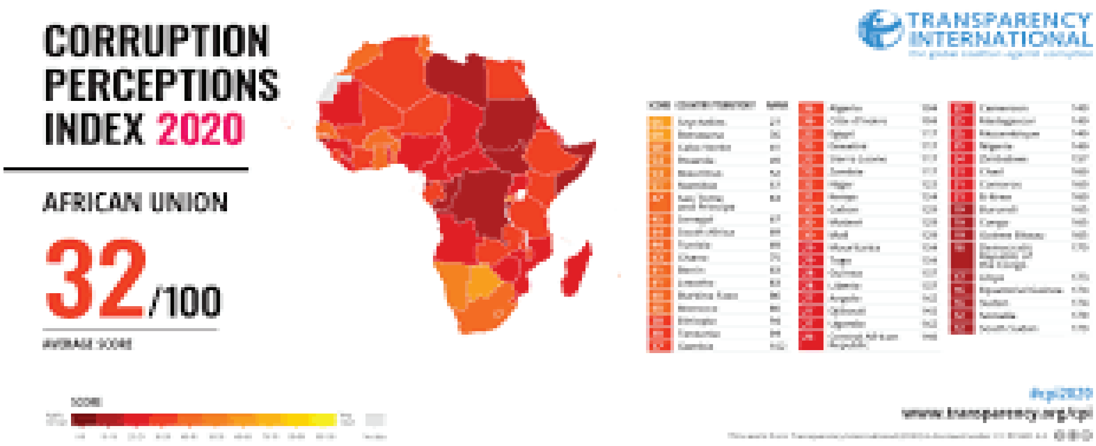


Figure 1.6: The SSA Corruption Perception Index (Source Transparency International) 2021

The international anti-corruption organisation (Transparency International, 2021) Corruption Index ranks 180 countries across the globe by measuring how corrupt each country's public sector is perceived to be. The results are given on a scale of 0 (highly corrupt) to 100 (very clean). A score of less than 50 indicates that a country has serious corruption problems. The Index is used by compliance professionals worldwide as a reference tool for risk assessments, due diligence and anti-corruption training purposes. This years' Index has revealed a stagnation of corruption levels across the world. More than two thirds of all countries scored below 50 and the average global score remained at 43. According to the (Transparency International, 2021) report, such stagnation is reflected in Sub-Saharan Africa, with 80% of countries receiving similar scores over the last 10 years and 44 out of 49 Sub-Saharan African countries scored below 50 and the average score was 33, far below the global average. This high corruption margins retards efforts for infrastructure development and economic growth.

Moreover, according to the same report, Seychelles is an outlier to the rest of the region and performed the best with a score of 70, having increased 18 points since 2012. Whilst countries such as Ethiopia and Angola have shown signs of improvement from previous years, others such as Botswana and Liberia have seen significant declines in scores. South Sudan remains at the bottom of the list. So why have perceptions of corruption remained so poor in the region? Amongst other reasons, (Transparency International, 2021) asserts that authoritarian regimes, weak institutions and unresponsive political systems have undermined anti-corruption efforts. Civil liberties have also been eroded due to the Covid 19 pandemic, and armed conflicts and terrorist threats have exacerbated problems.

As an illustration of the scale of potential grand corruption in the region, Transparency International refers to the Pandora Papers; a leak of almost 12 million confidential documents relating to providers of professional services to wealthy individuals and companies seeking to incorporate offshore entities within low or no tax jurisdictions. The International Consortium of Investigative Journalists' review of these documents found that nearly 50 politicians and at least 5 current or former heads of state from Sub Saharan Africa had connections to offshore entities. In Nigeria alone, over 100 members of the political and economic elite used offshore vehicles to buy properties with a total worth of £350 million in the UK.

In contrast, Transparency International highlights the South African inquiry into state capture, known as the Zondo Commission, and the corruption charges faced by former president Jacob Zuma as an example of positive progress to address corruption. Ultimately, the Index signals that, whist progress has been made in some countries, corruption remains a serious issue in many African nations. Any future steps taken to tackle corruption in individual countries are likely to be part of a longer-term process, and may be hindered by other issues such as armed conflict, coup d'etats, terrorism and the effects of climate change. Therefore as seen from the Transparency International corruption index for SSA, the infrastructure and economic growth of SSA countries was hampered by high corruption resulting in rent seeking tendencies thereby misallocate infrastructure-oriented investments for personal gains (Ndulu, 2014).

However, the (Mo Ibrahim Foundation, 2021) defines governance as the provision of political, social and economic public goods and services that every citizen has the right to expect from their government, and that a government has the responsibility to deliver to its citizens. As such, the foundation noted that the SSA countries especially in the Southern African regional block has improved their governance systems hence scored approximately 53.3% compared to the Western African region 53.1% and lastly Central Africa lowest score of 38.8% as shown in figure 1.7 below. This gives hope for infrastructure and economic growth for SSA region if the other regional blocks in Western Africa and Central Africa can learn and apply governance instruments in their systems.

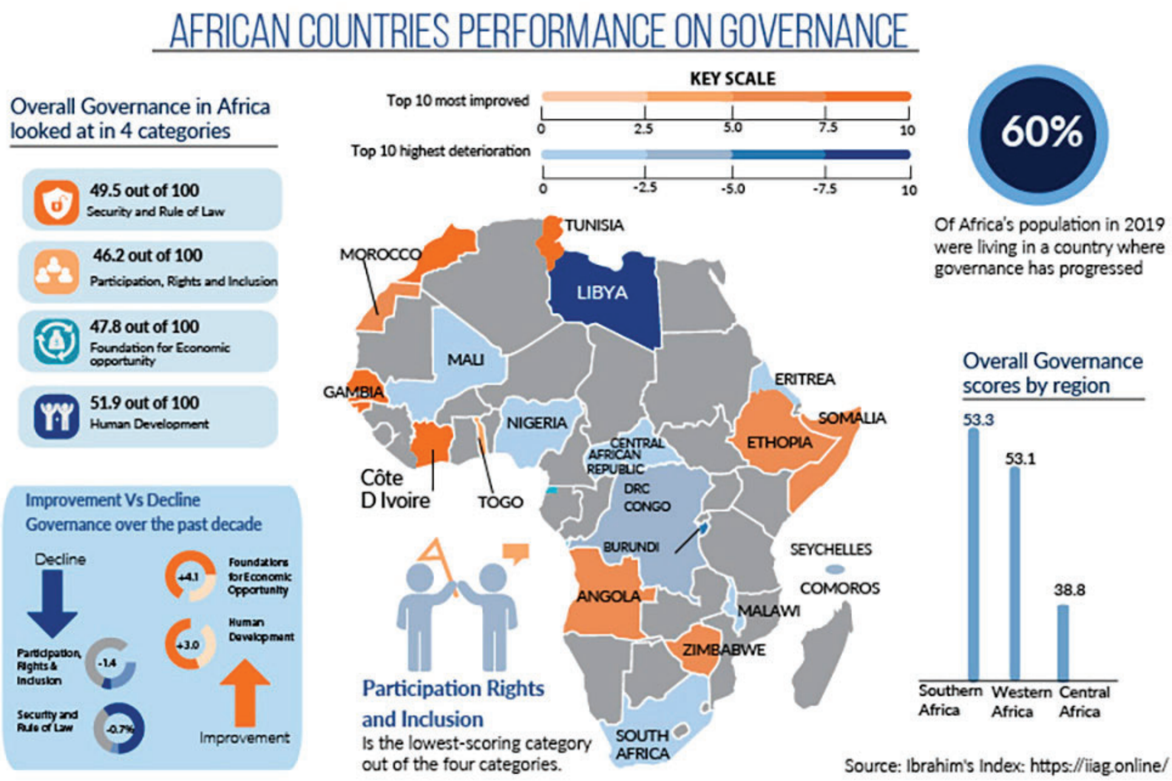


Figure 1.7 African Countries Performance on Governance (Source Mo Ibrahim, 2021)

1.2.3 Evolution of Institutions and Economic Growth in SSA

SSA has been punctuated by traditional institutions (Chief and Headman) before, during and after colonialism that were responsible for the socio-economic-political decisions of their communities regarding any development agenda (Ndulu, 2014). However, these traditional institutions were weakened by neocolonialism in the twenty first century whereby they were replaced by new democratic institutions that were founded on the basis of institutional quality index hence most SSA countries were demanded to abide by the institutional quality for them to benefit from international funding for economic or infrastructure development by the IMF and World Bank (Kaufman et al, 1999). As a result, most SSA countries did not receive adequate training on how to institutionalise their systems effectively and efficiently such that they can successfully implement infrastructure projects successfully that can culminate into radical economic growth in their region (Collier & Gunning, 1999). This resulted to huge deficit of institution to infrastructure impact assessment studies for the SSA region hence the challenge to account for the evolution of institutions and economic growth in SSA (Commander & Nikoloski, 2009). This institution and economic growth evolution was addressed also in the current study in chapter 2 because little is known from literature about how institutions in SSA has resulted to economic growth that finance infrastructure development in the region (Roadrik & Subramanian, 2003).

Moreover, institutions, as defined by North (1990: 6), "… are the rules of the game in a society or, more formally, are humanly devised constraints that shape human interactions. Institutions have been found to affect how efficient an economy is: economies with bad institutions are more inefficient relative to those with good institutions, implying that the quality of institutions is what really matters, and not the existence or non-existence of institutions in an economy (Calderon et al, 2012). Institutions (in the form of property right protection and less distortionary policies) could provide incentive or disincentives to investment and technological development, both of which are proximate causes of economic growth and development. Institutions of poor quality can increase uncertainty, unpredictability, instability, corruption and transaction costs (Zouhaier, 2012). According to Calderón et al. (2012), most emerging and developing countries have relatively low level of high-quality institutions compared to their counterparts in developed countries. Acemoglu and Robinson (2012) opined that many countries are poor and stay poor because of the preponderance of weak economic institutions and corruption, which can mainly be explained from their colonial experiences. In the colonies, sub-optimal institutions were put in place to the advantages to the colonizing countries in the pursuit of their extractive interests.

The surfacing arguments, therefore, is not just a question of whether institutions exist in Africa or not, but if the existing institutions are of the required standards to stimulate economic growth and infrastructure development. There are institutions (economic, political and legal) in SSA, and majority of the countries in the region also practice democracy, which studies have linked to being a stimulant of economic growth and development. There is therefore a concern as to why the African continent, especially SSA, still lags behind; and a much deeper concern about why, if these institutions are seen to be dysfunctional, do they still persist? (IMF, 2020) revealed that the SSA has been growing at an impressive rate for more than a decade now. There should be clear evidence as to whether this growth trajectory is institutionally-induced (fundamental cause) or driven by proximate factors as categorized by Acemoglu and Johnson (2005). Understanding this will, therefore, help countries in the region properly navigate their thinking on how to maintain this growth pace in the face of adverse shocks such as possible FDI reversal and invest their economic growth returns on regional infrastructure development (Ndulu, 2014). Therefore the literature noted that the evolution of SSA institutions and economic growth to determine whether the regional institutions were effective and efficient and supporting infrastructure and economic development in SSA was not well documented in the academic space due to little studies that attempted to close that knowledge gap hence there is huge infrastructure gap in the region thereto (Acemoglu & Robinson, 2012). This study closed that knowledge gap.

1.3 Problem Statement

The background has provided insightful stylized facts, which include Africa's largest infrastructure investment gap compared to other continents of the world, slowdown in economic growth, debt ridden and financially constrained public infrastructure financing mechanisms, weak and in some cases non-existent infrastructure specific policies, rules and regulations possibly shunning away private sector participation. Therefore the problem statement the study seeks to address is the reasons behind poor infrastructure development, financing, institutions and economic growth evolution and threshold effects on infrastructure development in Sub

Saharan African economies. This is so because there is little known literature concerning the evolution and threshold impact of infrastructure finance, investment and institutions on economic growth and infrastructure development concerning the SSA region (Ndulu, 2020) and (World Bank, 2021). As such, the main questions the study will address are: firstly, how has the SSA region's infrastructure investment gap and financing evolved over time? Secondly, does institutional quality threshold(s) has any role to play in promoting or hindering infrastructure development across SSA economies? If yes, what is its optimal threshold? Is it a maximum or minimum threshold? Thirdly, does infrastructure quality, quantity and access has any effect on the economic growth of SSA countries? If yes, what is its optimal threshold? Is it a maximum or minimum threshold?

1.4 Study Significance and Contribution

The background analogue has shown that Africa has the biggest total infrastructure investment deficit across the globe, irrespective of it being the second largest and second populous world region. Also, antecedent extant literature consistently agrees to the view that infrastructure is of paramount importance to economic and social development. From this observation, as a way of trying to demystify the origins of such a huge gap, the first paper in Chapter Two looks at the evolution of infrastructure financing in the SSA region and possible mechanisms to be adopted to close the identified gap. This will enable us to evaluate whether public and private sectors in African countries, especially in SSA, invest in new infrastructure and at the same time maintain the ones left by their colonial masters. In developed economies, where institutions are purported to be strong, there is extensive evidence supporting a positive relationship between institutional quality and infrastructure investment, particularly by the private sector.

On the contrary, in Africa especially within the SSA region, where institutions are viewed to be weak, there is paucity of such literature. As a result, the second paper in Chapter Three investigates the drivers of infrastructure investments within the SSA region, paying special attention to the threshold effect of economic and political institutional quality as potential hindrance or enabler. From the current body of knowledge, we observed the void on the determination of the optimal threshold effect of institutions on infrastructure development using a model that accounts for endogeneity bias, which this study intends to fill. Moreover, related to essay two in Chapter Three, another vacuum we observed in the current literature is omittance of political institutions and legal origins with emphasis on economic institutions only.

In addition, in advanced and emerged economies, literature on the effect of infrastructure investment at the expense of infrastructure development on economic growth is abundant but inconclusive on the sign. Furthermore, such studies done in emerging and developed countries did not capture both quality and quantity of infrastructure when analysing the infrastructure-growth nexus. Moreover, in such analysed aspects, both types of infrastructure, namely, soft and hard infrastructure were not evaluated separately when examining the infrastructure-growth nexus. Given the above deficiencies identified in developed economies case studies and dearth of literature in case of African countries, particularly SSA, the third paper in Chapter Four examines the infrastructure-growth nexus controlling for role played by institutional framework of SSA countries. The uniqueness of this last paper is on the need to identify the optimum threshold where infrastructure yield, either increasing or decreasing, returns to growth in the case of SSA countries and how such a threshold compares well with other selected emerging and developed regions of the world.

All in all, this study contributes to literature in three strands. Firstly, it provides an account of evolution of infrastructure and investment gap in Sub Saharan-Africa (SSA). There is little known information regarding infrastructure investment gap, causes or its drivers, the types of financiers whether private or public. This study closes that gap by updating the literature thereof. Secondly, it unpacks the relationship between institutions and infrastructure development. Again, there are few studies in SSA that were done to examine the relationship between institutions and infrastructure development contextual to SSA, hence the significance of this study. Thirdly, the current study analyses the relationship between infrastructure and economic growth using robust econometrics techniques contextual to SSA and taking into consideration the issue of threshold effect. Therefore, the contribution of the study is threefold.

1.5 Study objectives and research questions

The main broad objectives of this thesis are as follows:

1. To assess the evolution of infrastructure development, investment gap and financing gap of the SSA region.

2. To examine the optimum threshold of institution on infrastructure development of SSA countries.
3. To evaluate the moderating role of institutions on the effect of infrastructure development on the economic development of SSA economies.

1.6 Thesis Outline

The thesis comprises three distinct but interrelated essays, each with its own introduction, literature review, methodology and results. Chapter One has the general introduction to all the three essays. Chapter Two contains Essay 1: Evolution of infrastructure development and financing in Sub-Sahara Africa (SSA). Chapter Three has Essay 2: Effect of Institutional Quality on Infrastructure Development in SSA countries: A Static and Dynamic Panel Data Threshold Approach. Chapter Four contains Essay 3: The Nexus Between Growth and Infrastructure in SSA: A Threshold Analysis Approach. Chapter Five is the overall conclusion and policy recommendations.

CHAPTER 2: EVOLUTION OF INFRASTRUCTURE IN THE SSA REGION AND THE ROLE OF LEGAL ORIGIN

2.1 Introduction

The purpose of this chapter is to unveil the evolution of infrastructure financing gap and infrastructure development in selected Sub-Saharan Africa (SSA) countries. The purpose of this section is to investigate the performance of infrastructure and role of legal origin and income status in the performance of infrastructure. The results in Table 1.1 show that total infrastructure, educational infrastructure, water and sanitation and access to reliable drinking water are significantly different between middle income and developing countries. The evidence in this table attests to the expected trend that middle income performs better than low-to-developing countries in terms of soft infrastructure and combined infrastructure.

Sub-Saharan Africa enjoyed high growth rates that outpaced those of the developed countries for more than two decades. However, economic activity in the region has decelerated and that is explained by a plethora of factors, of which poor infrastructure is a main contributor (Calderón et al., 2018). As a result, the 2018 world economic outlook (WEO) by the International Monetary Fund (IMF) stated that there is a burning need to regain the growth trajectory and momentum amid an external environment characterised by lower global trade and commodity prices that may stay lower than pre-crisis levels for a longer time period. Various stakeholders including experts in academic and policy circles are suggesting a “big push” to help the region achieve inclusive growth, escape poverty, and narrow the income per capita gap vis-à-vis the rest of the developing world (Sachs et al., 2004; Collier, 2006; International Monetary Fund (IMF), 2014). These calls for action are advocating for a wide array of policy agendas and interestingly, all of them have infrastructure development as a serious priority among drivers that can foster productivity and inclusive growth in the region.

Literature and experts are in consensus that infrastructure is a crucial ingredient to foster growth and productivity world-wide, specifically in the developing countries such as the SSA region. The SSA region was the most affected by the post global financial crisis slowdown and it is now in ominous need to continue the growth trajectory and momentum it experienced during the period of the Africa Rising narrative, hence the need to develop its infrastructure base (IMF, period of the Africa Rising narrative, hence the need to develop its infrastructure base (IMF, 2018). According to Oxford Economics (2018), inadequate water and sanitation infrastructure is costing Africa approximately 5% of its GDP, high transport costs add 75% to the price of African goods, and about 30 countries have chronic power outages. All-in-all, underdeveloped infrastructure has been estimated to cost at least 2% of Africa's annual GDP growth. According to the World Economic Forum (WEF) (2019) report, in relation to Sustainable Development Goal (SDG) goal eight (decent work and economic growth), the least developed economies group, in which the bulk of SSA countries fall, has consistently missed the target by 7% since 2015 and by 2030, extreme poverty level will be twice the 3% set target for goal one. This is mainly attributed to inadequate infrastructure. Another crucial evolving consensus in the literature is that, under the right circumstances, an adequate supply of infrastructure can help foster growth in the region (IMF, 2014). According to Aschauer (1989); World Bank (1994), IMF (2014) and African Development Bank (AfDB) (2018), an adequate supply of infrastructure services is viewed as a key ingredient for economic development. Above literally considering adequate supply of infrastructure in SSA, which is a quantity dimension, Chakamera and Alagidede (2017) add a second dimension namely quality, and Calderón et al. (2018) furthermore include a third aspect, being accessibility. Therefore, SDGs and inclusive growth targets can be achieved if quality, accessible and adequate amounts of infrastructure are made available within the SSA region. Thus, this chapter chronicles the evolution of SSA infrastructure and financing gaps overtime.

According to Oxford Economics (2018), SSA ranks at the bottom of all developing regions in virtually all dimensions of infrastructure performance such as transport, energy, telecoms and water and sanitation. SSA, which accommodates approximately one-seventh of the world's population, on the WEF's (2019) fourth industrial revolution (4IR) overall Global Competitiveness Index (GCI 4.0) scale of 0 – 100 scored a paltry 46.3 against a global leader (Singapore) and world average scores of 84.8 and 60.7, respectively. Major contributors to SSA's dismal 12 pillar based overall GCI 4.0 index across all global regions are both hard and soft infrastructure based on three-pillars, namely health (soft infrastructure), ICT adoption and infrastructure (hard infrastructure). Higher significant cross-regional gaps from the optimal frontier score of 100 over the overall world gap between best-and worst-performing countries of

28 noticed in respect of the afore-mentioned three pillars are 38.4, 36.2 and 34.7 (WEF, 2019). From this least and much below average score, one can clearly deduce that there is a severe hard and soft infrastructure deficiency more pronounced and prevalent across SSA that needs to be dealt with as a priority if the region is to have any meaningful development. According to Calderon and Serven (2010), the region has some inherent characteristics that may facilitate the potential role of infrastructure for its economic development namely: The large number of landlocked countries, which are home to a major proportion of the region's total population (about 40%), and the remoteness of most of the region's economies from global market centres. This supports and shows how pertinent and urgent the need to unravel how the infrastructure and financing deficiency emanates and evolved overtime using SSA region as a laboratory.

Limao and Venables (2001); Elbadawi et al. (2006); Behar and Manners (2008) are of the view that the geographic disadvantages of most SSA region countries result in high transport costs that deter intra, inter-regional and international trade. Limited openness to trade is the main factor behind the stylized fact that holding other things constant, landlocked countries tend to grow slower than others (Limao and Venables, 2001). Given these drawbacks, adequate transportation and communication facilities are viewed as a breakthrough since they can help overcome these geographic disadvantages. If these are not dealt with, the result will be slow or negative growth. We feel the examination of the possible linkages between infrastructure and micro-and macro-economic sectors, which is more prominent in the extant literature, without chronicling and unravelling how the infrastructure and financing deficiency originated and evolved overtime is inadequate. Therefore, as a contribution to the existing body of knowledge, this chapter seeks to diagnose how actual physical stock infrastructure and financial needs deviate from the potential amount required over time.

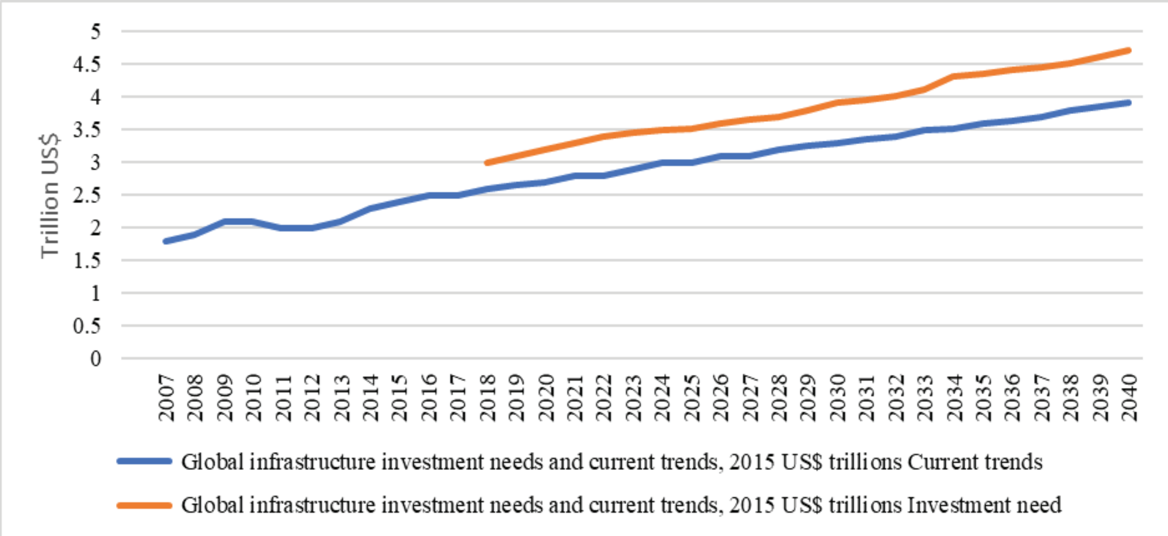
In the previous research work, a pattern can be seen were academic researchers have devoted considerable effort to theoretical and empirical analysis of the contribution of infrastructure development to growth and productivity and in virtually all cases, a positive relationship has emerged (Estache et al., 2002). In the early and late 2000s, more attention has also been paid to the impact of infrastructure on inequality and poverty (Estache et al. 2002; World Bank 2003, 2006; Calderon and Serven 2004, 2010). There is also an emerging consensus from the literature, which suggests that under the right conditions, infrastructure development can play a major role in promoting growth and equity—and, through both channels, help reduce poverty (Estache et al., 2002).

Despite all the slowdown in growth, underdeveloped and deteriorating infrastructure, it is also imperative to note that Africa also has a unique opportunity to develop its infrastructure in a sustainable manner that can boost productivity and growth to catch up with world standards. Using the vast minerals and human capital that the continent has, SSA could leapfrog to new, sound infrastructure, drawing on the best innovations from all over the world. SSA can also have benefits such as increase in productivity, especially in manufacturing and service delivery if it develops adequate and efficient infrastructure. There are also multiple effects that come with infrastructure development such as the creation of many jobs, increase in attractive investment opportunities, and encouraged efficient use of natural resources (Global Infrastructure Outlook (GIO), (2018)). Moreover, improved infrastructure will also contribute to social development in the areas of health and education and reduce societal inequalities through a more equitable distribution of national wealth (GIO, 2018).

2.1.1 Chapter Background

According to G20's 2018 GIO Report, global infrastructure investment gap is set to grow to US$14 trillion by 2040 (see Figure 1.1). Looking at 2018 figures alone, the global investment gap grew by over US$400 billion. Measuring, keeping records and giving updates of an infrastructure investment gap of the world at large and of various regions provides an ambitious target for governments looking to improve the provision of infrastructure in their country (Chartered Professional Accountants Canada (CPA), (2018)). From a global perspective, narrowing down to individual countries, the investment gap approach also reveals that many countries such as Mexico, Myanmar and Brazil are facing substantial and growing gaps (CPA, 2018). This is not unique to the few above-mentioned cases, SSA is the region with worrying trends, which need to be attended to with urgency. The SSA countries and region may benefit from looking at other countries for good practice and novel methods of meeting infrastructure need (CPA, 2018).

Figure 2.1: Global Infrastructure Investment Needs and Current Trends (2007-2040)



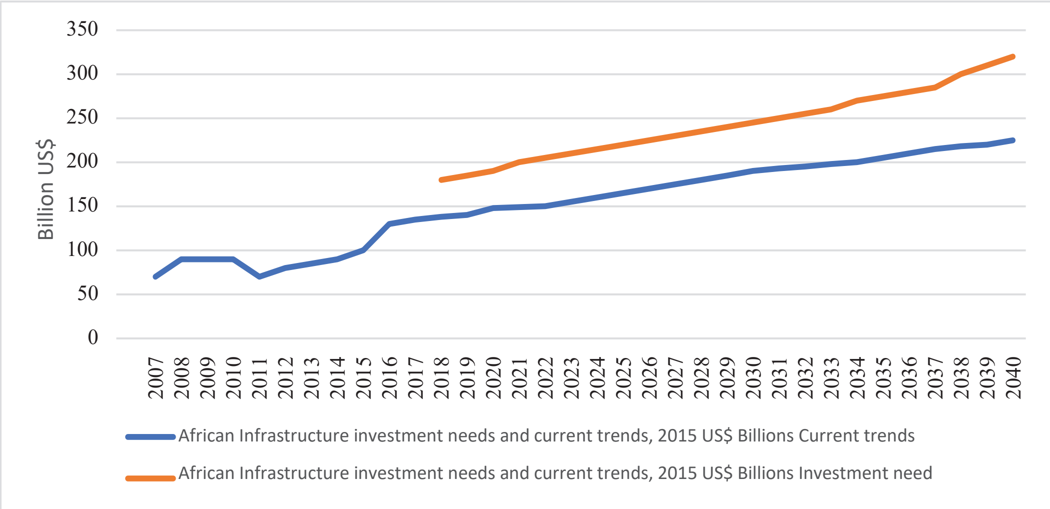
Source: Oxford Economics (2018)

According to Oxford Economics (2018), during the year 2018 alone, approximately US$132.8 billion was spent on infrastructure in Africa and it is estimated that US$177.7 billion of investment is required in the region to meet all infrastructure needs and that puts the infrastructure investment gap at US$45.5 billion. Furthermore, the 2018 Oxford Economics estimates show that between 2018 and 2040, the African infrastructure investment gap is expected to stand at US$1.59 trillion, with the amount of infrastructure investment needed expected to be 39% higher than under current trends (see Figure 2.2).

2.2.2.1 Total Infrastructure Spending Needs in Africa

GIO (2017) show that if the current trends continue, holding other things constant, the total infrastructure investment forecast for Africa is estimated to be $4.3 trillion, which translates to $174 billion per year by 2040. In addition, if SSA economies were able to raise their performance to match that of their best performing peers the total investment need would be US$6.0 trillion or US$240 billion per year, a difference of almost 40% (GIO, 2017). GIO (2017) estimated that since 2007, the major beneficiary of infrastructure investment categories has been the energy sector with 38% of investment in Africa directed towards the electricity sector and 20% going to water. Electricity has received much share compared to other infrastructure investment vehicles because most African countries are trying to steer their growth through primary production which in nature is energy intensive. Surprisingly, from our literature observation, it is glaring and persistent that much quantification on infrastructure and financing needs is biased towards hard infrastructure such as transportation, ICT, energy, water and sanitation while that of soft infrastructure like education and health are conspicuously absent.

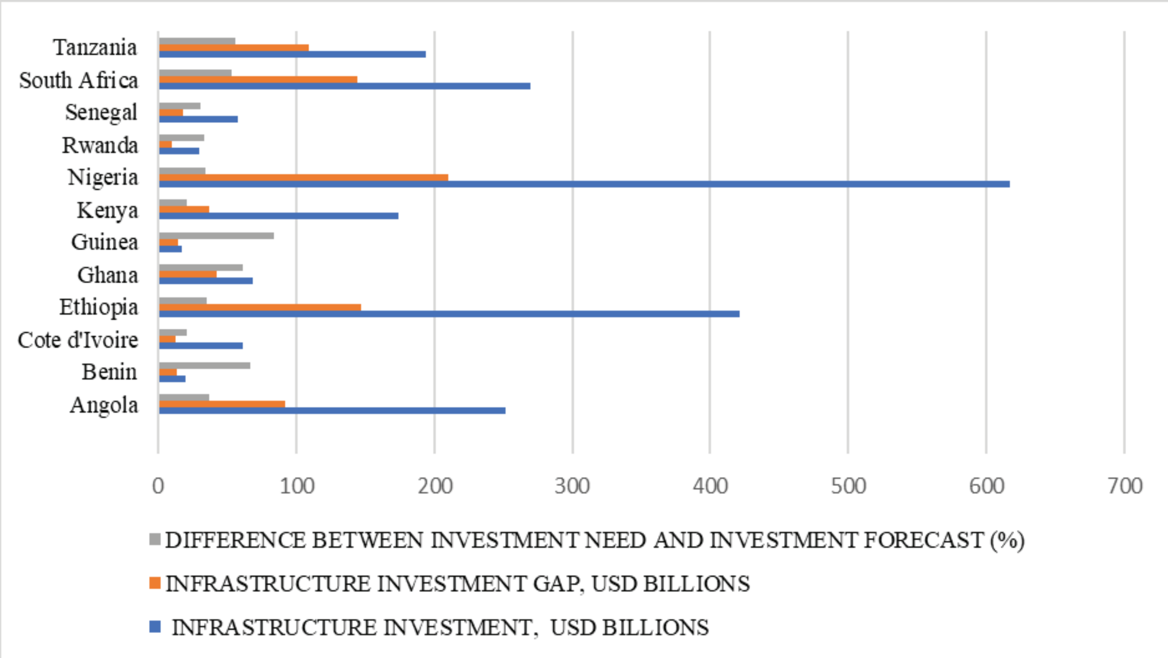
Figure 2.2: African Infrastructure Investment Needs and Current Trends (2017 - 2040)



Source: Oxford Economics (2018)

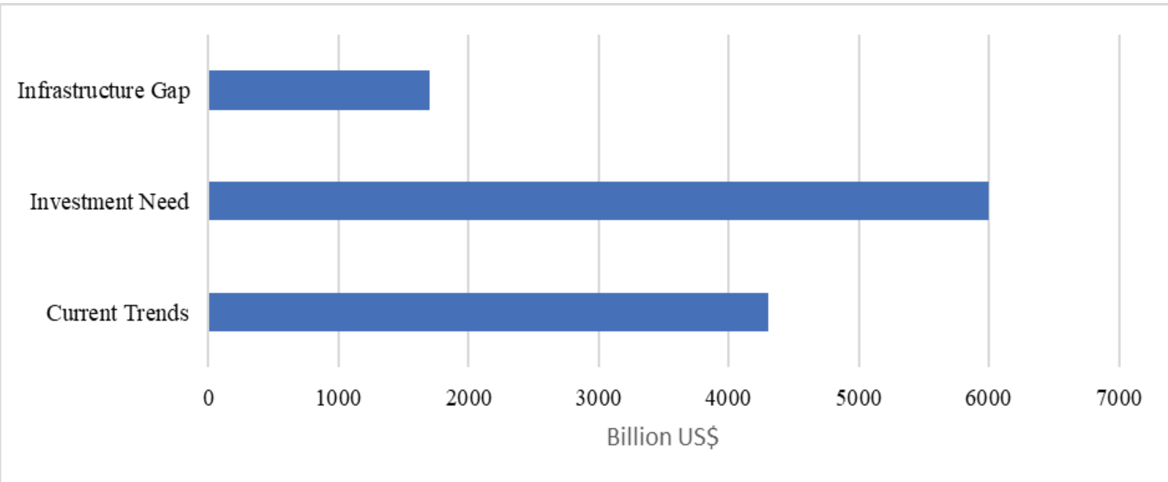
Narrowing down to individual SSA countries, a pattern can be seen to emerge where highly populated countries such as Nigeria (US$ 210.3 billion), Ethiopia (US$ 150.00 billion) and South Africa (US$ 144.2 billion have the largest infrastructure investment gaps.

Figure 2.3: Infrastructure Investment Gap Among Selected SSA Countries (2018-2040)



Source: Researcher's compilations from Oxford Economics Data

Figure 2.4: Total SSA Investment Needs and Gap in Billion US$ (2016-2040)

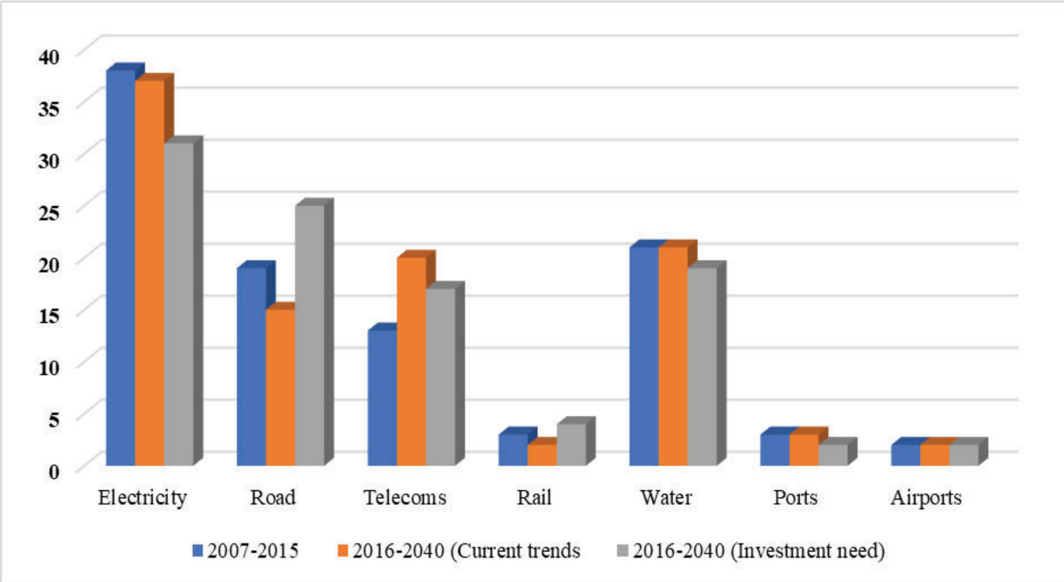


Source: World Bank, World Development Indicators.

2.1.1.2 African Investment Patterns by Sectors

The bulk of investment may be directed to the energy sector, particularly electricity, the share of investment dedicated to water infrastructure is more than twice the world average (GIO, 2018). These trends are a result of longer periods of SSA lagging back and other developed countries almost reaching 100% access to most infrastructure.

Figure 2.5: Trends of SSA Infrastructure Investment Patterns by Sector (2007-2040)

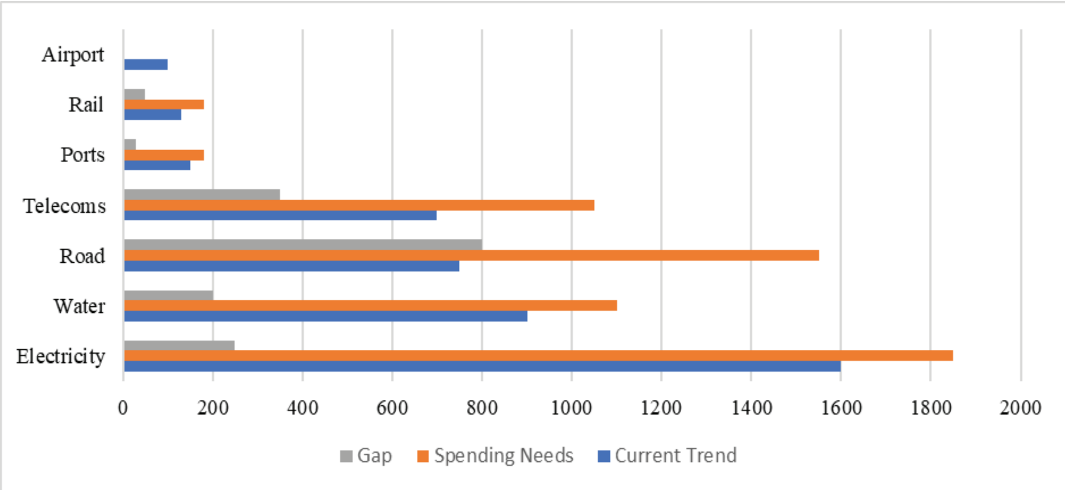


Source: IMF (2018)

On the other hand, despites 30% of SSA countries being landlocked, Africa dedicates a below average proportion of investment to the transport sector. The transport sector accounted for 27% of the total between 2007 and 2015, compared to the world average of 45% (WEO 2018) (refer to Figure 2.5). Rail is one of the three sectors that are receiving less share of investment since it received only 3% of the investment share during the same period, compared to the world average of 12%. WEO (2018) projects that the distribution of infrastructure spending is expected to remain broadly similar under both actual and forecast states, although the transport sector shoulders greater prominence under the investment need situation.

In actual US dollar values, energy, particularly electricity, is projected to receive approximately US$1.6 trillion of investment between 2016 and 2040 if the current trends hold, with water, roads and telecoms each receiving and average of US$800 billion. Figure 2.6 shows that, the gap between the current trends and investment need scenarios is proportionately largest for roads, where the investment need forecast is almost twice the current trends forecast (GIO, 2018).

Figure 2.6: SSA Infrastructure Spending Needs by Sectors



Source: GIO (2018)

2.2 Problem Statement and Study Objectives

It is imperative to note that literature has done quite a good job in bringing to the surface the importance of infrastructure to economic development. However, there have been relatively few attempts to track, monitor and give explanations of infrastructure investment, needs, financing and gaps across regions and less developed countries such as in the SSA region where the problems are more prominent. Most studies have concentrated on the subject either at a global scale and rich and/or developed country level. Given the importance of infrastructure development as a crucial tool in driving growth particularly in the SSA region, it is a matter that needs attention and one needs to track the genesis of the current status s to be in a better position to map the way forward. Where studies have assessed global infrastructure needs, it was done mainly using more heterogenous mixtures of developed, emerging and developing economies. Moreover, through such analysis, the adoption of myriad definitions and approaches has made it difficult to monitor trends over time on a consistent basis using a more homogeneous sample of countries.

Furthermore, a few researchers have managed to provide detailed forecasts for individual countries in SSA and sectors and go on to explain the reasons behind the trends (Druker, 2003) and (Estache, 2016). Also, in the case of SSA, there is paucity of a more detailed, chronological diagnosis of infrastructure and financing gaps on both hard and soft infrastructure dimensions. SSA lacks detailed and consistent historical infrastructure data and that creates problems in forecasting how, where and when infrastructure investment will be needed, and that confusion affects the region's growth prospects. As a result, it becomes difficult for both local and foreign investors to identify where there is likely to be strong demand in future. Regrettably, this information opaqueness has been one of the key reasons why the region has received little funding, in cases where funding has been accessed, it has gone to wrong sectors at the expense of needy sectors. Therefore, these observations have provoked and formed the basis of this chapter.

2.3 Study Objectives

This chapter seeks:

1. To examine the evolution of SSA infrastructure investment and financing needs and gaps.
2. To chronicle the SSA region's hard and soft infrastructure changes over time.
3. To assess infrastructure quantity, quality and access in the SSA region.
4. To correlate the relationships between soft and hard infrastructure components of SSA countries.

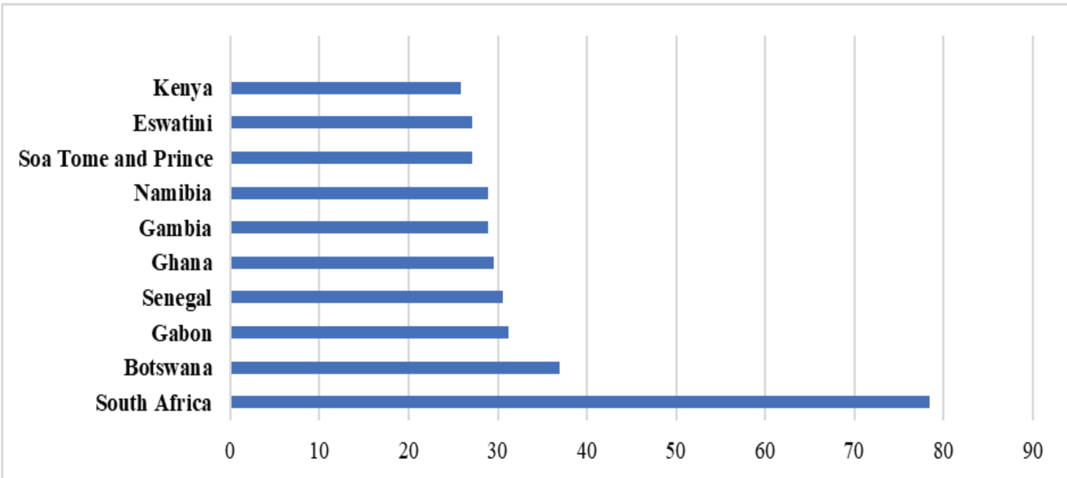
2.4 Study Significance

The study has been provoked by the observation that there is scant compressive and detailed literature evidence on the evolution of the SSA region's infrastructure investment and financing gaps which seem to be burgeoning over time. Possible linkage between infrastructure and legal origin is conspicuously absent in the current body of knowledge. Thus, this chapter intends to address these knowledge gaps. The study documented the historical SSA infrastructure trends, gave explanation to the trends and asked how much the SSA region needs to spend on infrastructure in the years to 2040 and which sectors this investment will be required. The researcher grouped countries according to the ones that seemed to be doing right and the ones that still had to do more on the infrastructure arena. In addition, the study also examined the individual role played by public, private, public private partnerships and the correlation between public and private investment in SSA. The researcher expected to have some challenges such as lack of consistent source of SSA data on infrastructure investment by region, sector and country. To go around this drawback, the researcher made use of various sources of data to come up with verifiable data. The outcome of this chapter is to help infrastructure and development financial institutions identify specific infrastructure sector requirements. This will afford them a chance of efficiently allocating their scarce financial productively in infrastructure. This will also provide governments of SSA countries a detailed diagnosis on their infrastructure requirements which are possible stalling or retuning their economic growth prospects and provoke them to device ways on how to tape into unutilised trillions of sovereign funds held by mutual funds across the globe.

2.5 Historical and Current SSA Infrastructure Trends

This section documents the evolution of infrastructure in SSA over time from the pre-colonial and post-colonial era. Despite governments effort to revive it, the infrastructure network in SSA remains poor compared to the rest of the world. On an infrastructure scale that ranges from 0 (worst infrastructure) to 100 (best infrastructure), only one country, South Africa goes beyond the half mark with a score of 78.43. The second country on that index is Botswana with a score of 36.96 (see Figure 2.7).

Figure 2.7: Top 10 SSA Countries on Infrastructure Development (2019)



Source: Oxford Economics (2019)

To measure and compare the performance of infrastructure sectors in SSA countries requires the assessment of economic infrastructure across three dimensions namely: quantity, quality, and access. To picture where SSA is on the infrastructure investment arena, the researcher used a comparative perspective. In most cases, the researcher used different comparator regions, namely: The Middle East and North Africa (MENA), East Asia and the Pacific (EAP), South Asia (SA) and Latin America and the Caribbean (LAC). In other fewer cases, the researcher examined the infrastructure trends across income groups in the region including upper-middle-income countries (UMCs, low-income countries (LICs) and lower-middle-income countries (LMCs).

2.6 Physical Measures of Infrastructure: Trends in Quantity, Quality and Access

A comprehensive and detailed analysis on the evolution of infrastructure in SSA requires an evaluation of all different sectors, namely, energy, telecommunications, transportation, water and sanitation. Accomplishment of this task demands a deeper dive within each sector's diagnosis and where data allowed, the researcher examined infrastructure trends in terms of their quantity, quality, and access. Time series availability and country coverage across the different indicators of infrastructure are heterogeneous. Table 2.1 gives a summary of the indicators that are used to examine the performance of infrastructure in SSA.

Table 2.1: Infrastructure Performance Indicators

Dimension	Energy	Transport	Water & Sanitation	Telecommunication
Access	-Access to Electricity (% people)		-Access to safe water (%people) _Access to sanitation facilities (% people)	
Quality	-Energy quality (%) -WEF quality of power supply	-Paved roads (%) -WEF quality of roads -WEF quality of railroads.		-International Internet bandwidth -Number of secure servers
Quantity	-Electricity-generating capacity	-Total road length -Total railroad length		-Telecommunications density -Internet density -Fixed broadband

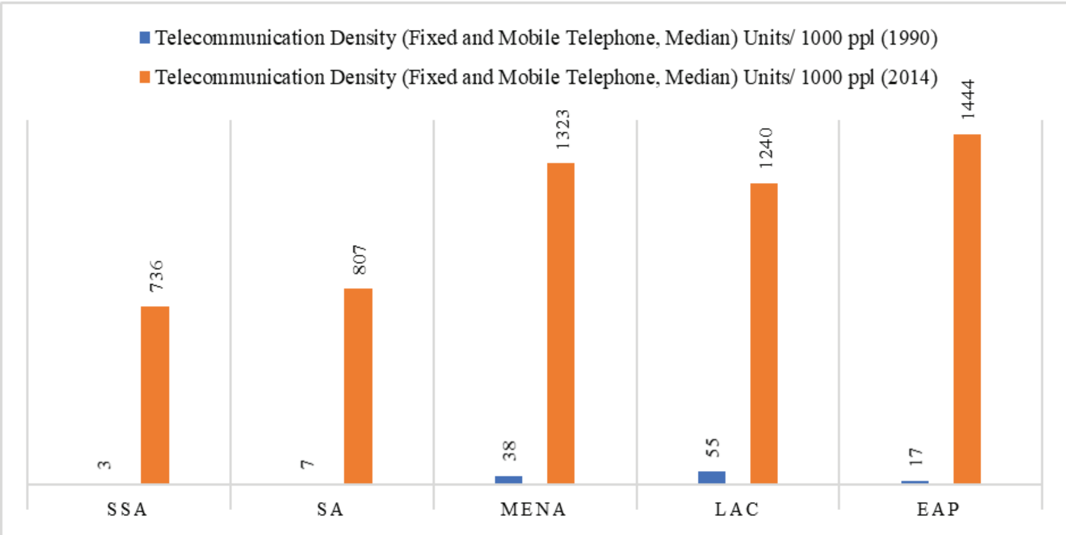
Source: World Economic Forum and World Bank

2.6.1 Infrastructure Quantity

2.6.1.1 Telecommunications

Due to technological breakthroughs in the mobile cell phone industry that made mobile phones cheaper, affordable and user friendly and the encouragement by the proponents of financial inclusion, SSA has witnessed a histrionic shift in telecommunication density over the past quarter century. According to the International Telecommunications Union's World Telecommunication/ICT indicators (2015), the median number of fixed and mobile phone lines per 1,000 people has risen sharply, from approximately 3 in 1990 to 736 in 2014 (see Figure 2.8). This case is not only unique to SSA, since one can also observe a similar trend in other benchmark regions in the world, reflecting the global nature of the boom in mobile phone technology. In contrast, the telecommunications density among regions from the World Bank's 2017 Africa's Pulse indicates that despite a surge, SSA is still far behind other regions.

Figure 2.8: Telecommunication Density by World Regions



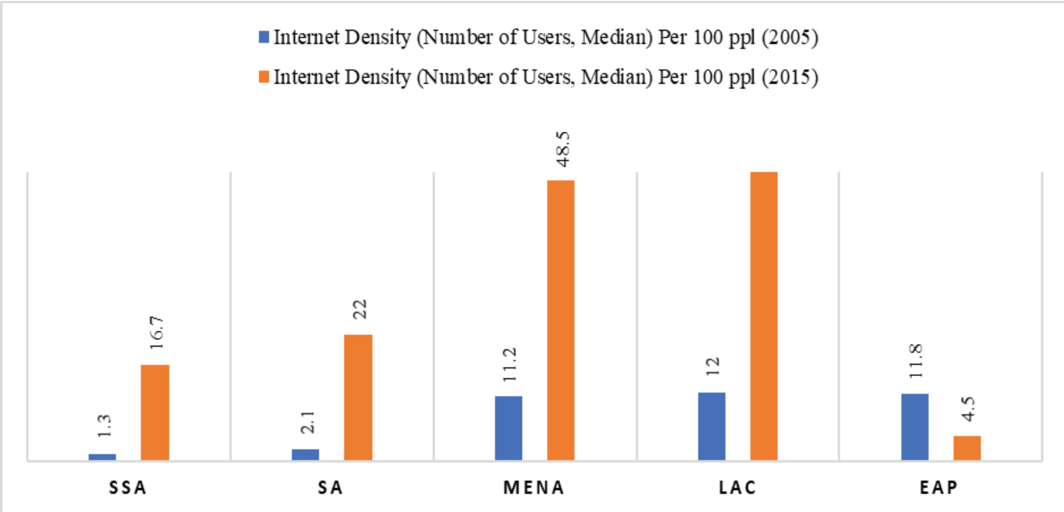
Sources: International Telecommunications Union's World Telecommunication/ICT indicators

Notes: EAP-East Asia and Pacific, LAC-Latin America and Caribbean, MENA-Middle East and North Africa, SA-South Asia and SSA.

"While Africa's information and communication technology (ICT) market is still relatively immature, robust economic growth, population boom, rapid urbanisation, an emerging middle class, strong competition among providers, and the increasing affordability of mobile devices have propelled it to grow dramatically in recent years" (World Bank, 2017 p. 46). Considerable development aid has been channelled to the ICT sector in Africa in an attempt to foster growth through financial inclusion. In the same vein, private investment amounted to US$50 billion over the last decade (GIO, 2017).

Due to coordinated efforts by the United Nations, the World Bank and other private investors, Africa has become number one at growth and the second largest mobile phone market in the world (World Bank, 2019). According to GEO (2017), 8 out of 10 Africans have a mobile phone, amounting to 760 million mobile subscriptions, up from only 15 million in 2000 across the continent and this pace is expected to continue over the next 5 years, with the number of subscriptions projected to cross the one billion mark by 2016. Between 2010 and 2013, the average penetration rate has also risen from 37% to 80% and is still growing at a pace of 4.2% yearly.

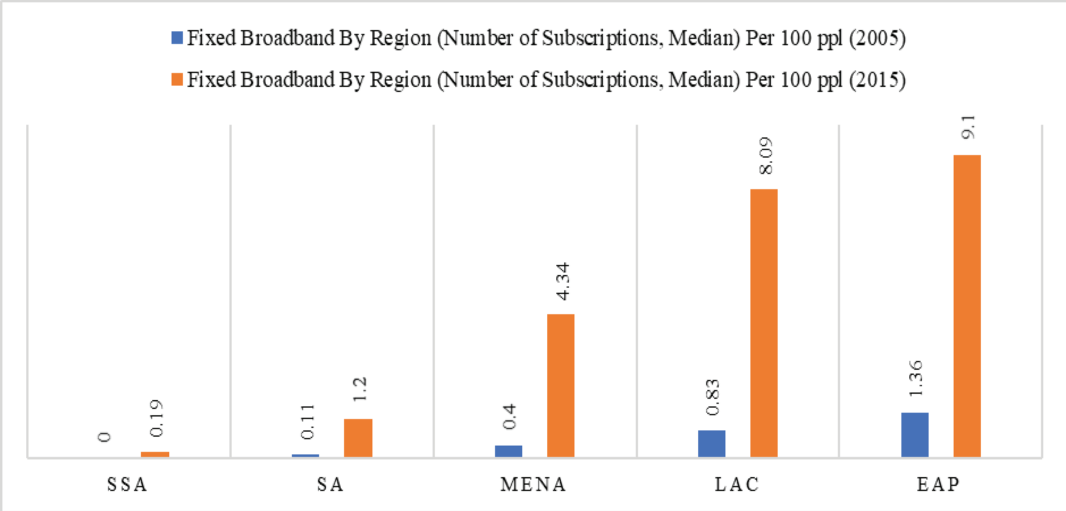
Figure 2.9: Internet Density by Region



Sources: International Telecommunications Union's World Telecommunication/ICT indicators

IMF (2018) suggested that Africa's data network has been boosted through the rapid spread of submarine data transmission cables, bringing significant international bandwidth within reach of many Africans. Africa's Pulse (2017) by the World Bank indicated that people who use the internet increased from four million in 2000 to 197.6 million in 2012 and broadband coverage increased from a meagre 0.1% of the population in 2005 to 16% in 2012.

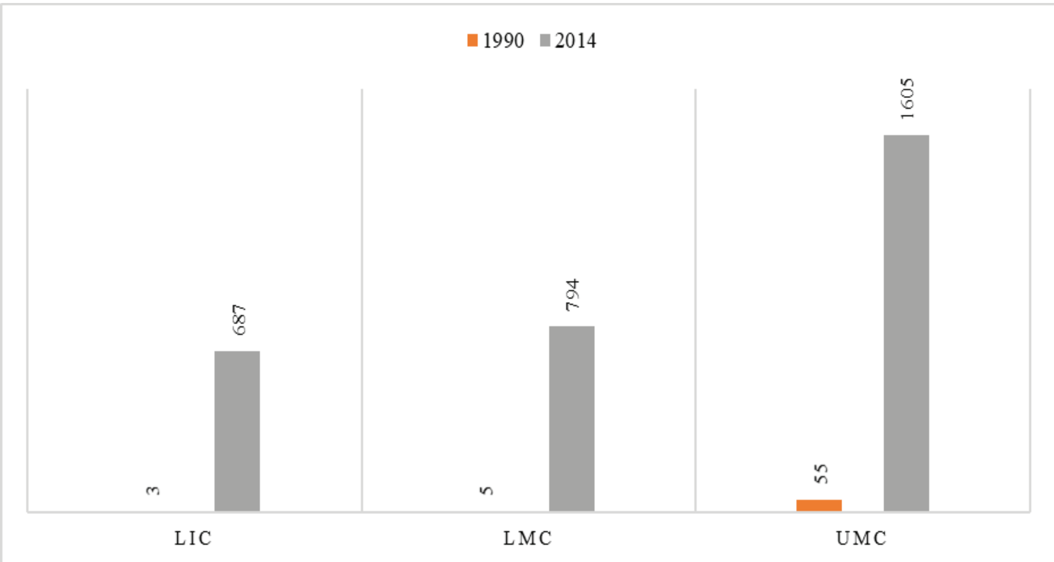
Figure 2.10: Fixed Broadband by Region



Sources: International Telecommunications Union's World Telecommunication/ICT indicators

It is estimated that there will be a sharp increase such that by 2060, 99% of the population will be having internet access. This is more likely possible because the internet is increasingly accessed through mobile phones (IMF, 2018). Of the world's total internet traffic, Africa's mobile data usage amounts to 15%. For specific countries such as Kenya, about 99% of internet users get it through mobile phones.

Figure 2.11: Telecommunication Access in SSA by Income Group

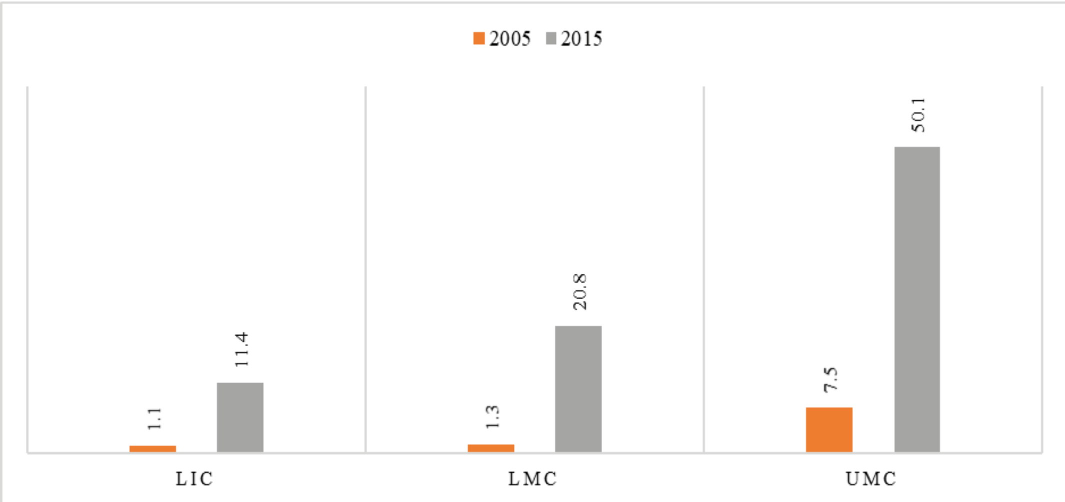


Source: World Bank, Africa's Pulse (2017)

Notes: LIC-Lower Income Countries, LMC-Lower Middle-Income Countries and UMC-Upper Middle-Income Countries.

Figure 2.11 shows that access to telecommunication services increases with the country's income level. Since the bulk of African countries fall in the LIC category, there is much need for infrastructure investment in the telecommunications sector. Telecommunications is viewed as a vital force to economic growth. Telecommunications underpins business growth by providing connectivity access to global markets and supporting trade communications; it has also brought on innovations in e-business, e-payments, e-learning, e-health, and e-government, and propelled private consumption (World Bank, 2017). Despite the progress of the ICT sector in recent years, the biggest impact has yet to come.

Figure 2.12: Internet Density in SSA by Income Group

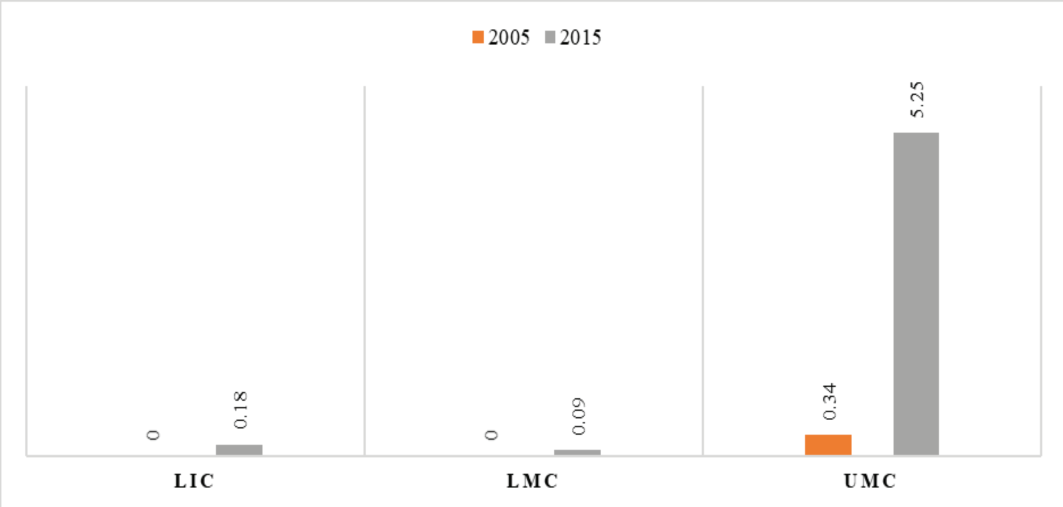


Source: World Bank, Africa's Pulse (2017)

Africa's ICT contribution to GDP is currently low standing at 1.1%, it is half the amount in other regions, but it is expected to jump to at least 6% by 2025 thereby catching up with developed countries.

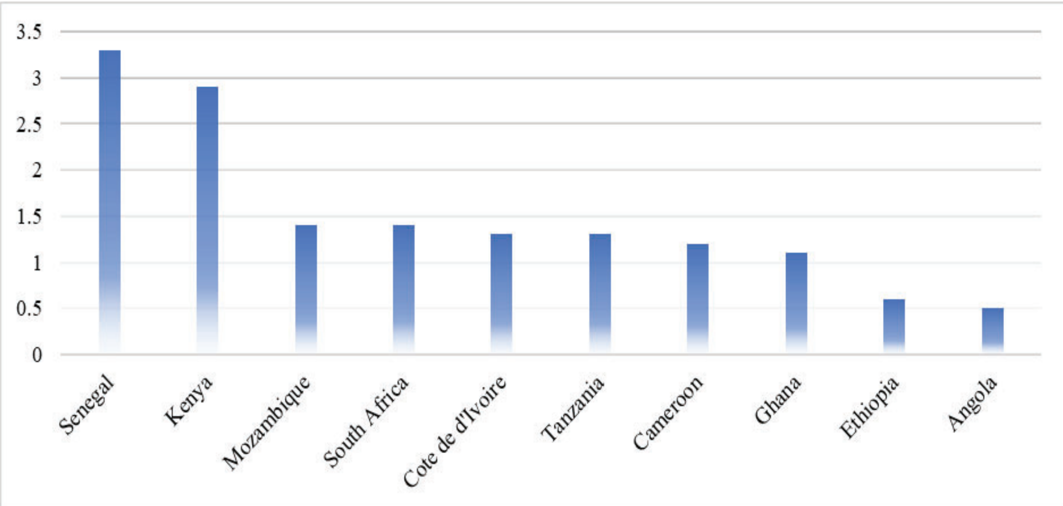
Inside SSA, it is noticeable that there is progress across all income groups. On top of the list are the LICs, where telecommunications density expanded at the fastest pace among the region's LICs, although it originated from low grounds. Precisely, the number of fixed and mobile phones per 1,000 people among LICs grew tremendously from three in 1990 to 687 in 2014 (World Bank, 2017).

Figure 2.13: Fixed Broadband in SSA by Income Group



Source: Oxford Economics

Figure 2.14: Internet Contribution to GDP in some Selected SSA Countries in 2018

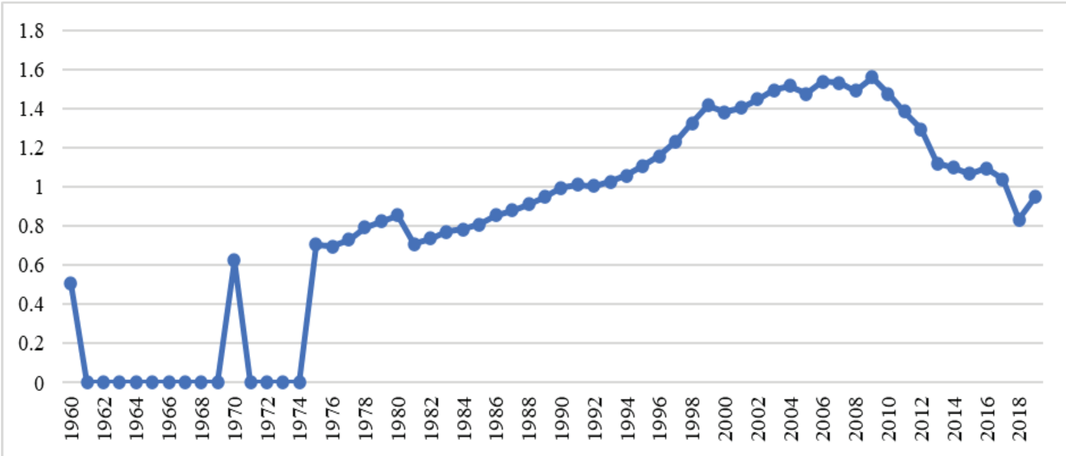


Sources: World Development Indicators; and IMF staff estimates.

The gap in telecommunications density relative to UMCs has narrowed significantly for LICs and LMCs over the past two decades. For example, telecommunications density was two times as high in UMCs compared with LMCs in 2018 however, it was 11 times as high in 1990.

Some of the advantages that come with telecommunications infrastructure development among others include: "governments could improve transparency and public service delivery, teachers and students could gain access to education content and training via tablets and e-books, remote diagnosis and treatment could be provided to those with lack of access to a health clinic, farmers could access up-to-date weather and market information, and more people could gain access to finance via mobile and online banking" (IMF, 2018 p 32). As the continent becomes more connected, social and economic growth will accelerate, transforming lives in the process.

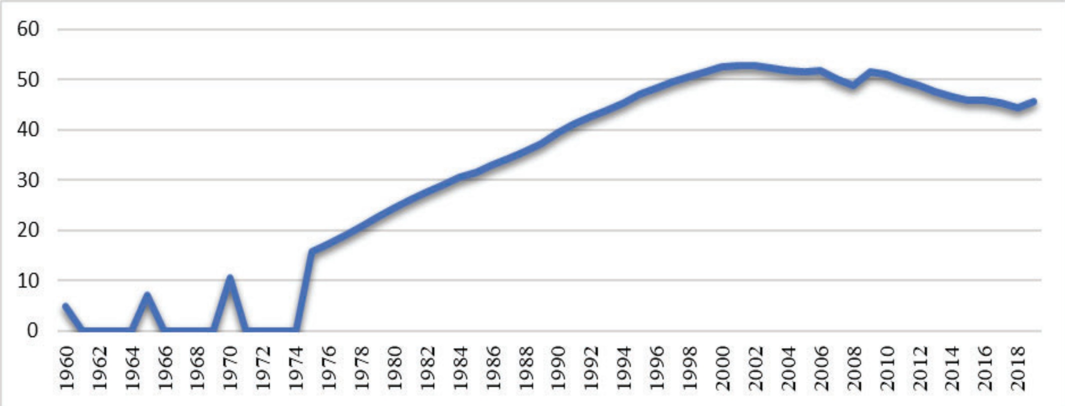
Figure 2.15: SSA Fixed Telephone Subscriptions per 100 people (1960-2019)



Source: Researcher's own Compilation from UN Data

To date, technological invention has provided other forms of telecommunication connectivity. Of much concern from Figure 2.15 is the sudden drop in telephone subscription in between 2009 and 2018. The number of internet users and fixed broadband are proxies for telecommunications density other than phone lines. Internet density as measured by the number of users per 100 people for SSA in 2015 was only 16.7, less than that of any other benchmark region. Another indicator of internet penetration is the number of fixed broadband subscriptions per 100 people. Again, SSA, with a penetration rate of only 0.19, lags significantly behind other regions (for comparison refer to Figure 2.16). The fast growth of telecommunications density over the past two decades among the region's UMCs, increasing from 55 lines per 1,000 people in 1990, to 1,605 in 2014, has placed this group above the medians of other regions.

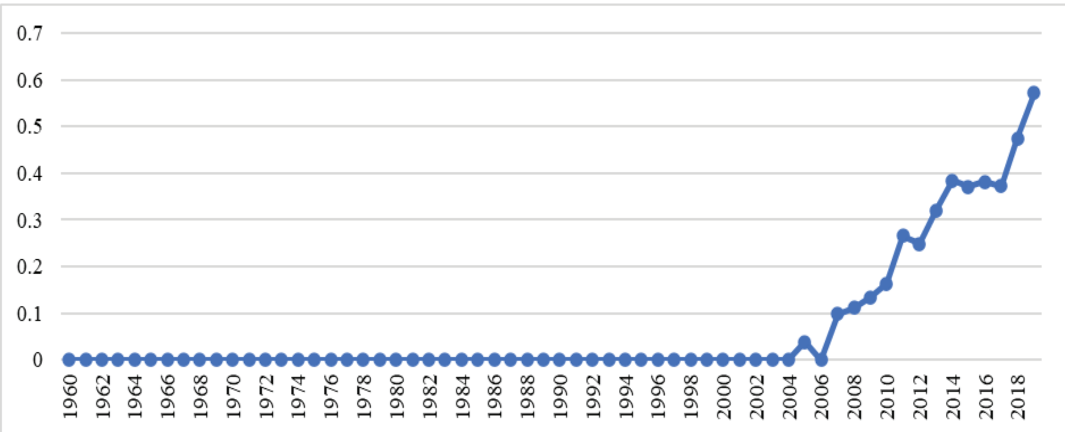
Figure 2.16: European Monetary Union (EMU) Fixed Telephone Subscriptions per 100 people



Source: Researcher's own Compilation from UN Data

Moreover, Figure 2.16 shows that the European Monetary Union (EMU) Fixed Telephone Subscriptions per 100 people started at a very low fluctuating range of five in 1960 to zero in 1961 then fluctuated from approximately eight in 1965 to eighteen in 1975 probably because the demand for fixed telephone lines was low due to poor marketing of the importance of fixed telephone services to the people (Fay & Yepes, 2003). However, Figure 2.16shows a sudden sharp increase of fixed telephone subscriptions in 1974 to the year 2000 maybe due to the high demand of telecommunication services globally for both domestic and commercial purposes. The increase maintained a peak till 2002, probably due to the telecommunication services global boom before a slight drop in 2004 to 2018 due to pressure from mobile telephones that were competing with the fixed telephone services (Kandiero, 2019).

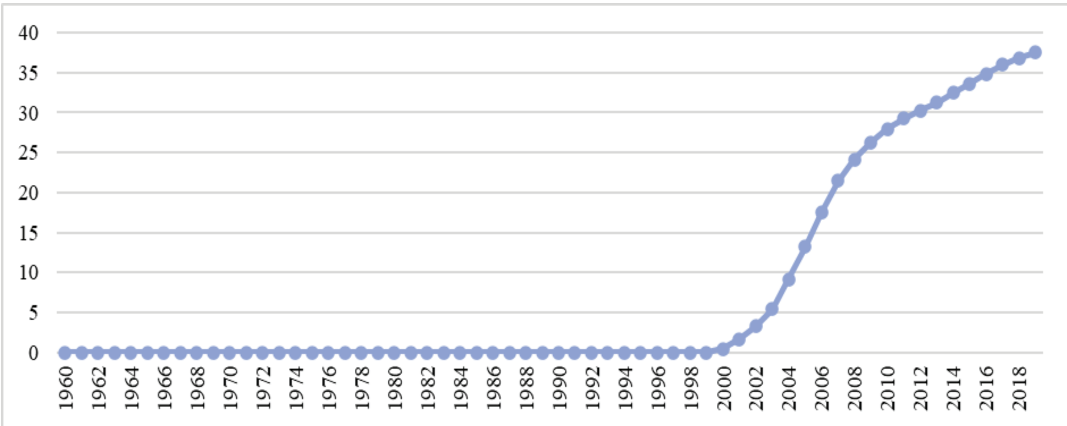
Figure 2.17: SSA Broadband Subscriptions per 100 people (1960-2019)



Source: Researcher's own Compilation from UN 1960-2019 Data

The figure 2.17 above shows the SSA Broadband Subscriptions per 100 people (1960-2019). From it, it was noted that from 1960 to 2004, the level of Broadband Subscriptions per 100 people was zero probably due to the fact that there was no fibre installed in most of those countries in SSA during that time (Kandiero, 2019) and began to rise from zero to 0,4 in 2014 because the ICT drive within SSA region gained momentum hence most countries started to invest in fibre and broadband infrastructure in their countries (IMF, 2018) and thereafter began to fluctuate from the year 2014 to 2017 probably due to saturation of fibre in the market that led to fluctuating demand for it (Kandiero, 2019) . The
Broadband Subscriptions per 100 increased from 0,4 to approximately 0,6 from the year 2016 to 2018 respectively. This increase was perhaps due to new innovative technology in fibre that increased the demand for it.

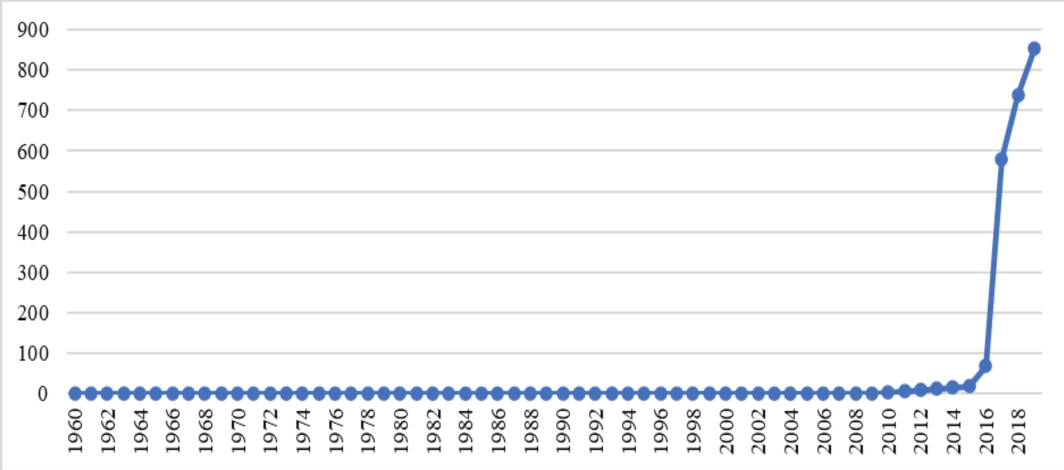
Figure 2.18: EMU Fixed Broadband Subscriptions per 100 people (1960-2019)



Source: Researcher's own Compilation from UN 1960-2019 Data

The figure 2.18 above presents the EMU Fixed Broadband Subscriptions per 100 people (1960-2019). It was noted from the figure under study that from 1960 to 2000, the number of EMU Fixed Broadband Subscriptions per 100 people was zero due to no ICT fibre optics investment in the SSA region (Kandiero, 2019). However, from 2001 when the millennium began, most SSA countries invested in ICT hence the EMU Fixed Broadband Subscriptions per 100 people increased rapidly from zero in 2000 to approximately 38 in 2018 (IMF, 2018).

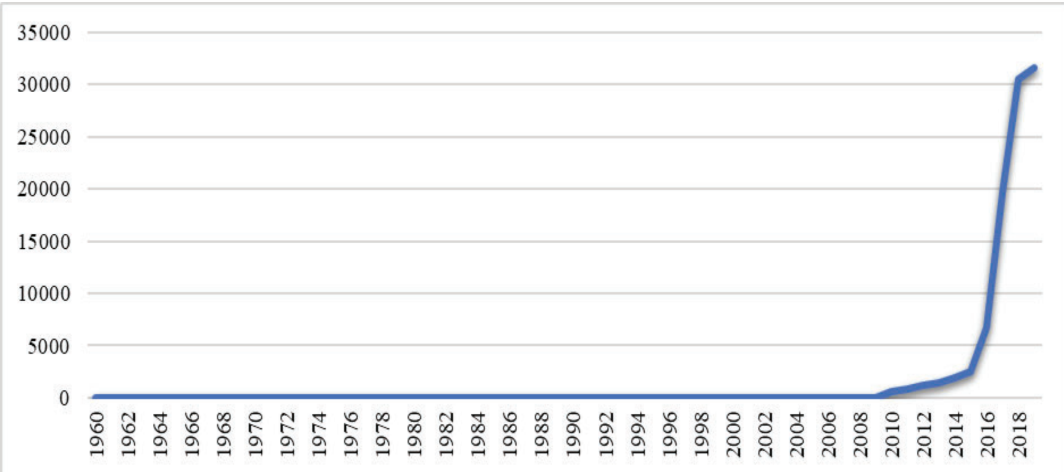
Figure 2.19: SSA Secure Internet Servers per 1 000 000 people (1960-2019)



Source: Researcher's own Compilation from UN 1960-2019 Data

The Figure 2.19 above shows the SSA Secure Internet Servers per 1 000 000 people (1960-2019). From the year 1960 to 2015, the level of SSA Secure Internet Servers per 1 000 000 people was zero due to Poor to no ICT Data fibre optics investments within SSA region during that time (Kandiero, 2019). However, the level of SSA Secure Internet Servers per 1 000 000 people increased rapidly in 2016 to2018 from zero to approximately 880 by the year 2018 due to intensive investment in data and fibre optics infrastructure within SSA (IMF, 2018).

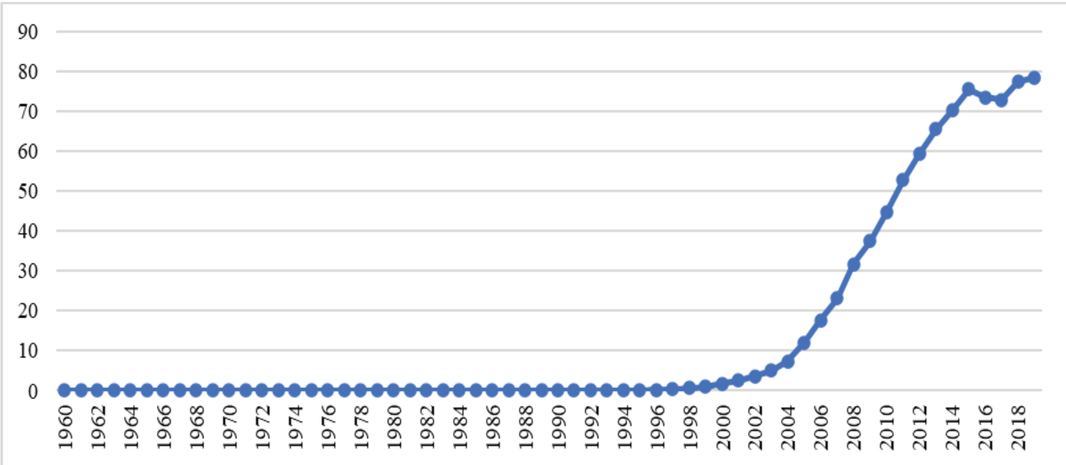
Figure 2.20: EMU Secure Internet Savers per 1 000 000 people (1960-2019)



Source: Researcher's own Compilation from UN Data

Synchronisation of previous figures indicates that internet density has risen sharply over the past two decades for all income groups in SSA. For instance, the number of internet users increased from 1.1 per 100 people in 2005, to about 11.4 in 2015 among LICs, while it grew from 7.5 to 50.1 for UMCs. Fast growth of internet density among LICs and LMCs in the region has narrowed their gap relative to UMCs. Finally, the extent of internet density among SSA's UMCs is above the regional median of countries in East Asia and the Pacific (45.5 users per 100 people). The density of fixed broadband subscriptions is dismal and disappointing for virtually all income groups in SSA. Notwithstanding the low penetration, there is a very large gap between the region's LICs and LMCs relative to UMCs. At the same time, the density of fixed broadband across UMCs (5.25 subscriptions per 100 people) is lower than that of Latin America and East Asia (8.1 and 9.1 subscriptions per 100 people, respectively).

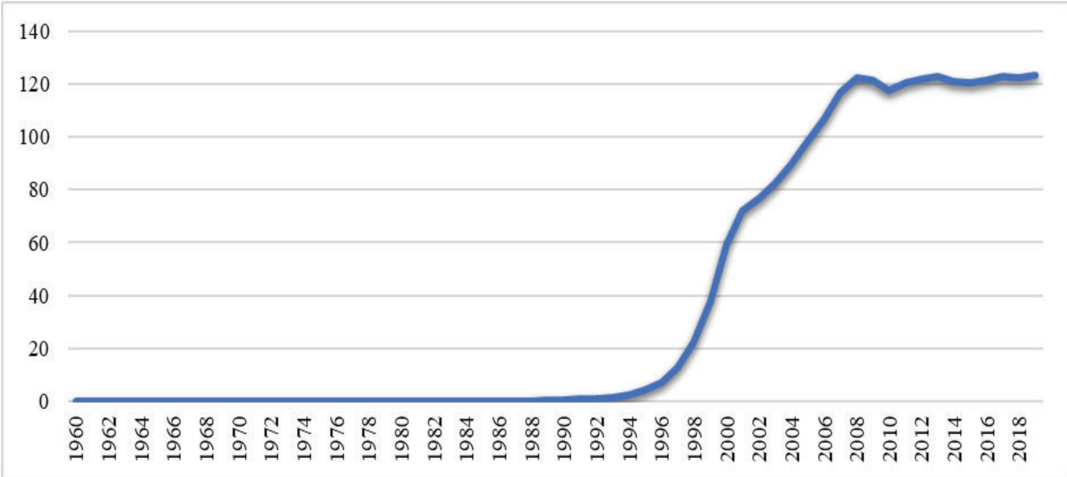
Figure 2.21: SSA Mobile Phones Subscriptions per 100 people



Source: Researcher's own Compilation from UN Data

The Figure 2.21 shows the SSA Mobile Phones Subscriptions per 100 people from the year 1960 to 2018. It was noted that from 1960 to 2000, the level of SSA Mobile Phones Subscriptions per 100 was zero due to little to no mobile investments and ICT infrastructure in most SSA region (Kandiero, 2019). However, the level of SSA Mobile Phones Subscriptions per 100 rapidly increased from the year 2001 to 2014 from zero(0) to approximately eighty (80) due to massive mobile investments and ICT infrastructure in most SSA region during that time (IMF, 2018). The SSA Mobile Phones Subscriptions per 100 slightly fell due to poor demand in 2015 and increased again in 2016 from 72 to approximately 80 due to renewed demand in the market (Kandiero, 2019).

Figure 2.22: EMU Mobile Phones Subscribers per 100 people



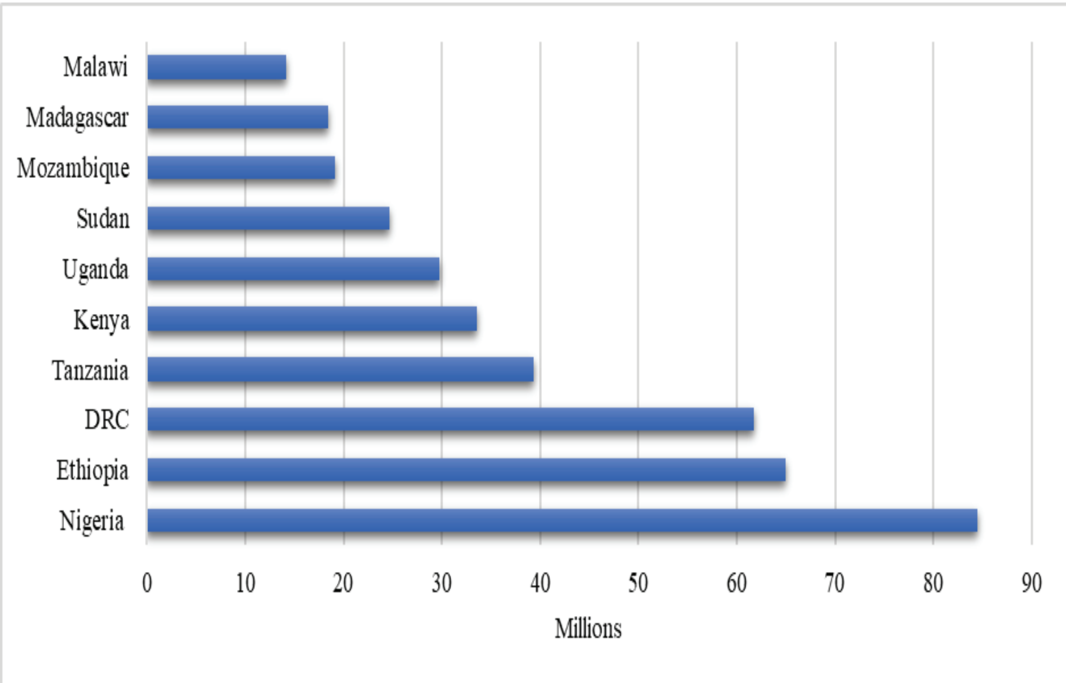
Source: Researcher's own Compilation from UN Data

The Figure 2.22 above shows the EMU Mobile Phones Subscribers per 100 people from the year 1960 to 2018.The EMU Mobile Phones Subscribers per 100 people was zero (0) from 1960 to 1994 due to little ICT infrastructure investments and mobile phones awareness by the people within the SSA region (Kandiero, 2019). However, the EMU Mobile Phones Subscribers per 100 people rapidly increased from 1995 to 2007 from zero (0) to approximately 125 people per 100 due to increased investments in ICT and mobile technology within the SSA region during that period (IMF, 2018). The EMU Mobile Phones Subscribers per 100 people began to fluctuate from 2007 to 2018 within the 120 people per 100 zone due to market demand fluctuation and saturation (World Bank, 2018).

2.6.1.2 Electric Power

Oxford Economics (2019) estimates that power demand will increase by 93% between 2018 and 2035. However, this may be hindered by lack of affordable and reliable energy. Although there is an upward trend, the household electrification rate in Africa stands at just 43%, which means about 600 million people and 10 million small and medium-sized businesses are without access to any form of energy. It is also critical to look at the statistics that separate the rural and urban population electrification degrees. As it stands, IMF (2019) estimates that urban and rural population with electricity are 65% and 28%, respectively. According to World Bank (2018), approximately 700 million people live without clean cooking facilities and roughly two-thirds of the population are still burning biomass for fuel, which poses both health and environmental hazards and requires time-consuming foraging by women and children. In the same vein, statistics show that the average cost for electricity in African countries is also three-fold as high as in the United States and Europe. In addition, those families and businesses that do have access to power often face load-shedding (see Figure 2.23). Figure 2.23 shows the top ten SSA countries with the largest population without electricity, led by Nigeria with 84.5 million people while that of Malawi is 14.2 million people.

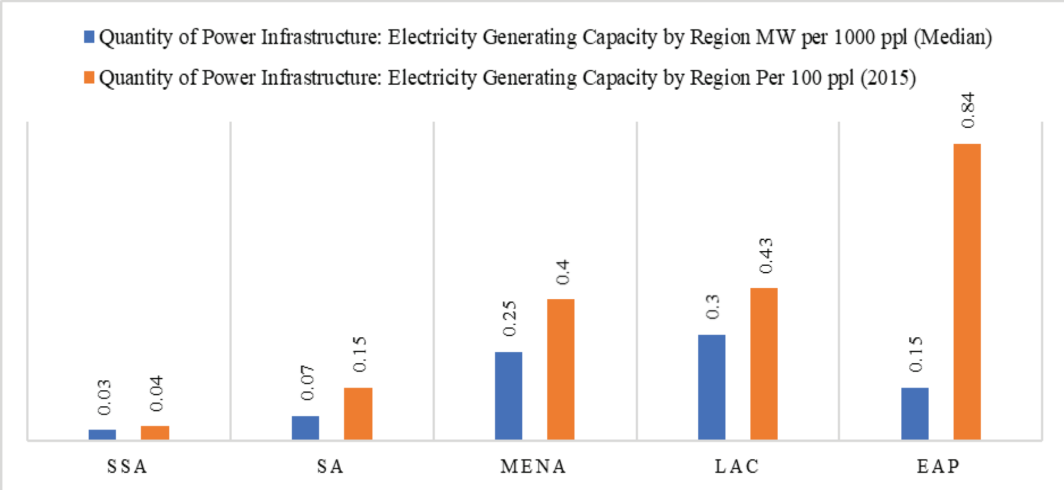
Figure 2.23: SSA Countries with the Largest Population without Electricity by 2019



Source: Researcher's own Tabulations from African Development Bank Data

Note: Together, these countries account for 65% of the people who lack access to electricity in Africa.

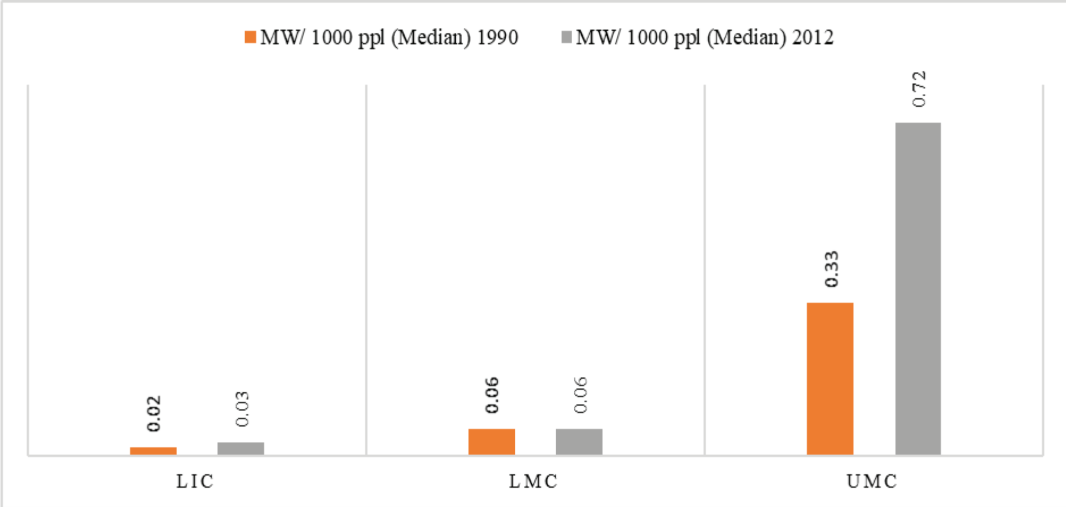
Figure 2.24: Quantity of Power Infrastructure by Region in Mega-Watts (MW) per 100 people



Source: Researcher's own Tabulations from African Development Bank Data

World Bank's Africa's Pulse (2017) projects that if Africa reinvested only 5% of its oil and coal export revenue (although highly unlikely), it could achieve modern energy for all by 2030. Owning to vast water sources and clear skies (for solar energy), Africa also has enormous potential for clean and affordable energy (Ndulu, 2016). To be specific, there is vast hydropower potential in Central and East Africa, barely less than 10% of which is currently being utilised. Moreover, East Africa has large geothermal energy potential, while North Africa, Southern Africa, and the Horn of Africa offer favourable conditions for wind and solar energy (World Bank, 2017). Compared to other parts of the world, Africa has the potential to leapfrog old technologies and become a global leader in renewable energy (World Bank, 2019). Oxford Economics (2018) statistics of electrification rates show a steady rising trend in the upcoming three decades that is expected to hit 70% by 2040, which can open valves of accessibility of up to 800 million additional people.

Figure 2.25: Quantity of Power Infrastructure in SSA

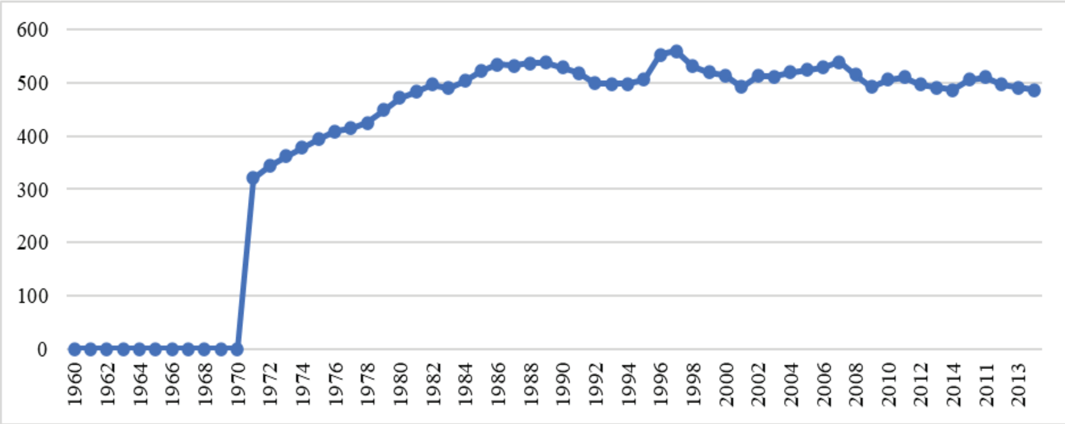


Source: International Energy Agency, World Energy Outlook.

SSA was the last in the power sector when compared to other developing regions in 2012. There are no significant changes being seen in the sector as evidenced by the electricity-generating capacity of the region that has not changed much in over 20 years and International Energy Agency (IEA) (2018) estimates that there are 0.04 megawatts (MW) per 1,000 people in the region and this amounts to less than a third that of South Asia (which has 0.15) and less than one-tenth that of Latin America and the Caribbean (see Figure 2.25). Within the examined regions, East Asia and the Pacific registered the fastest growth in power generating capacity over the past two decades jumping from 0.15 MW per 1,000 people in 1990 to 0.84 in 2015 (see Figure 2.25).

Figure 2.26 shows inadequate electricity power–producing capacity in SSA. This is explained by the trends observed in LICs and LMCs. Figure 2.27 indicates that there has been a little progress of MW of installed capacity per 1,000 people over the past two decades for these groups of countries. That is, keeping capacity as low as 0.03 and 0.06 MW per 1,000 people for LICs and LMCs, respectively, by 2012 (World Bank, 2017). According to IEA (2018), electricity-generating capacity has more than doubled among UMCs, increasing from 0.33 MW per 1,000 people in 1990, to 0.72 MW per 1,000 people in 2012.

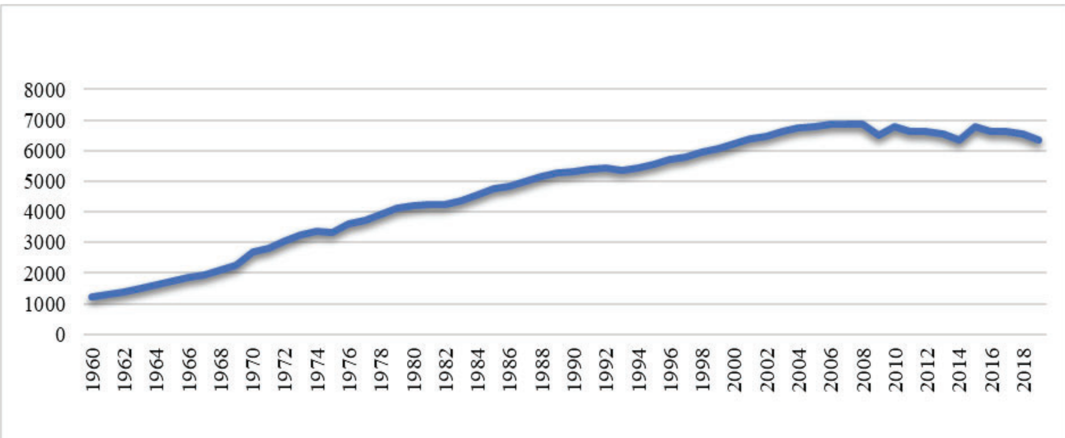
Figure 2.26: SSA Electric Power Consumption in Kilowatt-hour per Capita



Source: Researcher's own Compilation from UN Data

Figure 2.26 above shows the SSA electric power consumption in Kilowatt hour per capita being extremely low from the year 1960 to 1970 at zero-Kilowatt hour per capita, possibly due to the fact that most SSA countries were very under developed and still waging wars to attain their political independence. From the year 1972 to1988, the consumption rate increased from zero to five hundred and fifty (550) Kilowatt hour per capita possibly because most SSA countries received their freed on from colonialism and demanded numerous power consumption to cater for their developmental needs (Kodongo & Ojah, 2016). Moreover, Figure 2.26 shows the SSA electric power consumption in Kilowatt hour per capita being wavering between 500 to 580-Kilowatt hour per capita from 1990 to the year 2013, probably because the SSA markets were well established and were consuming the power in a continuous form.

Figure 2.27: EMU Electricity Power Consumption in Kilowatt-hour per Capita



Source: Researcher's own Compilation from UN Data

Figure 2.27 above shows the EMU Electricity Power Consumption in Kilowatt-hour per Capita. From the figure, it can be observed that from 1960 to 1970, the EMU Electricity Power Consumption in Kilowatt-hour per Capita was very low, maybe due to low industrialisation and demand for electricity since most countries were still in wars and underdeveloped. As a result, they consumed approximately 1000 to 2000 Kilowatt-hour per Capita and steadily increased from 2000 Kilowatt-hour per Capita in 1972 to approximately 5500 Kilowatt-hour per Capita 1992 with a margin of 3500 difference. This was possibly due to the high consumption demand during that period because of industrialisation in SSA countries (Maliane, 2014). Moreover, the EMU Electricity Power Consumption in Kilowatt-hour per Capita steadily increased in 1993 from approximately 5500 Kilowatt-hour per Capita to approximately 7000 Kilowatt-hour per Capita in the year 2008 hence, reached a peak in the year 2007 and 2008. This was probably influenced by the saturation point in the market whereby the demand was neither increasing nor decreasing. However, Figure 2.27 above shows the EMU Electricity Power Consumption in Kilowatt-hour per Capita dropping in 2009, may be due to low demand in the market and beginning to fluctuate in 2010 to 2018 due to changes in market preference and income.

2.6.1.3 Transportation Infrastructure

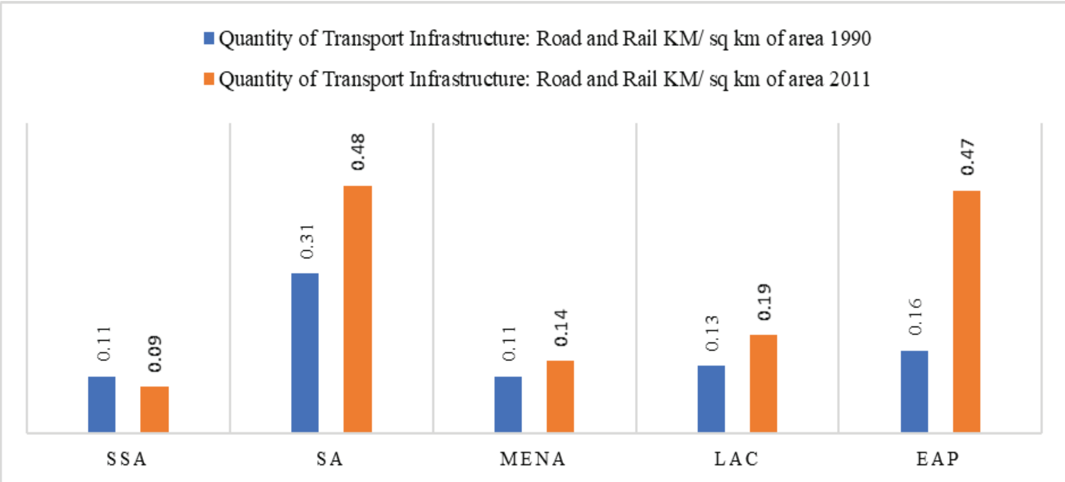
Evaluating the performance of transport infrastructure entails the investigation of trends in the lengths of rail and road networks (stated in kilometers (km). Figure 2.27 shows that in 2011, SSA registered the lowest road density among the developing regions that are being examined. Surprisingly, SSA is the only region where road density has declined over the past 20 years (World Bank, 2017). This is not unique to the road density statistics as data also indicates that, the density of the railroad network is also low, with less than 0.002 km per square km of surface area by 2014, and this density has been declining (Oxford Economics, 2018).

The evolution of road density (basing on income groups) in SSA over the past two decades shows that road density has declined over time among LMCs. This trend can be explained by the fact that the expansion of the road network is not as fast as the pace of urbanisation in these countries. The data also reveals a large gap in road density for LICs and LMCs relative to UMCs, and the gap has been sharply increasing over time. Finally, the road density among UMCs in SSA of 1.04 km per square km of surface area, is larger than the regional median of all other developing regions. The trends observed in railroad density are similar to those in roads: there has been a decline in the density of railroads among the region's LICs and LMCs over the past two decades, which might be attributed to poor maintenance. At the same time, railroad density remained almost invariant among UMCs, and it was outperformed only by South Asia.

Reliable transport infrastructure, in all four sub-sectors namely, roads, railways, air transport, and ports is an essential component of all countries' competitiveness. Roads and railways are particularly crucial for landlocked countries, for which transportation is a pre-requisite to opening production zones. Reliable transport must be in place for companies to import and export goods, to fill orders, and to obtain supplies.

2.6.1.3.1 Roads

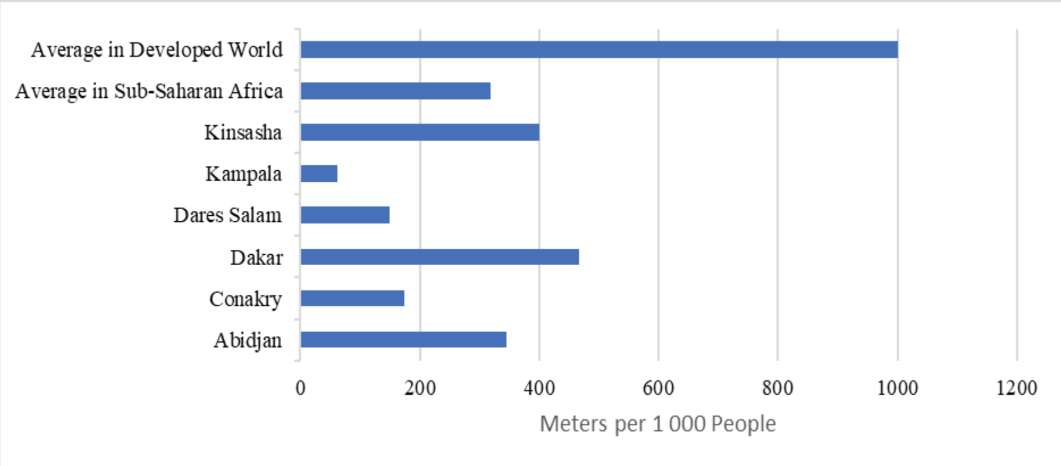
Figure 2.30: Quantity of Road Infrastructure Density by Region



Source: World Bank, Africa's Pulse (2017)

Despite 30% of SSA countries being landlocked, which implies that roads are the chief mode of transport in SSA, carrying at least 80% of goods and 90% of passengers, key shortfalls exist in its infrastructure throughout the region (World Bank, 2017). Relatively, a big chunk of Africa's road network is unpaved, isolating people from basic education, health services, transport corridors, trade hubs and economic opportunities (IMF, 2019). In addition, access to the road network is not equitably distributed between the urban and rural, since the rural areas are largely marginalised (Ndulu, 2014). This uneven access makes the flow of goods and services to and from rural areas difficult and expensive, hence widening the gap between the rich and the poor. In most SSA countries, maintenance of the road network is also inadequate and when done, often inefficient, with statistics showing that it was better done during the colonial era compared to the post-colonial period. To make matters worse, the road network in various countries continues to deteriorate due to vehicle overloading and increasing vehicular density, causing road surfaces to prematurely degrade, and resulting in reduced construction life span and high maintenance costs (World Bank, 2017).

Figure 2.31: Paved Roads in SSA Countries and Selected Cities (Meters per 1 000 people)



Source: Commonwealth Business Council and African Development Bank.

Although SSA has fewer vehicles on its road than any other region, the underdevelopment of the road network has resulted in severe traffic congestion (Kandiero,2019). There is a notable trend in SSA that shows an increase in the number of automobiles owners caused by an increase in the number of middle-income segments of the population.

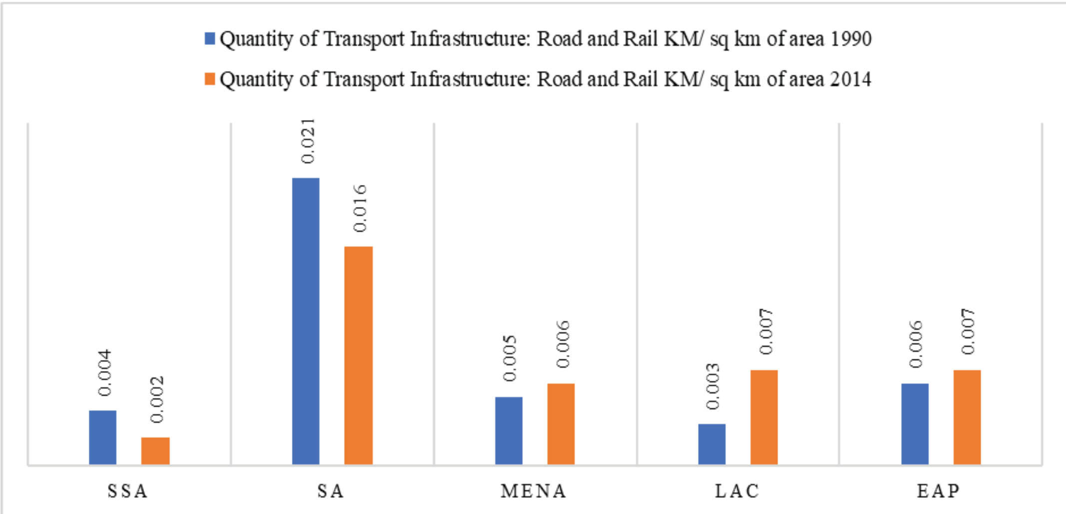
Credit must be given to initiatives such as the Programme for Infrastructure Development in Africa (PIDA), investment rates in transport infrastructure have been increasing. Some countries such as Ethiopia are making good progress. For example, World Bank's Africa's Pulse (2017 p.62) shows that Ethiopia has reduced the average distance to an all-weather road from 21 kilometres in 1997 to 12.4 kilometres in 2012, and access to an all-weather road is said to have decreased poverty by 6.9% and increased food consumption by nearly 17%. Senegal, too, has embarked on an ambitious programme of infrastructure development, which involves the construction of a 32-kilometer toll highway that will link Dakar to Diamnadio in the western part of the country. In 2021, Zambia, Botswana and Namibia completed the Kazungula bridge with the intension of decongest the Beitbridge Boarder post and promoting trade through the road mode of transport.

Cross-border corridors are also being used to link markets, particularly important for landlocked countries and enhance intra-African trade. The Trans-Africa Highway (Cairo–Dakar) is the most ambitious road network on the continent: it comprises nine interlinked highways with a total length of 56,683 kilometres. Other planned or ongoing regional projects include the Abidjan, Ouagadougou, Bamako Transport corridor, connecting Côte d'Ivoire, Burkina Faso and Mali.

2.6.1.3.2 Rail

Rail infrastructure is the least developed in SSA, with very few additions during the post-colonial period. Kandiero (2019), is of the opinion that outdated infrastructure and limited maintenance have undermined the effectiveness of railways across Africa, resulting in a significant reduction in usable track.

Figure 2.32: Quantity of Rail Infrastructure by Region

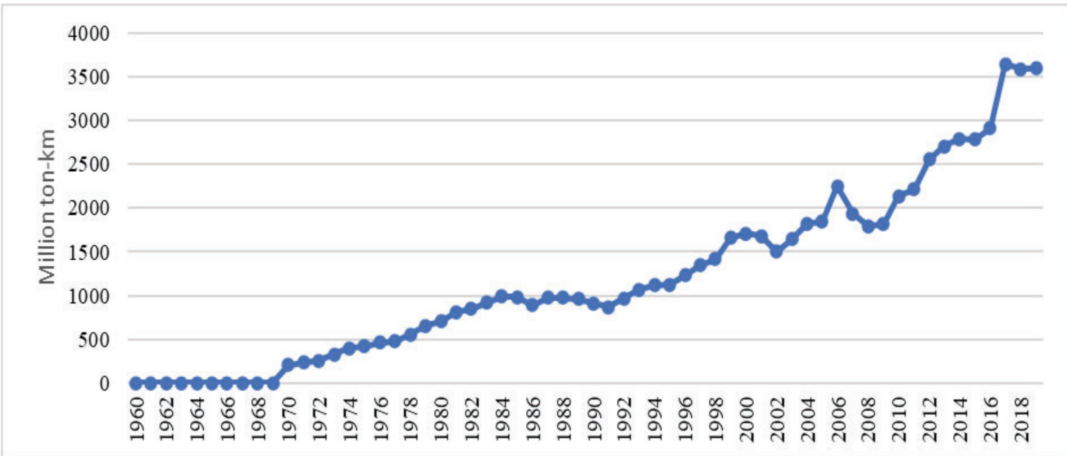


Sources: International Road Federation, World Road Statistics; World Bank.

In summation, Africa counted 84,000 kilometres of rail track, for a surface of about 30 million square kilometres, most of it in Southern and Northern Africa (World Road Statistics (WRS), (2018)). According to WRS (2018), 13 SSA countries have no operational rail networks, while the spatial density of operational rail ranges from 1 to 6 route-kilometres per thousand square kilometres. A snapshot from World Bank's Africa's Pulse (2017) on page 72 reports that "The network density for most African countries ranges from 30 to 50 kilometres per million people, with a few countries (Gabon, Botswana, and South Africa) having network densities of more than 400 kilometres per million people. These network densities are very low compared to Europe's range of 200 to 1,000 kilometres per million people".

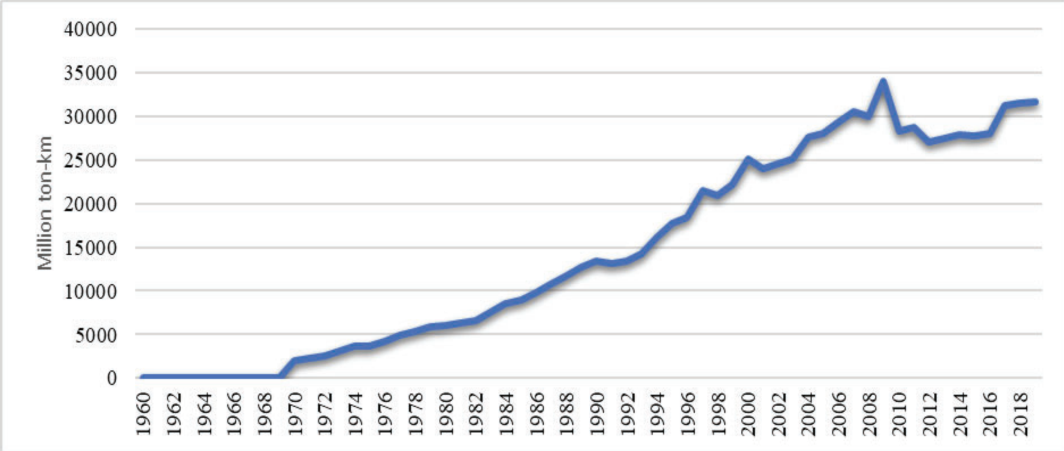
Although the current statistics are not impressive, Calderón et al. (2018), is of the opinion that, the African rail system has the potential for expansion and to act as a catalyst for regional integration, trade, and economic development. Inadequacy and inefficiencies in the railroad network are increasingly being tackled by countries in recent years. Taking for example, Zambia has been working on improving the operational efficiency of the Zambia Railways and the TAZARA Railway and Kenya in October 2019 opened a US$1.5 billion 120km railway line project funded and built by China. There are also plans to extend the Zambia Railways network to the Botswana Railways network via the planned Kazungula Bridge. It is also notable that African exports are largely bulky primary commodities, which could be transported more efficiently and at lower cost by rail than by road. Rail development therefore holds some opportunities for investors. Investments in associated activities like locomotive building, logistics, and communications also exist.

Figure 2.33: SSA Air Transport (Freight per 1000 000 ton-km)



Source: Researcher's own Compilation from UN Data, 2018

Figure 2.34: EMU Air Transport (Freight per 1000 000 ton-km)



Source: Researcher's own Compilation from UN Data, 2018

2.6.1.3.3 Airports

With reference to figure 2.34 above, it was noted that by providing a quick link to export markets, air transport enables the trade of time-sensitive, perishable exports such as cut flowers, vegetables, fruits, meat, and fish, which are becoming increasingly important foreign-exchange earners for African countries. However, air transport in Africa remains expensive by international standards. This is mainly because of lower passenger traffic, limited liberalisation of air space, high passenger and airport taxes, safety issues, and limited infrastructure (airports, runways, and safety systems) (Calderón et al., 2018). According to Oxford Economics (2018), Africa still records the lowest safety standards in air transport of any region in the world. African airlines have also lagged in terms of technological upgrades; notably surveillance equipment and fleet modernization. Progress is further hampered by poor airport infrastructure and inadequate air connections.

The importance of air transport, especially for landlocked countries, cannot be overemphasized. It is imperative that African countries enhance this sector's development to improve connectivity and safety as well as to reduce costs in order to promote intra-African and global trade. Air transport must be enhanced not only by the amount and quality of physical infrastructure but also, even more importantly, by the way it is operated with regard to air-traffic control and ground-air communications, which are inadequate in many parts of the region and need to be boosted.

2.6.1.3.4 Ports

Seaports too are badly in need of investment and regulatory reforms to remove the bottlenecks and chronic congestion problems. Although Africa operates 64 ports, many of them are poorly equipped and uneconomically operated. Huge problems exist with respect to inadequate capacity, particularly in terminal storage and maintenance. Delays are often caused by long processing times and poor shipment handling rates, with over-the-quay container-handling performance running below 20 moves per hour in the African region, compared to either 25 or even up to 30 moves in modern terminals worldwide (The Economist Intelligent Unit (EIU), 2015). In addition, handling costs average 50% more in Africa than in other parts of the world (Calderón et al., 2018). Further challenge stems from a lack of efficient linkages between roads and rail lines, and their poor connectivity to ports.

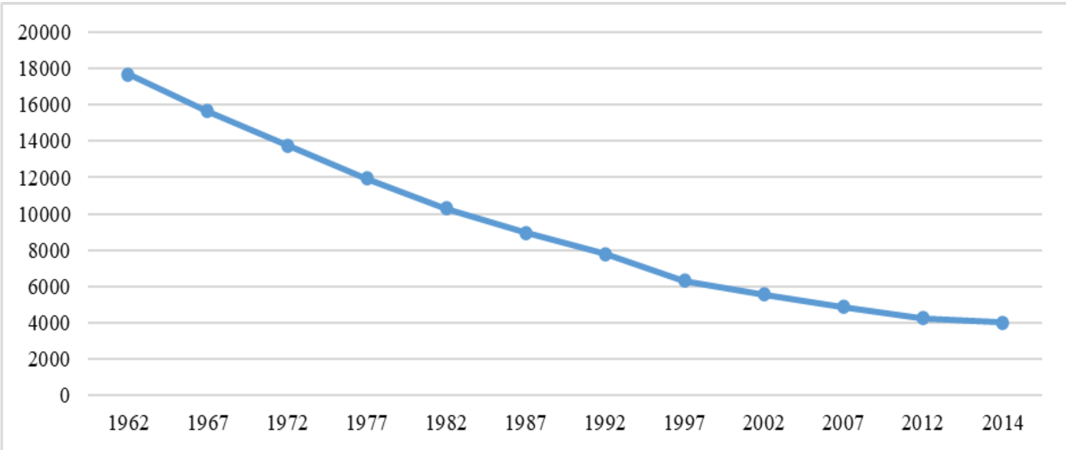
Private investment in ports is low; yet there is a great need for trans-shipment facilities and maritime structures. Four regional hubs exist, and these include Durban in Southern Africa, Mombasa, and Dar-es-Salaam in East Africa, with Djibouti also emerging as a new hub. In West Africa, Abidjan used to play this role but as a consequence of the civil war, its role has been supplanted by the port of Malaga in Spain. With about half of the coastal countries that operate port facilities introducing sectoral legislation and regulatory reforms, new investment opportunities will present themselves.

Enhancing port infrastructures can substantially reduce the cost of production for companies and contribute to economic growth. For instance, as a result of the recent Dakar Port Container Development Project, Senegal has been able to expand its exposure to international markets, increase the volume of port traffic by 13%, and reduce average waiting time for ships from 15 hours to 2 hours and for trucks from several hours to less than 30 minutes. The port enhancement project will increase berth capacity by 50% and vessel productivity from 20 moves per hour to 61 moves per hour. Moreover, the port will operate the terminal continuously, on a 24-hour a day basis. Costs have also been reduced by the implementation of an electronic customs clearance system and the liberalisation of the container shipping market.

Africa's prolonged underinvestment in transportation has resulted in a dilapidated transport infrastructure. Indeed, compared with other developing countries, excluding the provision for maintenance, African countries invested, on average, 15 to 25% of GDP in transport infrastructure over the period 2005-2012, while India and China invested about 32% and 42% of GDP, respectively, over the same period (Kandiero, 2019).. With many national economies relying on the transport of bulky primary produce, increased attention is being given to developing roads, rail networks, airports, and inland waterways. As Africa looks at scaling up infrastructure investments in the transportation sector, the trade impact of such investments will spur economic growth and development. This, in turn, will have spill-over effects in all other sectors, opening further opportunities for private sector investments. Within the transportation sub-sector, there are considerable opportunities to develop systems that will improve intermodal efficiency.

2.6.1.4 Water and Sanitation

Figure 2.35: SSA Renewable Internal Freshwater Resources per Capita (cubic meters)

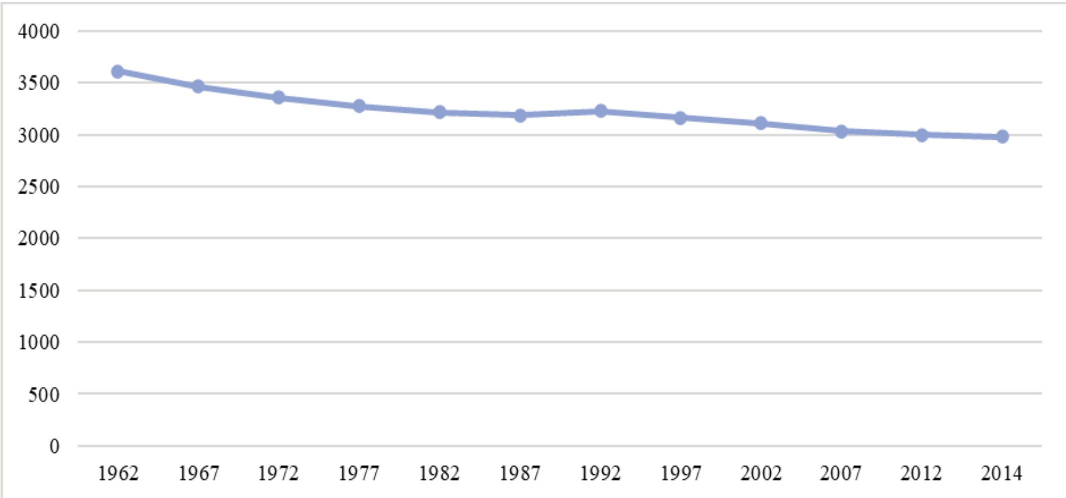


Source: Researcher's own Compilation from UN Data, 2018

Increasing access to clean water and sanitation has been among the most challenging of the Millennium Development Goals (MDGs) to implement in Africa, since the continent has the highest short fall (PIDA,2014). UN (2018) data shows that the share of the population in Africa's poorest countries with access to an improved water source increased from 56% in 2005 to 59% in 2012, compared to an average access rate of 87% across the developing world. Sanitation lags even further behind. Only 28% of these countries have access to improved sanitation facilities, and the rate of investment is only just ahead of population growth. While access has been improving in rural settings, progress in urban areas has stagnated, with growing disparities between wealthier and poorer neighbourhoods.

In many cases, the lack of access to improved water source has slowed the progress on sanitation and contributed to outbreaks of diseases like cholera and diarrhoea. Factors hindering progress in access to safe drinking water include political instability, the increasing number of refugees, and growing populations putting pressure on the available resources. Additionally, African countries generally lack the technologies needed to improve water and sanitation. Where these technologies exist, they do not trickle down to the many rural areas that would benefit from them. Women and girls are the most affected because they bear the primary responsibility of fetching water, taking up a lot of time that could be used more productively and further raising child labour and gender discrimination issues.

Figure 2.36: EMU Renewable Internal Freshwater Resources per Capita (cubic meters)



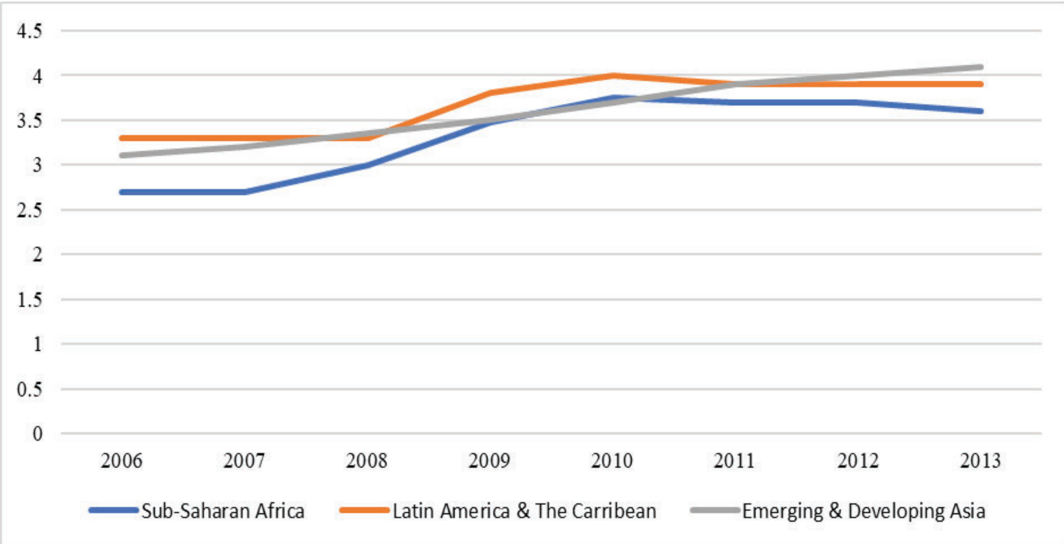
Source: Researcher's own Compilation from UN Data, 2018

Water is one of the most essential natural resources for livelihoods, food security, and economic growth. Africa urgently needs to invest in the sustainable development of its vast water resources to protect against the impact of climate change in the coming years. This includes improving cooperation on the shared management of Africa's eighty or more international water basins. There are a number of successful models to follow such as the Senegal River Basin Development Authority and the Nile Basin Initiative.

2.7 Infrastructure Quality

In addition to the quantity gap, the region's infrastructure is perceived as being of relatively low quality. While it is imperative for the region to reduce the gap in the quantity of infrastructure, the quality of these service-providing capital goods will be the major contributor to their optimal use. The WEF (2016) Report shows that the region's overall infrastructure quality is perceived as being relatively poor. The quality of electricity supply, roads, and railroads also scored below those of regional peers. The low quality of infrastructure is only loosely correlated with public investment levels, pointing to significant inefficiency across SSA countries compared with regional comparators. As shown in Figure 2.37, the relationship between real public capital stock per capita and perceptions of infrastructure quality is positive but relatively weak. This suggests the existence of considerable scope to enhance the efficiency and impact of public investment in most SSA economies.

Figure 2.37: Infrastructure Quality Perceptions



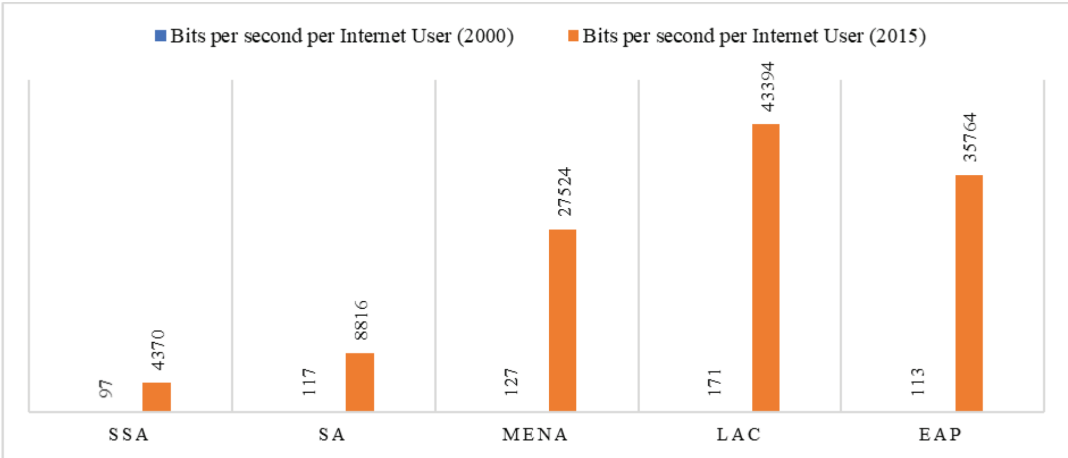
Sources: World Economic Forum, Global Competitiveness Report.

It is imperative for the region to reduce the gap in the quantity of infrastructure since it has the least score on the basis WEF perception index. At the same time, the quality of these service-providing capital goods will be the major contributor to their optimal usage. The quality measures examined here can be objective or subjective. The former refers to hard/objective measurements (for example, electric power and transmission losses); the latter refers to perceptions of the quality and reliability of these services obtained from entrepreneur surveys, such as the quality of infrastructure indicators from the WEF's Global Competitiveness Report.

2.7.1 Telecommunications

Lack of data availability across sections and, more importantly, over time prevents us from capturing the quality of the services of fixed telephone and mobile lines. However, the quality of internet services can be approximated by the international bandwidth connection (which captures used capacity and average traffic load).

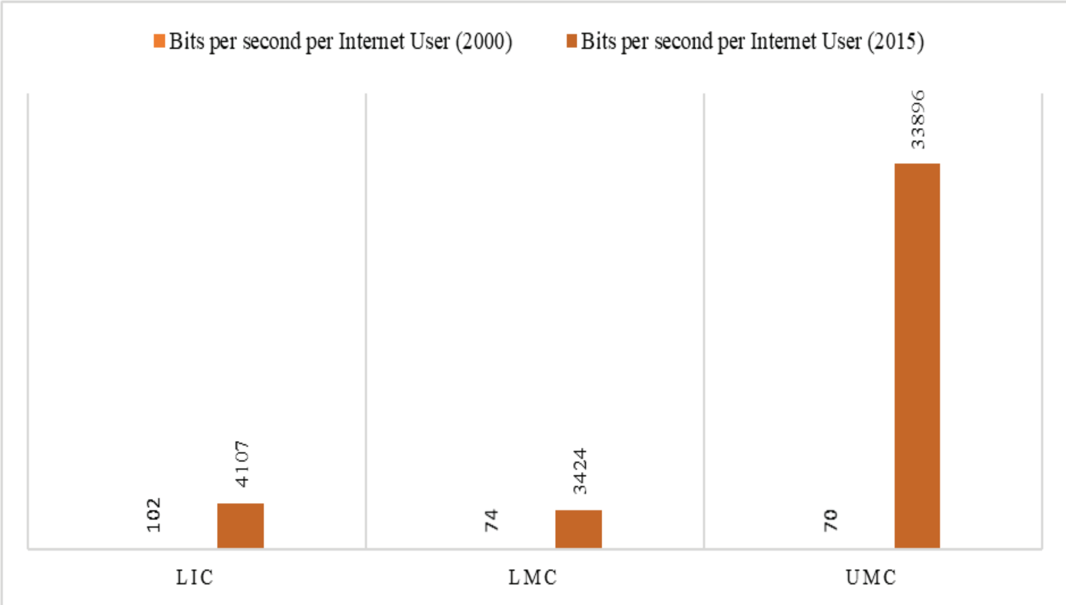
Figure 2.38: Telecommunications Quality by Region



Source: World Bank, Africa's Pulse (2017)

Over the past 15 years, there has been a broad-based increase in internet speed throughout the world. In SSA, the bits per second per internet user grew from 97 in 2000, to 4,370 in 2015 (see Figure 2.38). In South Asia, this indicator is nearly twice as large (8,816), and in the remaining regions, it is between 27,000 and 44,000 bits per second per Internet user.

Figure 2.39: Quality of Telecommunications Infrastructure in SSA by Income Category

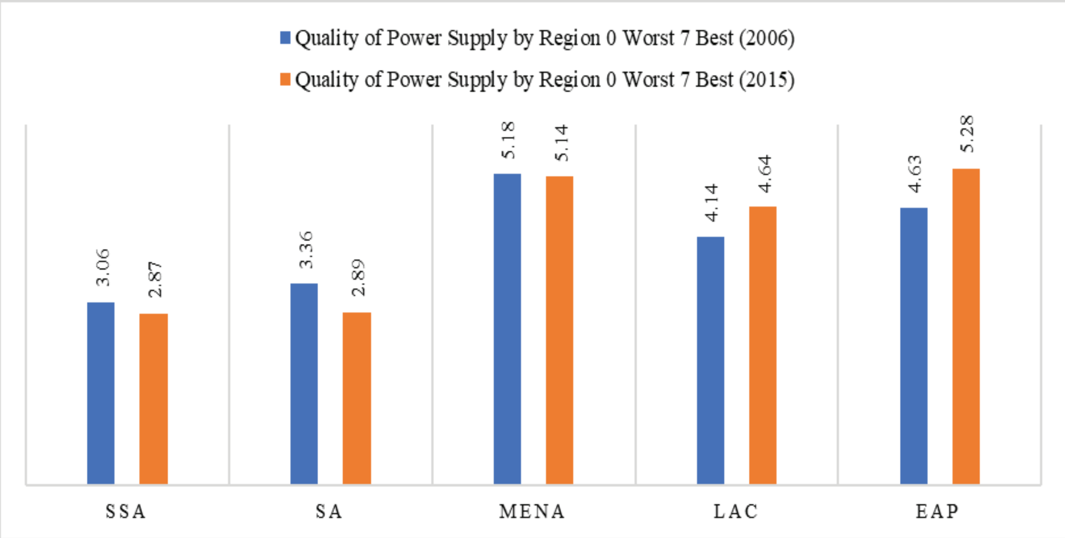


Source: World Bank, Africa's Pulse (2017)

There has been an increase in capacity and traffic on the internet for all income groups in SSA. The largest improvement is evidenced for UMCs, with this group seeing internet traffic volume greater than the regional median of other developing areas, except in the case of East Asia and Latin America (35,764 and 43,394 bits per second for every user, respectively).

Electric Power.

Figure 2.40: Quality of Power Supply by Region



Source: World Bank, Africa's Pulse (2017)

One measure of the quality of the electric power infrastructure sector is captured by the percentage of electric power transmission and distribution losses (as a percentage of electricity output). Electric power losses increased in SSA over the past quarter century, from 15.5% in 1990, to 16.7% in 2014, while declining in most other regions. Another measure of the quality of power supply is from WEF, which is a qualitative indicator that fluctuates from a low of 0 to a high of 7. According to this indicator, the perceived quality of power supply in the region dipped from 3.1 to 2.9 between 2006 and 2015. SSA registered the lowest scores in quality of power supply in 2015, with a regional median of 2.9, practically the same as for South Asia, which also experienced a decline in quality. Other benchmark regions such as Latin America and the Caribbean or East Asia and the Pacific, saw an improving trend in quality and scored above 4.5.

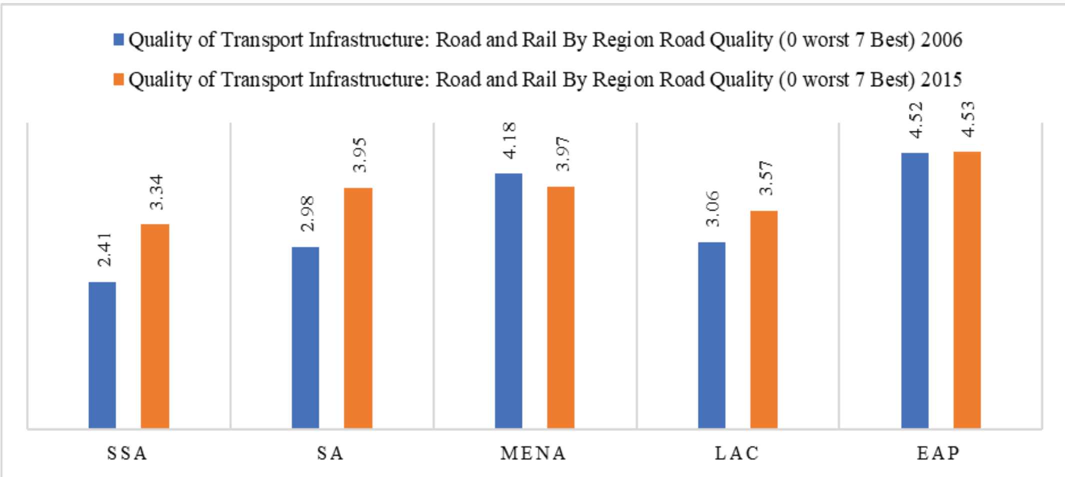
Within SSA, there is considerable disparity in the evolution over time of power losses across the different income groups. For instance, power losses declined sharply in LMCs, to 11.8% of output in 2014, from 22.5% in 1990; power losses in UMCs remained almost invariant over the past decade. In contrast, power losses slightly increased from 15.5% of output to 16.9% during this period among the region's LICs. Power losses in SSA's LMCs and UMCs are smaller than those in other regions, except for East Asia and the Pacific.

The perception of the quality of power supply in the region is comparable across income groups. This convergence is the outcome of different trends between 2006 and 2015: quality increased slightly among LICs, varying between 2.8 and 2.9; it increased from 2.4 to 3.1 among LMCs; and it declined sharply among UMCs, from about 5 to 2.9.

2.7.2 Transportation.

The quality of transport infrastructure is measured by the share of paved roads in total roads, and the WEF perception scores on the quality of roads and railroads. The results with the objective measures should be taken with caution as not all road networks in the country are necessarily meant to be paved. Other likely measures for example, percentage of roads in good condition, are not available for the wide array of countries and over time.

Figure 2.41: Quality of Roads by Region

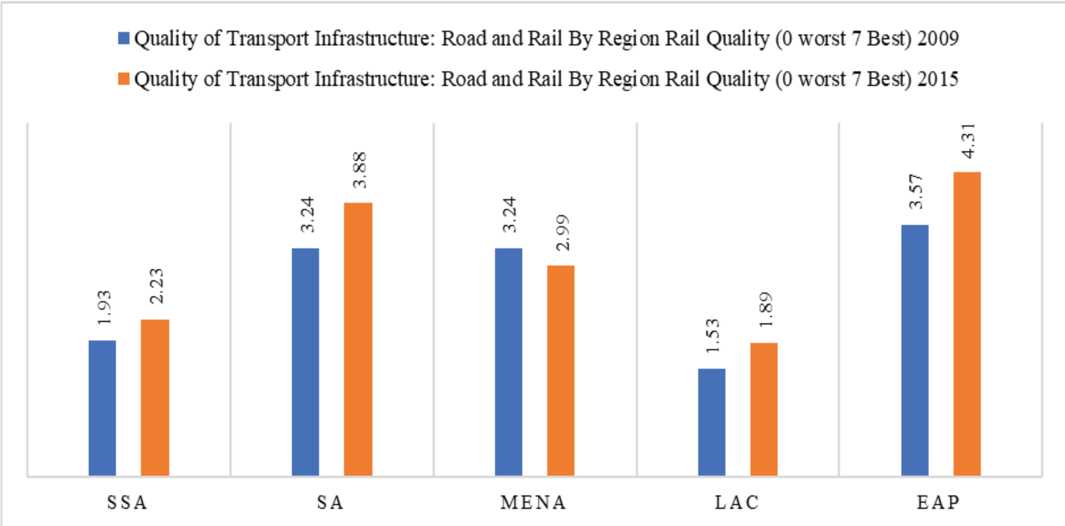


Source: World Bank, Africa's Pulse (2017)

In comparison to other world regions, Figure 2.41 indicates that the SSA region has the least quality score in both 2006 and 2015. Calderón et al. (2018) further found that the share of paved roads in SSA declined from 17% in 1990 to 16% in 2010, against the rising trend observed in other regions. It further indicates that, SSA also has the lowest share of paved roads in the total road network of any region, and well below that of South Asia and East Asia and the Pacific.

The perception of road quality in SSA, as well other developing regions, shows an improving trend during 2006 to 2015. WEF scores for SSA on perceived road quality climbed from 2.4 in 2006, to 3.3 in 2015. Still, SSA is the weakest performing region in this category of quality, well below the score of 4.5 for East Asia and the Pacific. There is also a slight increase in the surveyed perception of railroad quality in SSA, from a score of 1.9 in 2006 to 2.2 in 2015. However, the region has among the lowest perceptions of railroad quality among developing regions and is well below regions such as South Asia and East Asia, which have scores in the range of 3.9 and 4.3, respectively.

Figure 2.42: Rail Quality by Region



Source: World Bank, Africa's Pulse (2017)

The share of paved roads to total roads is similar across income groups in SSA for 1990 (in the range of 16.5 to 17%) (Calderón et al., 2018). It grew slightly to 18% among LICs and declined to 10% among LMCs. The trends in perceived road quality are quite low in Figure 2.42 hence different from those of the share of paved roads in the total road network published by the World Bank, 2018. Firstly, the perception of road quality increased for all income groups in SSA, although at different rates. Secondly, at a score of 4.8, the median perception of road quality among UMCs in SSA outperforms the regional median of other developing areas. The evolution of the perception of railroad quality for the different country groups in SSA during 2006 to 2015 shows improvement among LICs and LMCs in the region, and a decline among UMCs.

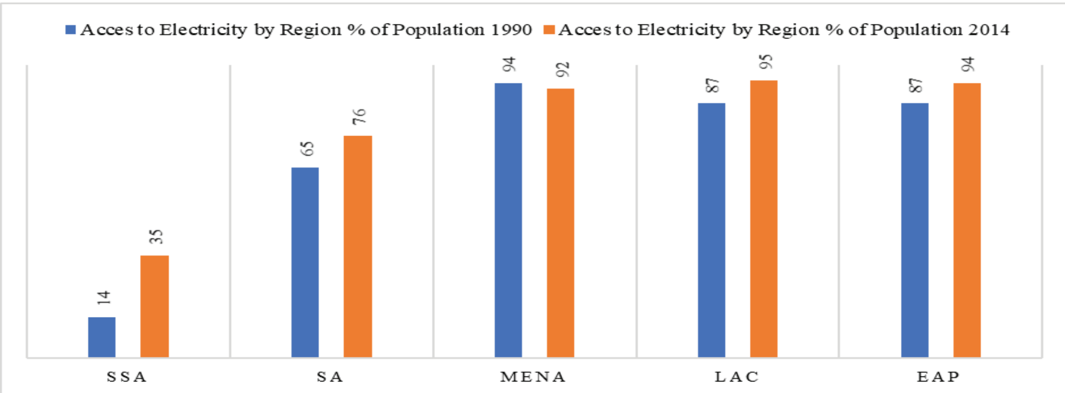
2.8 Infrastructure Access

Infrastructure performance relies not only on assessing its quantity and quality, but also on the universality of access. From the point of view of equality of opportunities and poverty reduction, it is important to examine the extent to which infrastructure assets yield services to the broad population rather than just a few. This sub-section discusses the evolution of indicators of access to electricity, safe water sources, and improved sanitation facilities.

2.8.1 Access to Electricity

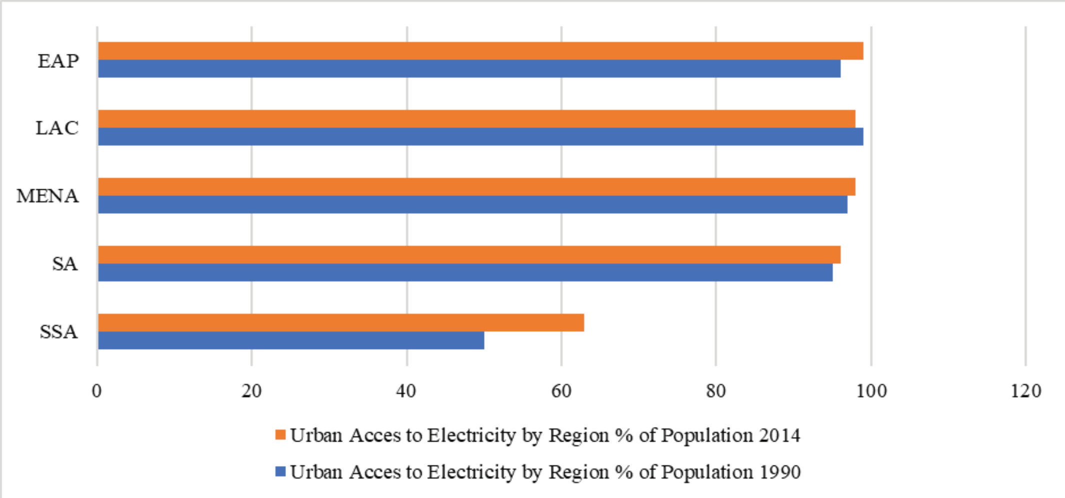
Figure 2.43 presents the percentage of the population with access to electricity in SSA and other developing areas in 1990 and 2014. The figures depict total access as well as access rates for urban and rural populations. The data shows that total rates of access to electricity almost doubled over the past two decades, growing from 14% in 1990, to 35% in 2014. Yet, all developing regions significantly outperformed SSA in access to electricity in 2014, with close to universal access to electricity in MENA, LAC and EAP. The disparity in rates of access to electricity between urban and rural areas is especially marked in SSA, where about 63% of the urban population and only 19% of the rural population had access to electricity in 2014.

Figure 2.43: Percentage of Population with Access to Electricity by Region



Source: Oxford Economics, 2018

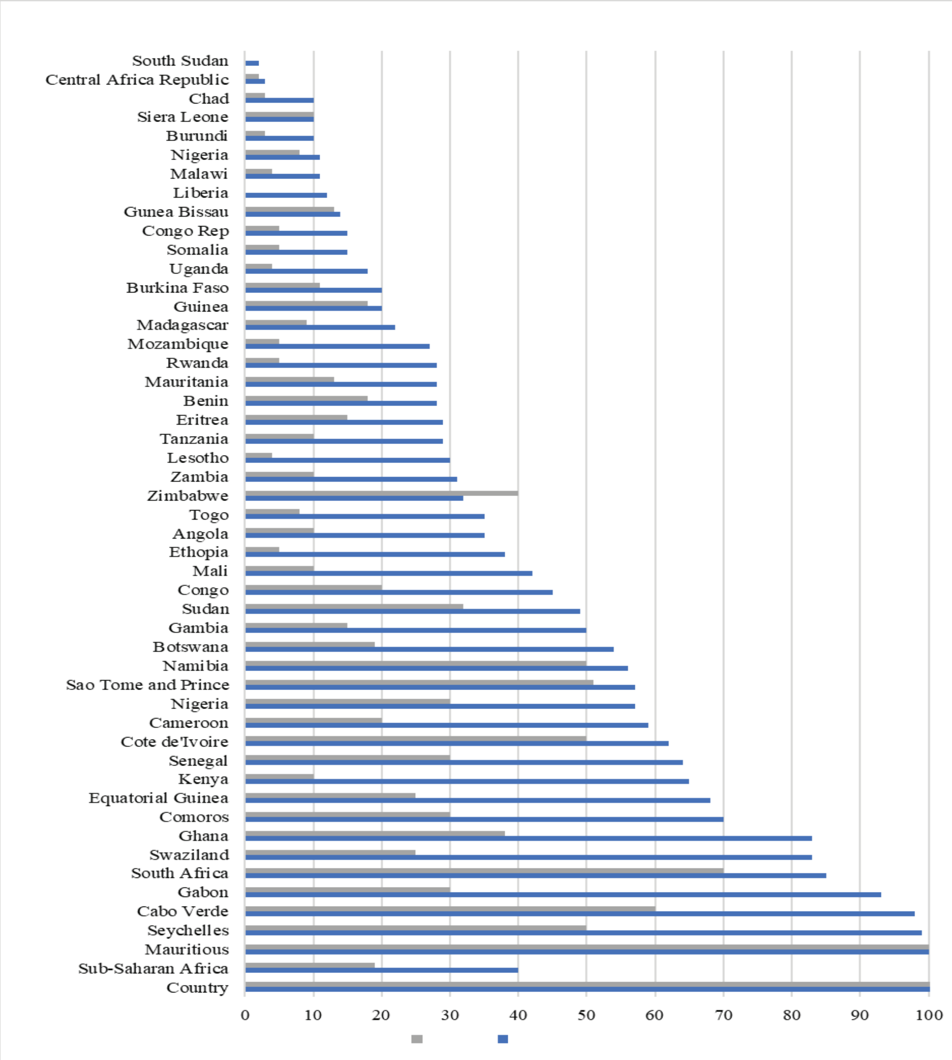
Figure 2.44: Urban Population Percentage with Access to Electricity by Region



Source: World Bank, Africa's Pulse (2017)

The figure 2.44 above shows the urban population percentage with Access to electricity by region. From this figure, it is observable that SSA has the lowest urban population percentage with access to electricity due to poor energy infrastructure investments whereas East Asian Pacific has the highest urban population percentage with access to electricity, with approximately 96 in 1990 to 99 in 2014. This is mainly because the East Asian Pacific has invested billions of dollars in infrastructure programme for the past three decades more than all other regions (Mbku, 2015).

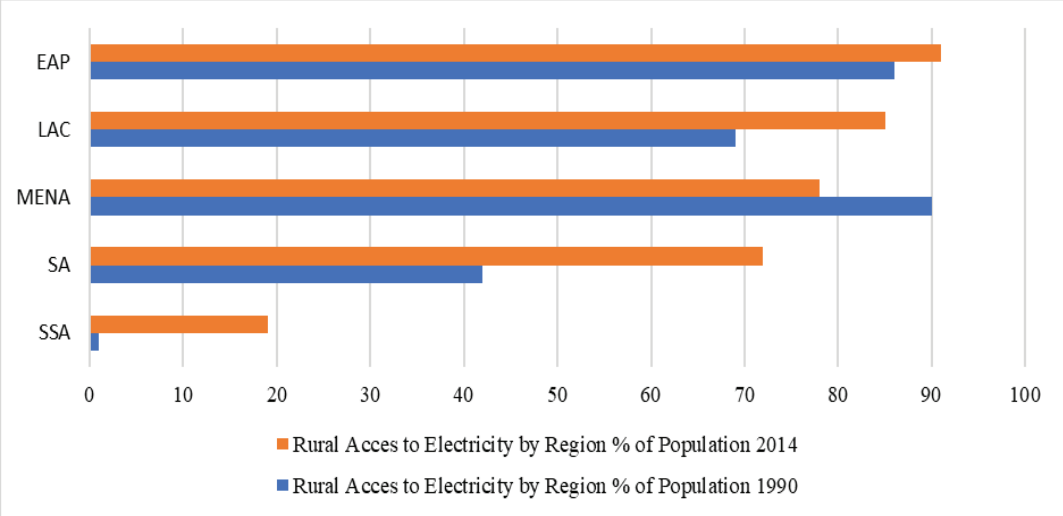
Figure 2.45: Percentage of Population with Access to Electricity in selected SSA Countries



Source: Researcher's own Tabulation from IEA, Energy Access Outlook 2017

Access to electricity has increased across all SSA income groups over the past two decades, although at a slower pace among LICs. Overall access rates to electricity went from 10% in 1990 to 23% in 2014 among this income group, while it increased from 29 to 45% among LMCs over the same period. The region's UMCs have the largest overall access rate to electricity (with 89% of the population in 2014).

Figure 2.46: Percentage of Rural Population with Access to Electricity by Region



Source: Oxford Economics (2019)

The fast increase in the overall access rate in the region is driven by rising rural access rates, although they were coming from low levels in 1990. Yet, there is great disparity between urban and rural rates of access to electricity across income groups in SSA. For instance, in LICs, about 62% of the urban population had access to electricity in 2014, while only 8% had access in rural areas. The urban and rural rates of access for the region's LMCs are 83 and 18%, respectively. Finally, the rural rate of access to electricity in UMCs (about 67%) is still below than that of other developing regions.

Electricity Access and Utilization Figure 2.45 presents information on changes over time in household electrification in SSA. In some countries, such as Gabon, Swaziland, and Kenya, the pace of electrification has been rapid, with access rates increasing by more than 50% between 2000 and 2016. In contrast, electrification has lagged population growth in Zimbabwe, so that electrification rates declined.

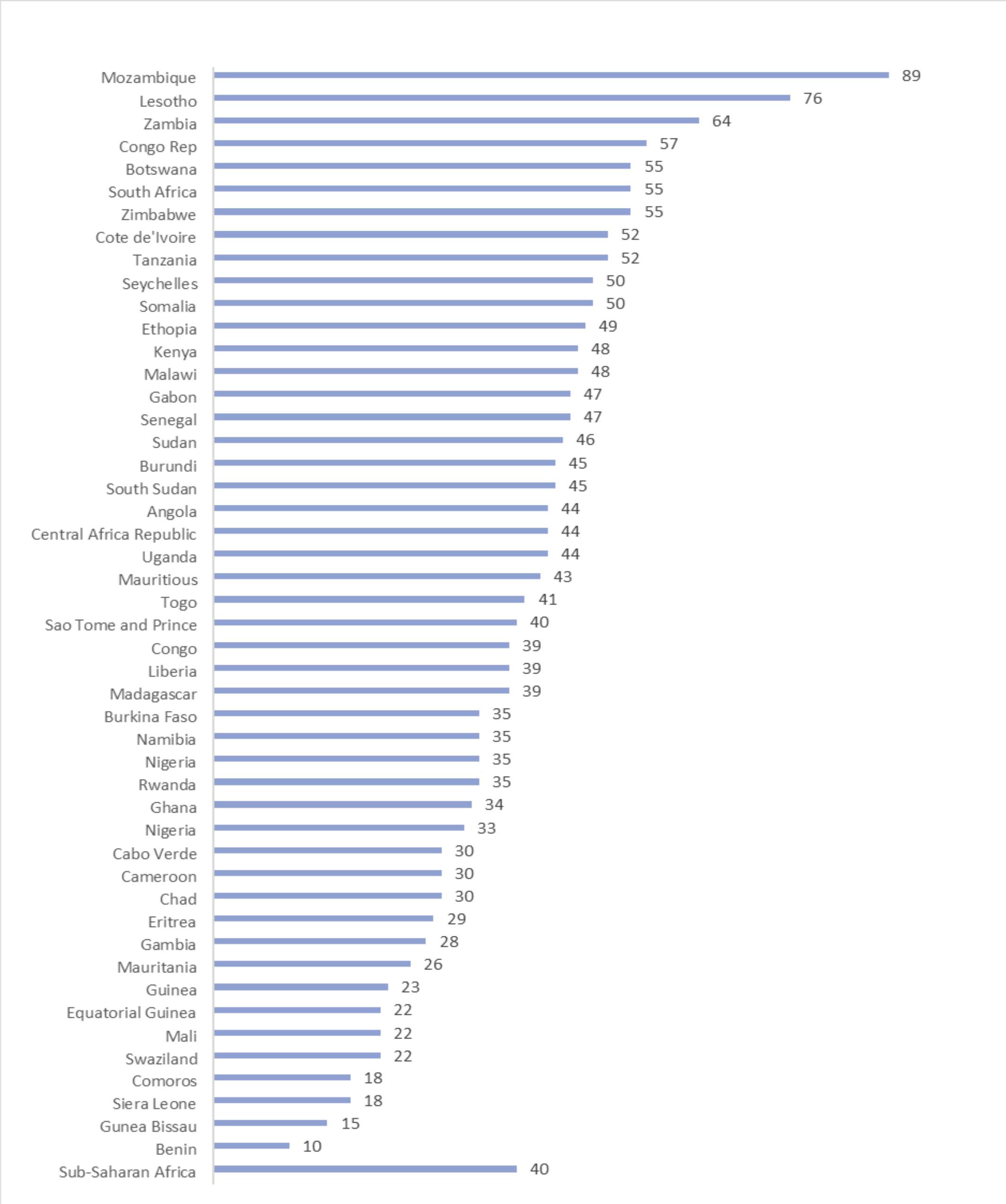
Overall, the household electrification rate in SSA is the lowest in the world, averaging 42% in 2016. There are also huge gaps in electricity access between rural and urban households in SSA. Access rates among urban households are about 71%, compared with 22% among rural households (and even lower if a few countries with more significant rural electrification are excluded) (IEA, 2014). These gaps mirror income and wealth inequalities in the region (World Bank, 2016).

Electricity consumption in the region is low compared with other parts of the world (World Bank, 2016). From 2010 to 2014, the average annual consumption per capita in SSA was equivalent to just 4% of consumption per capita in the United States, and 15 and 21% of that in in China and Brazil, respectively. Except for South Africa, industrial consumption across SSA is low, reflecting the low level of industrialisation in the region. Utilization of electricity in the agriculture sector is also low, accounting for just 2% of total electricity consumption. Low levels of electricity consumption are relevant not just in and of themselves, but also because they hint at challenges in measuring actual versus nominal electricity access. Protocols differ in defining access, but in some cases, the existence of one grid-connected household in a village is sufficient to establish that the whole village is electrified. In other cases, access is identified by the existence of physical connections, even if no electricity is actually flowing.

Utilization of installed generation capacity is low in a number of SSA countries, as shown in Figure 2.47. On average, electricity generation in SSA was only 40% of the potential output given the installed capacity (Briceno & Shkaratan, 2010). The low-capacity utilization rates are an additional indication of the inefficiencies in the electricity sector that have resulted in undermaintained and often inoperable generation capacity.

Aside from low access rates, the electricity sector in SSA is beset with huge problems of reliability. Households and firms often endure several hours of the day (night) without power. In some cases, outages are unscheduled, thereby constraining the utilization of electricity for productive purposes.

Figure 2.47: Capacity Utilization in Electricity Generation in SSA as a percentage

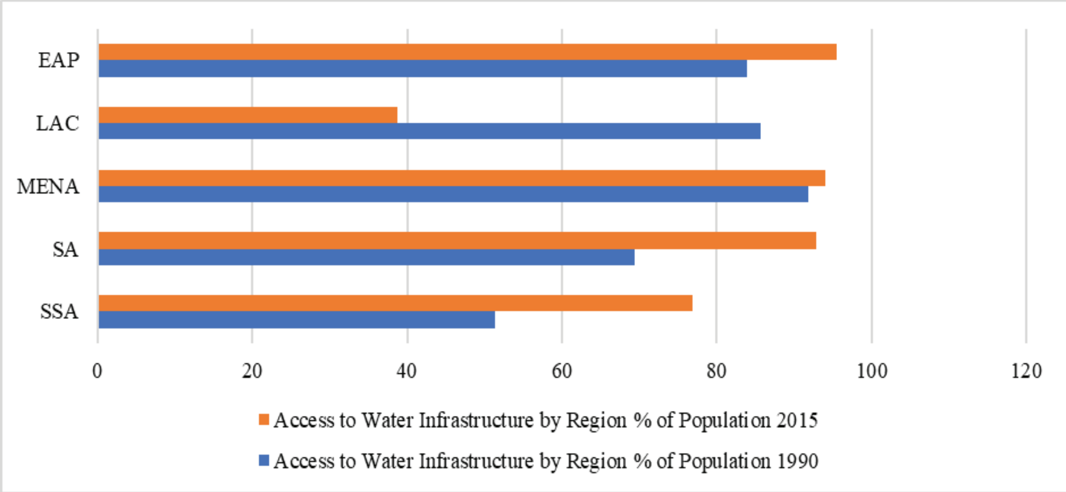


Source: Researcher's own Tabulation from IEA, Energy Access Outlook (2017)

2.9 Access to Safe Water and Sanitation Facilities

Total access rates to improved sources of water grew sharply in SSA over the past quarter century (to a median of 77% in 2015, from 51% in 1990). Although more than three-fourths of the region's population had access to water in 2015, other benchmark regions have access rates that exceed 90% (see Figure 2.48).

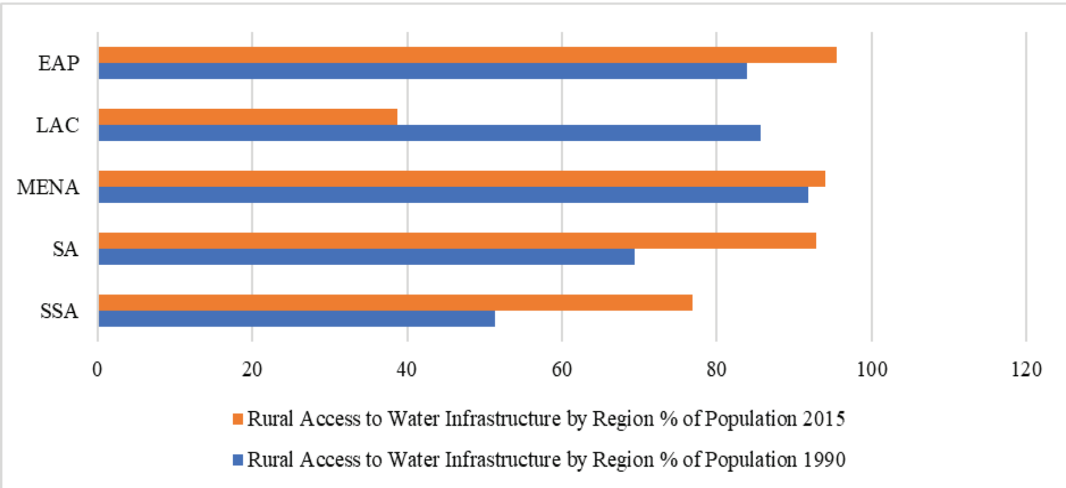
Figure 2.48: Access to Water Infrastructure by Region



Source: IMF, World Economic Outlook

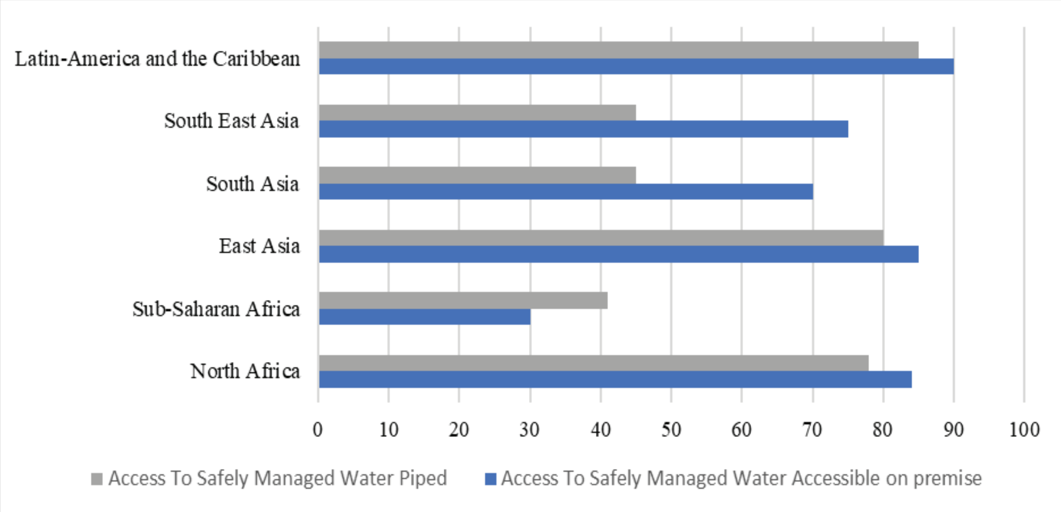
Again, there is a large disparity in urban and rural access rates in Sub-Saharan Africa, despite the sharp growth of rural access. In 2015, more than 90% of the urban population had access to water, while only 67% had access in rural areas. For other developing regions, rural access exceeded 85% of the population.

Figure 2.49: Rural Access to Water by Region



Source: Oxford Economics (2018)

Figure 2.50: Safely Managed Water Access by Region



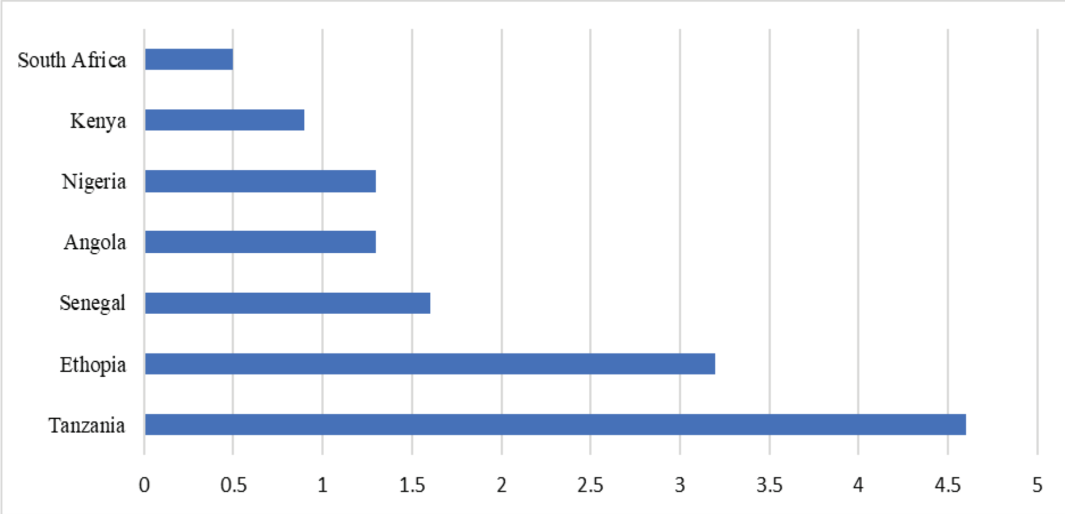
Source: WEO (2019)

The percentage of the population with access to improved water sources increased over the past quarter century across all income groups in SSA, with LICs showing the largest improvement rates. Their overall access rates jumped from 48% in 1990 to 77% in 2015. The disparities across income groups are driven by those in rural areas. Interestingly, a greater proportion of the rural population has access to water among LICs in the region (67% in 2015) than among LMCs (57%). Among UMCs in the region, access is nearly universal in urban areas, while it covers 81% of the population in rural areas. Despite covering four-fifths of the rural population in 2015, rural access rates among UMCs in SSA are not higher than those in other developing areas.

2.10 Access to Improved Sanitation Facilities.

Over the past quarter century, SSA has doubled total access rates to sanitation; however, they are still low relative to other benchmark regions. Sanitation access rates went from under 15% in 1990, to about 30% in 2015 (see Figure 2.51). In 2015, about 55% of the population of South Asia had access to sanitation facilities, while that proportion exceeded to 80% for Latin America and the Caribbean and East Asia. With a median rate of 38%, access to sanitation has changed little for SSA’s urban population. In the region’s rural areas, only 25 out of 100 people had access to improved sanitation facilities in 2015, up from 9 in 1990.

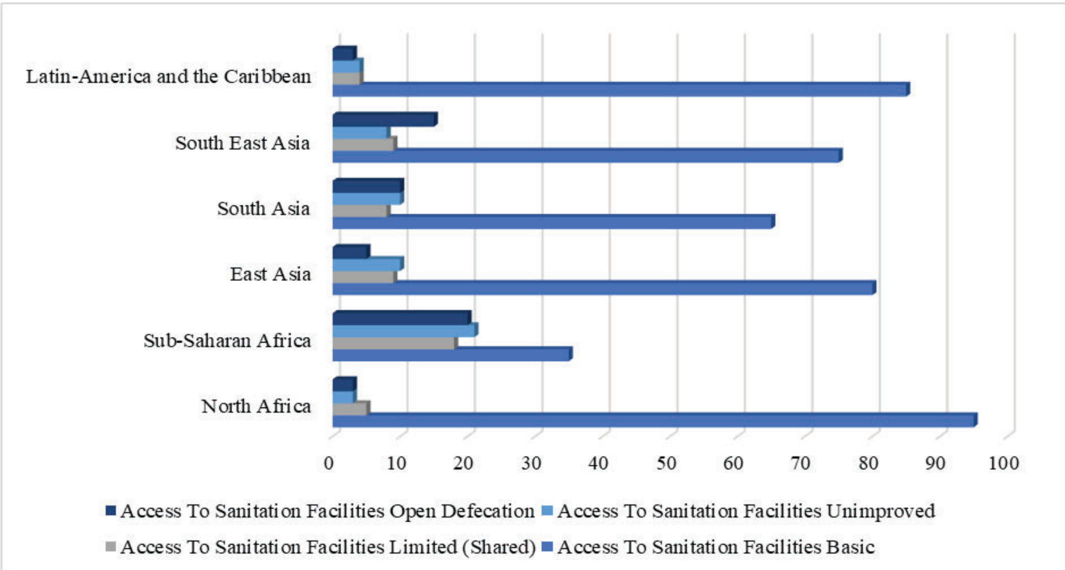
Figure 2.51: Access to Improved Drinking Water as a percentage of total population



Source, Oxford Economics, 2018

Overall access rates increased over the past 25 years for LICs and LMCs in SSA and declined for UMCs. Again, these developments are primarily driven by the evolution of rural access rates. Across rural areas, access rates more than doubled among LICs (jumping from 7% in 1990 to 16% in 2015). Gains in access were significant, although not as high, in LMCs (they went from 18% in 1990, to 25% in 2015).

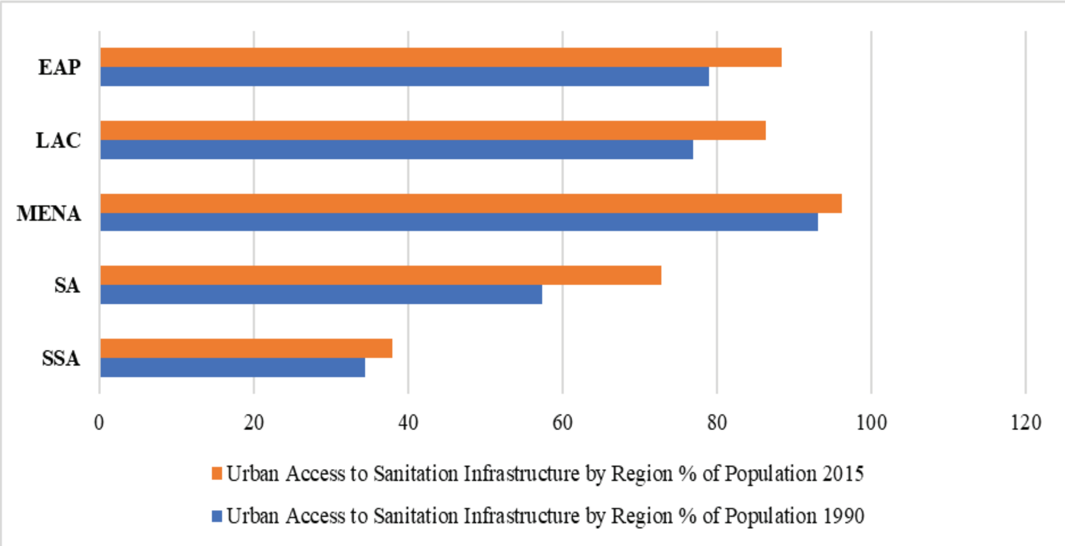
Figure 2.52: Access to Sanitation Facilities as percentage



Source: Oxford Economics, 2018

Among UMCs, rural access rates declined, from 64% in 1990 to 61% in 2015. Finally, the rural access rate for UMCs was only higher than the regional median for South Asia.

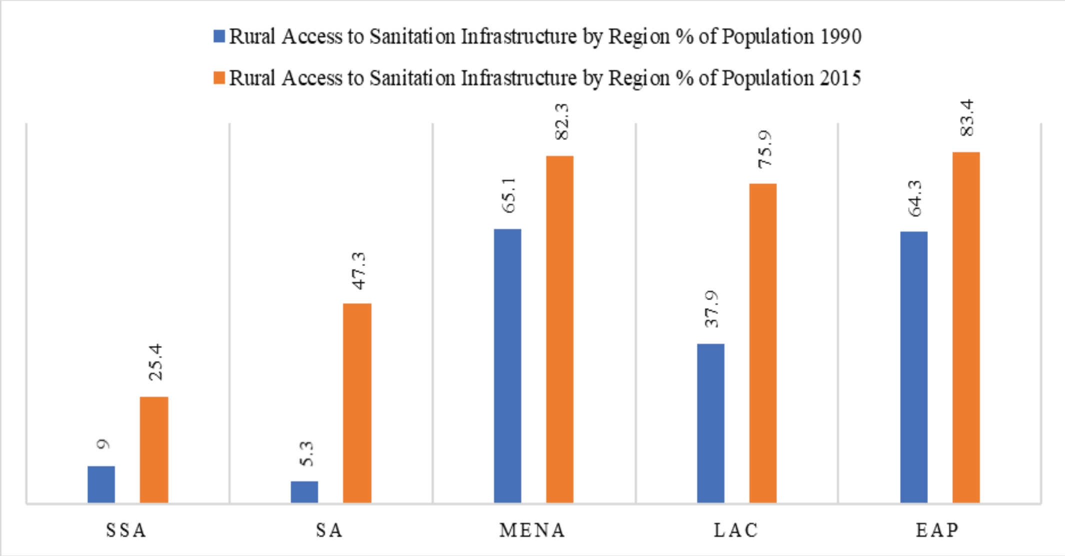
Figure 2.53: Urban Access to Sanitation Facilities by Region



Source: World Bank, Africa's Pulse (2017)

Countries with greater income per capita also tend to have greater rates of access to improved sanitation facilities. For 2008 to 2012, Mauritius and South Africa remained along the international norm, while Gabon appears to have fallen off track. Over the past decade, Ethiopia moved from being the weakest performer to being close to the access rates predicted by the international norm. Niger, Togo and Tanzania continued to have the lowest adjusted rates of access in the region.

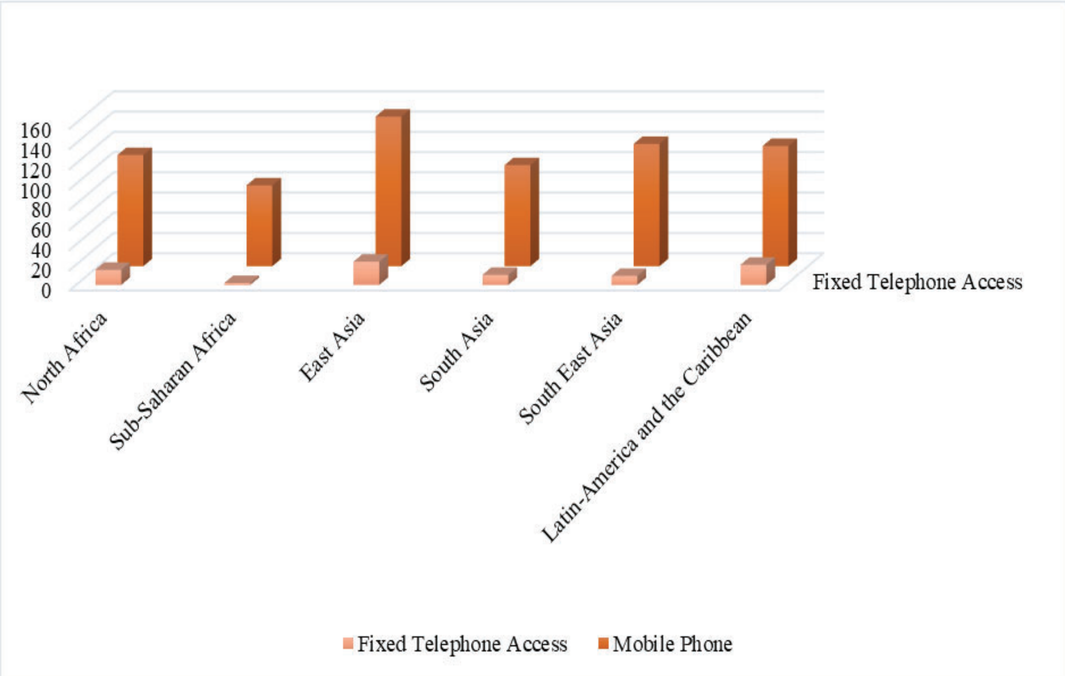
Figure 2.54: Rural Access to Sanitation Facilities



Source: World Bank, Africa's Pulse (2017)

Access to Telecommunication

Figure 2.55: Access to Telecommunication by Region

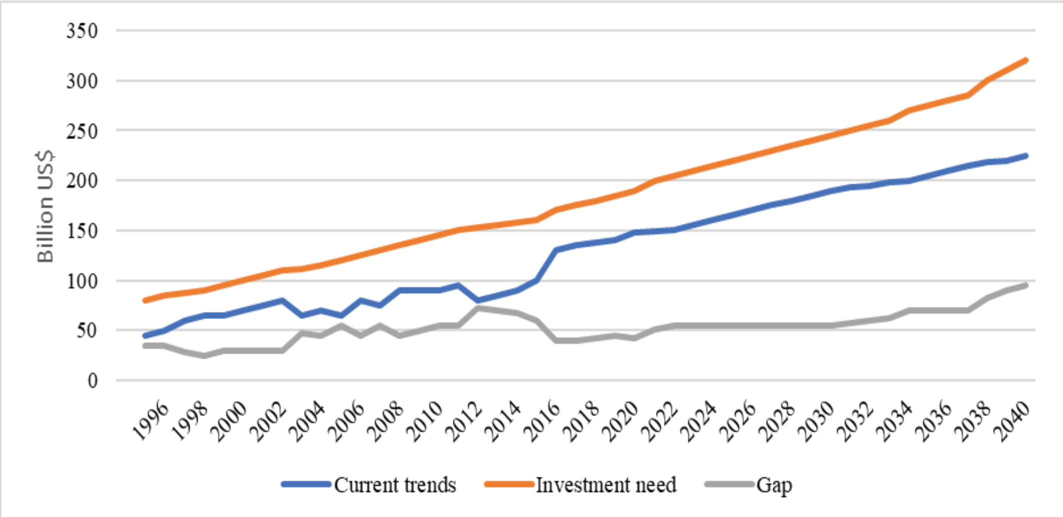


Source: GIO (2019)

2.11 SSA Infrastructure Gap 1995-2040

This sub-section assesses the patterns of infrastructure stocks and their accumulation across countries in the region. It updates the benchmarking analysis of infrastructure in the region conducted by Calderon and Serven (2004) and confirms the continuing existence of a wide gap in infrastructure provision between SSA and other regional comparators.

Figure 2.56: African Infrastructure Investment Needs, Current Trends and Gap (1995-2040)



Source: GHI and Oxford Economics (2018)

Despite a recent surge in investment across the region, SSA countries have recorded larger infrastructure gaps compared with their peers. The infrastructure network in SSA countries suffers from a clear deficit. SSA economies are lagging behind their regional peers in electricity supply, paved road density, public education infrastructure, telecommunication infrastructure, and access to water (see Figure 2.56).

Between 2012 and 2016, commitments to Africa's infrastructure from all sources averaged $75 billion, with 2013 recording the highest commitment of $83.3 billion. Commitments declined to $62.5 billion in 2016, the lowest level in five years. Overall commitments fell by $16.4 billion from 2015 to 2016. This was mainly due to a large reduction of $14.5 billion of reported funding from China, and a $4.9 billion decline in private sector investment. African governments, whose contributions to infrastructure financing were sharply curtailed in 2014 after the commodity price shock, increased their share slightly from $24 billion in 2015 to $26.3 billion in 2016 (down from the peak of $43.6 billion in 2014). With investment needs estimated at $130 to $170 billion a year, and commitments from all sources at $62.5 billion in 2016, the financing gap for Africa's infrastructure is in the range of $67.6 to $107.5 billion. These numbers are all flow variables, not stocks.

The value of the infrastructure stock in Africa for 2016 is difficult to calculate rigorously using the inventory method. Few African countries publish estimates of their infrastructure stock. Most of them have a public infrastructure asset management system, especially if they have a ministry of infrastructure, and ministries of finance typically compute figures on public infrastructure assets. But most countries define those assets to include public buildings hosting social services (hospitals, schools, and so on), which the researcher did not include in the definition of infrastructure as per the IMF functional classification used in this study. For Africa, the share of infrastructure investments in transport is the largest at around 39%, followed closely by the energy sector at 32% and water and sanitation at 17%. The increasingly important ICT sector is under 3%.

Guided by World Bank (2019), the researcher dug deeper into sectoral allocations, commitments to the transport sector fell sharply in 2016 to $24.5 billion, down from $34.4 billion in 2014 and $32.4 billion in 2015. The sector benefited from strong Chinese support in 2015 while budget allocations to transport from national governments peaked at $17.6 billion in 2014 before they were depressed by weak oil and commodity prices in the two following years. African national governments nevertheless continued to be the main funders of the continent's transport infrastructure in 2016, providing $14.6 billion (59.6%) of the $24.5 billion committed that year. West Africa received the highest transport commitments in 2016 ($6.6 billion or 26.9% of the total), and East Africa had the highest in 2015 ($11.8 billion, or more than one-third of commitments).

According to GIO (2019), commitments to the water sector increased substantially from $7.5 billion in 2015 to $10.5 billion in 2016 and surpassing the $9.7 billion reported in 2014. African national governments again provided substantial funding to the sector, with $4.4 billion allocated, while bilateral and multilateral agencies committed $1.5 billion. In keeping with previous years, North Africa ($2.6 billion) and East Africa ($2.5 billion) accounted for almost half of the total commitments to water in 2016. West Africa received $2.1 billion in the water sector financing in 2016, a substantial increase from 2015 ($1.1 billion). Financing for projects in Southern Africa stood at $1.9 billion (18%), while Central Africa received $851 million and South Africa $528 million. Financing of energy projects in Africa fell to $20 billion in 2016, from a peak of $33.5 billion reported in 2015, which included African national government allocations of $6 billion.

GIO (2018) indicated that Chinese commitments almost halved to $4.6 billion, though this still accounted for 23% of total commitments to the sector. The relative lack of renewable energy projects reaching financial closing in South Africa, compared with previous years, was a major factor in the overall decline, with the private sector investing just $1.3 billion in 2016. Southern Africa, historically a primary destination for investment in energy, received only 18.3% of total commitments in 2016, down by 50% compared to 2015. By contrast, West and East Africa accounted for more than half of total commitments, receiving $5.6 billion and $5.2 billion, respectively. Commitments to North Africa fell from $4.5 billion to $3.3 billion, while those to Central Africa rose from $1.2 billion to $1.4 billion. ICT sector commitments stood at $1.6 billion in 2016, less than the $2.4 billion reported in 2015. African national government allocations increased to $853 million, but Chinese investments declined from just over $1 billion in 2015 to $300 million.

2.12 Factors Explaining the Infrastructure Gap in SSA

The growing SSA infrastructure gap can be explained by various factors ranging from institutional, political, economic, cultural, and technological. This section examines key factors responsible for the widening SSA infrastructure gap.

2.12.1 Weaknesses in infrastructure planning and project preparation

The absence of well-defined infrastructure programmes and bankable project pipelines is also a major issue in many African countries. At the core of the challenge is the private sector, which is not prepared to assess, develop, and prepare infrastructure projects, given the costs, risks and long-time horizons. That means governments, donors and international financial institutions (IFIs) need to act through long-term infrastructure planning based on population growth and development objectives and considering the economic importance of different regions of a country.

A lack of planning may also prevent a government from taking a programmatic approach to building infrastructure and implementing complementary projects to maximize benefits. For instance, a national highway passing through an agricultural region can be built or upgraded along with rural roads to ensure that farmers benefit from the highway. Even with infrastructure plans, individual projects need preparation to demonstrate their bankability and reach financial viability. Project preparation includes project identification, pre-feasibility and feasibility studies (proof of concept), detailed studies (feasibility, environmental and social impact, design), project structuring, and procurement and concession agreements (including contract negotiation). Strong administrative capacity may also be required for setting up the laws, regulations and institutions necessary for a specific project. This step can be challenging for African countries due to their lack of capacity and financing. Sometimes an African country may lack the human capital in the public sector to undertake infrastructure project preparation, which can require highly skilled professionals, so many must seek external expertise.

2.12.2 Weak regulatory, legal, and institutional frameworks

Africa's legal, regulatory, and institutional frameworks are major constraints to attracting private capital to infrastructure. Ineffective or non-existent institutions also pose a challenge. Even when laws are enacted, they may not be implemented or may lack the implementation decrees. In light of the Law and finance theory (La Porta et al., 1997, 1998, 2000; Beck and Levine, 2008), in the energy sector for instance, strong and credible financial institutions are required for the sector to work. Private sector players tend to participate in power generation as independent power producers (IPPs) and in the distribution to final consumers (DISCOs). Between the two, a public company often owns the transmission lines and purchase the power produced by IPPs (off-taker) to sell it to DISCOs. The off taker typically guarantees the payment of the IPPs production at a pre-agreed rate. The lack of a financially credible off-taker is often a major constraint for IPPs to negotiate and sign power purchase agreements, which can be mitigated through government guarantees backed by guaranteed schemes from development finance institutions. This increases project costs and offtake tariffs.

The often inappropriate regulatory framework also limits private sector participation in infrastructure funding. For example, a large number of pension funds in Africa are not allowed to invest in infrastructure projects, even less so outside their countries. Given the small size of most economies, and the cross-border nature of many infrastructure projects, this obstacle is crucial. When allowed, institutional investors may find it difficult to invest as they are often subject to stringent guidelines, such as those for the credit ratings of facilities they invest in, except in Botswana, Mauritius, Seychelles and South Africa. Most pension funds lack the technical skills to assess complicated infrastructure projects, and there is no incentive for them to assume the extra risk of investing in infrastructure. Fixing these failures would allow African pension funds to allocate up to $4.6 billion a year to infrastructure.

Another area that requires strong institutional intervention is the PPP framework. PPP agreements are often poorly structured and drafted due to lack of skills or experience in government departments. Lacking actual PPP laws, each project is then subject to individual workaround existing public investment laws and procurement regulations case by case. In the worst case, all project elements have to be developed with all levels of government, adding to uncertainty and extending project development times and complications in procurement. Overall, however, interest is growing for PPPs to support infrastructure in Africa, as reflected in the development of regulatory and institutional frameworks, with many African countries passing laws, national policies, regulations and PPP units for implementation over the years.

2.12.3 Governance and corruption

Poor governance and political economy issues can be major bottlenecks for infrastructure development in Africa frequently because these projects are complex. They require heavy, long-term investment, have strong public-good characteristics, a long-life, and high sunk costs. And they are very sensitive to local political conditions. These issues naturally affect private investors' risk perceptions of infrastructure funding in Africa. Political rather than economic and social considerations may dictate where infrastructure projects are executed. In many African countries, airports, paved roads and power plants are built to yield political benefits in the regions of powerful politicians and end up as "white elephants." This was particularly common in the 1980s. Georgieva (2019), the IMF managing director stated that 40% of the debt burden accumulated by most SSA economies is lost through rent seeking and managerial inefficiencies of bureaucrats necessitated by porous, opaques and unclear infrastructure related tender processes. These leakages represent huge welfare losses imposed on SSA citizens by their government's inefficiencies and rent-seeking tendencies.

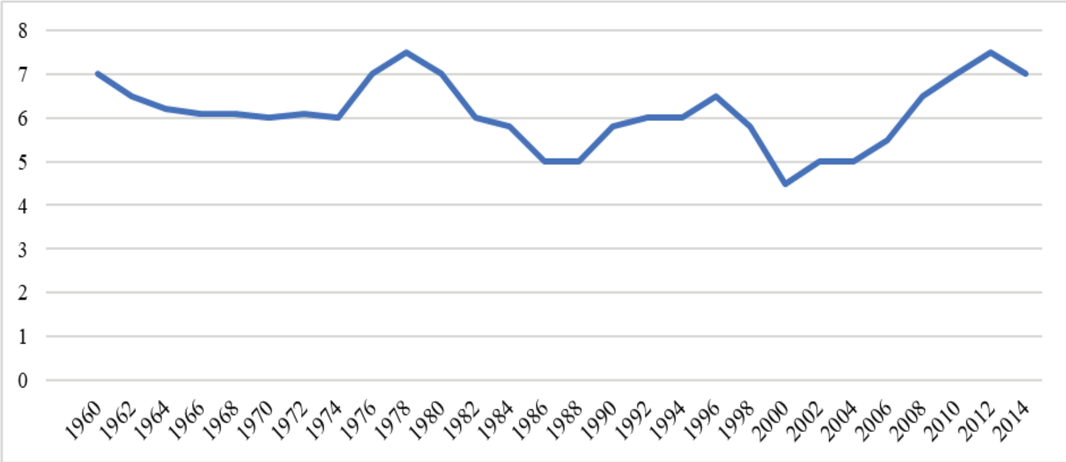
Political bias in project selection also leads to a large number of unfinished projects as new governments fail to complete old projects given their lack of economic returns or their perceived benefits favouring constituencies that may not support them. Elections and political considerations can shift the composition of public spending towards “more visible” current expenditures instead of capital expenditures. A major infrastructure project can easily take more than five years from inception to commissioning. So, governments might prefer not to undertake such projects in one or two years since they won’t be able to show outcomes ahead of the next election. In addition, political considerations may favour constructing new infrastructure as opposed to optimizing the use of what is already there.

The negative consequences of political considerations are often worsened by rent-seeking and corruption, lowering the quantity of productive public investment. Corruption also reduces the efficiency of public investment as corrupt officials give priority to projects that generate higher private material and political gains over projects with higher social returns. In such circumstances, projects take a long time to develop and involve multiple stakeholders. Civil servants at various levels of responsibility play critical roles at various stages in the project development cycle, which increases their opportunities to seek bribes. Projects involve large sums of money and cumbersome regulatory systems with ambiguous rules, leaving room for subjective interpretations, weak accountability, and ineffective transparency mechanisms.

2.13 Public Investment in SSA

The unprecedented economic performance in SSA over the past two decades, coined as Africa Rising, was characterised by many SSA countries growing at a rate that exceeded 5% per annum. The Africa Rising’s earlier narrative attributes the region’s faster growth to external tailwinds, progress in macro-economic management and robust public investment. As economies in the region decelerated in the post-crisis period, there was a significant countercyclical effort to support aggregate demand among countries in the region; partly reflected in a large increase of public investment. For instance, the cumulative increase of public investment exceeded 5 percentage points of GDP in Togo, Guinea, and Ethiopia during the period 2008-2015.

Figure 2.57: Public Sector Investment in SSA as a Percentage of GDP



Source: International Monetary Fund (2017)

The evolution of public investment as a percentage of GDP in the region exhibits three marked periods: firstly, a rising trend in the 1970s that reaches a peak of about 7.8 % in 1977-78, secondly, a steady decline throughout the 1980s and stagnation in the 1990s that reached a trough of 3 % of GDP in 2002, and lastly, an increase in public investment that reached a peak of 5.8 % of GDP in 2014. When comparing the public investment for the region, East Asia and the Pacific outperformed all other regions with levels of public capital spending that exceeded 10 % of GDP (see Figure 2.57).

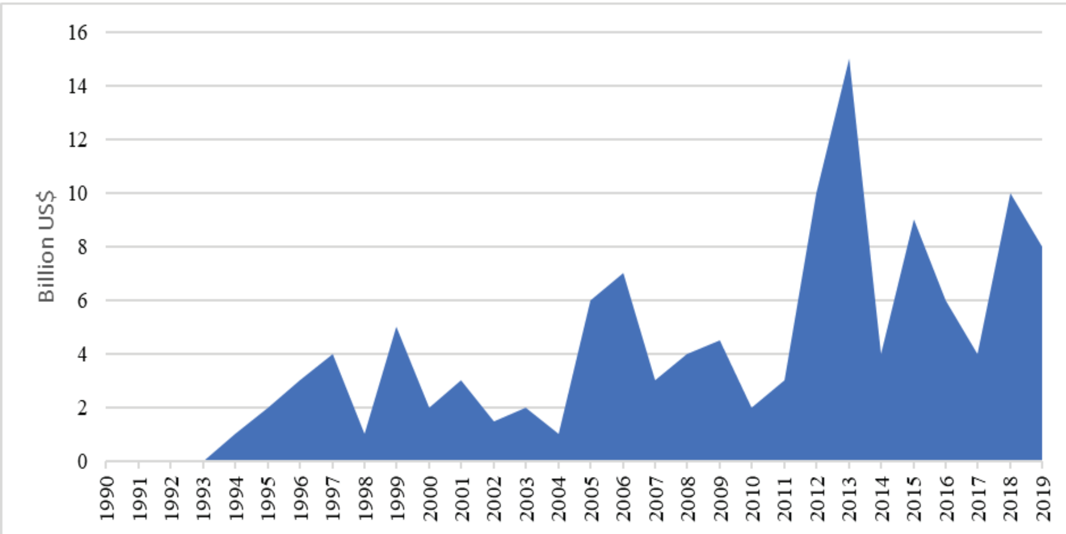
2.14 Public-Private Partnerships (PPPs) in SSA

There is renewed interest in PPPs. However, they remain a very small market in SSA to attract private investors into the region's different infrastructure sectors. The development of PPPs has been slow and started in the early 1990s, starting with projects in South Africa and Côte d'Ivoire in 1990. It eventually spread to 41 of the 48 countries in SSA, with Botswana and Somalia in 2011 and 2013, respectively. According to the World Bank's Private Participation in Infrastructure (PPI) database, there are 335 PPP infrastructure projects in SSA that have reached financial closure in the last 25 years.

According to AfDB (2018), Burundi, Eritrea, Equatorial Guinea, Mauritania, the Seychelles, South Sudan, and Swaziland did not have any PPPs throughout this period. Although many SSA countries started early, they never produced another PPP after their first one, for example, Central African Republic (1991), Guinea-Bissau (1991) and DRC (1995). The most active countries in the region are South Africa (85 projects), Nigeria (35), Kenya (22) and Uganda (22). There were 9 countries that have only produced one PPP, and another 13 that have produced only two or three in the last 25 years. The low number of PPPs in these countries can be attributed to the fact that some are small economies, others have been in conflict for several years or they have a weak legal and regulatory framework to procure and implement PPPs (The World Bank, 2017). The number of PPP infrastructure projects in SSA is a relatively small proportion of the total number of projects in Emerging Markets and Developing Economies (EMDE), ranging from 2 to 12%.

Additionally, PPP investment commitments in SSA are also relatively modest: they account for a small portion (2 to 10%) of PPP commitments in EMDEs. When adjusting the data by the size of the economy, it can be observed that before the Asian Financial crisis (1997-1998), PPP investment as a percentage of GDP was clearly below the average for the rest of the EMDEs, reaching a peak of 0.2 % in 1997 compared to 1.1% for the rest of the EMDEs. However, after the Asian financial crisis, investment as a percentage of GDP fluctuated between 0.2 and 0.6, closer to the average for the rest of the EMDEs. Fluctuations on the public private partnership investment in SSA is summarised by Figure 2.58.

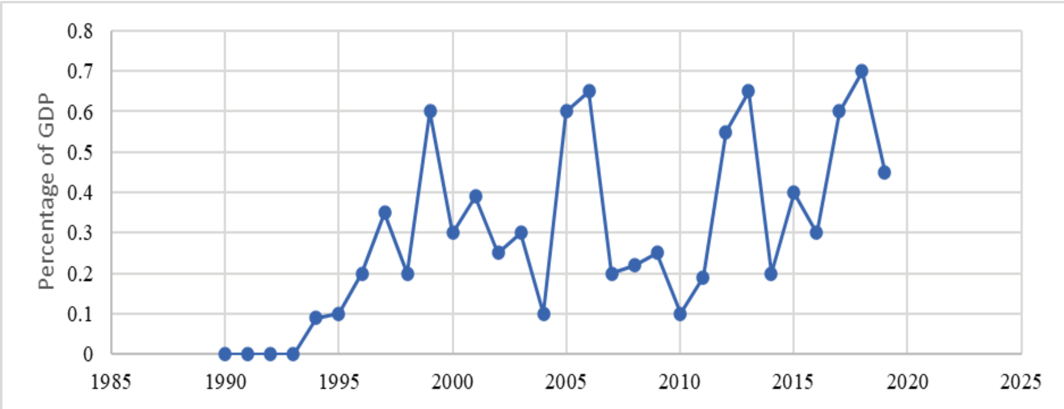
Figure 2.58: Public Private Partnership (PPP) Investment in SSA



Source: UN Data, 2019

PPP projects in SSA have been concentrated in only a few countries, namely - South Africa, Nigeria, Kenya and Uganda, which are the top four countries in terms of both investment and number of projects (AfDB, 2018). Together they have accounted for 48% of the 335 total PPP projects in SSA in the last 25 years. This amounts to $36.7 billion of investment commitments, or 62% of the $59 billion of total investment commitments in the region. Investment as a percentage of GDP tends to be somewhat sporadic for the top four countries, jumping during commodity boom years such as 2005-06, 2012-13, and 2015 (see Figure 2.59). In three of the past five years, the top four countries (especially South Africa and Nigeria) have played a significant role in the development of SSA PPPs. This has been largely due to renewable energy initiatives in South Africa and port renovations in Nigeria.

Figure 2.59: PPP Investment in SSA as a Percentage of GDP



Source: World Bank PPI Database (2020)

2.15 Public and Private Investment in SSA (Compliments or Substitutes)

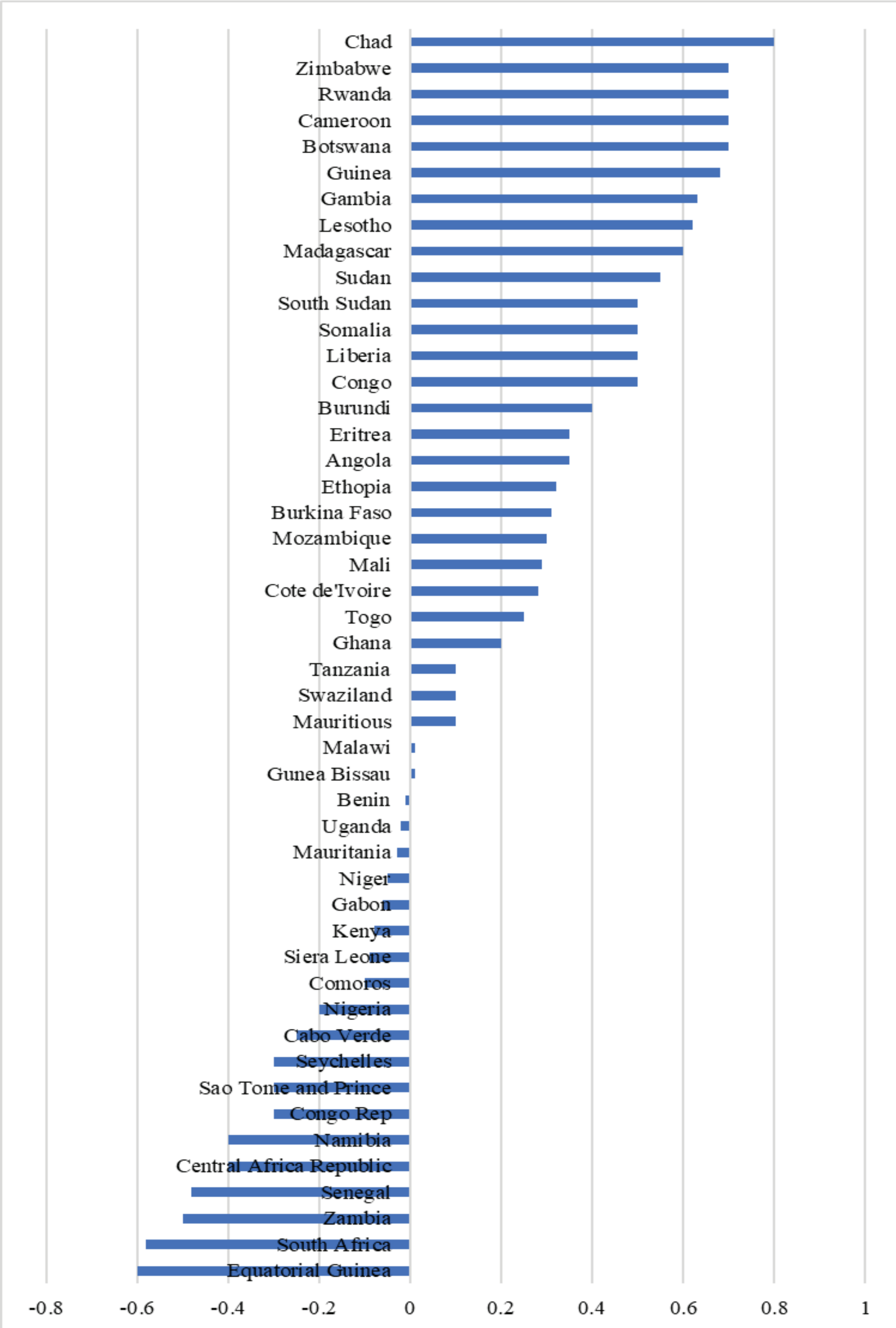
The interaction between public and private investment remains a subject of controversy. Do public and private investments have different growth effects? If they both matter for growth, what are the possible links between them? If public investment crowds in, say, the participation of (domestic and/or foreign) private investors in transportation or energy projects, the relevant policy question becomes how to maximize the complementarities and prioritise public investment in sectors with high productivity and/or large positive spill-over effects (for example, infrastructure). By contrast, if private investment is crowded out by public investment, the relevant policy question is what can be done to reduce this crowding-out effect, so that countries can reap more benefits from higher public investment (Cavallo and Daude, 2011).

Figure 2.60 depicts the correlation between public and private investment ratios for 45 countries in the region over 1970–2015. The correlation ranges from -0.59 (Equatorial Guinea) to 0.85 (Chad), and the regional median (average) public-private investment correlation is 0.11 (0.08). Two findings emerge from this figure: first, 19 of 45 countries display a negative correlation between public and private investment, and the median correlation for these 19 countries is -0.275. Second, there is a positive association between private and public investment for 26 of 45 countries, and their median correlation is 0.282. In other words, the evidence suggests that public and private investment are substitutes in 19 countries and complements in 26 countries. Although central measures of correlation do not appear to be large, there are countries where either the degree of substitutability is important (for example, Equatorial Guinea, Zambia, South Africa, and Senegal) or the extent of complementarity (for example, Botswana, Zimbabwe, Rwanda, and Chad).

To reduce the crowding-out effect of public investment on private investment or to foster crowding-in effects, there is the need to formulate policies that elevate the marginal product of capital or alleviate financial constraints (Aschauer, 1989; Cavallo and Daude, 2011). In this context, policies to foster institutional quality and/or enhance access to international credit markets will help to reduce the substitutability or increase the complementarity between private and public investment. The correlates of the degree of substitutability or complementarity between public and private investment and measures of institutional quality, financial openness, and financial development are examined.

Cavallo and Daude (2011) estimated the private investment equation for 116 countries for 1980 to 2006, using dynamic panel data techniques that address issues of unobserved components and reverse causality. On average, they found a negative effect of public investment on private investment in developing countries: a one percentage point increase in public investment (as a percent of GDP) reduces private investment by 0.22 percentage points. This finding suggests that the crowding-out effects of public investment through weak public institutions or borrowing constraints tend to outweigh the crowding-in effects from the rising marginal product of private capital.

Figure 2.60: SSA Public and Private Investment Correlations (Complements vs Substitutes)



Source: IMF Investment and Capital Stock Database.

Note: The figure depicts the correlation between the private and public investment ratios to GDP during 1970–2015. These two ratios are expressed in first differences.

Raising the efficiency of public investment and improving the ability to crowd-in private investment should be at the top of the policy agenda. In this context, efforts to improve institutions (at the country and project levels) and implement policies to alleviate borrowing constraints such as, creating fiscal space and fostering financial openness, are necessary.

Table 2.2: Correlations Between Energy, Transport, Water & Sanitation and Telecoms

	Energy	**Telecoms**	**Transport**	**Water & Sanitation**
Energy	1.00			
Telecoms	0.64	1.00		
Transport	0.43	0.53	1.00	
Water & Sanitation	0.68	0.80	0.89	1.00

Source: Own Computations using World Bank data

Table 2.2 presents a summary of correlation results between four infrastructure groups in the SSA Region. All four infrastructure categories are positively related to one another indicating that development in one sector has downward positive effects to other sectors.

2.16 Financing of Infrastructure in sub-Saharan Africa.

The Infrastructure Consortium for Africa (ICA) was formed in 2005 to ensure that there are sustainable and reliable water, energy, transport, and ICT systems in the continent. In table 2.3, there is evidence that total infrastructure development is higher among the middle-income countries in our sample and evidence from previous section attests that Kenya, South Africa and Nigeria are among countries with robust PPPs projects. Evidence shows that education, water and sanitation and access to reliable drinking water is significantly higher among the middle-income countries in our sample compared to the lower income countries.

Table 2.3: t-statistics on infrastructure performance			
	Group 2	Group 1	Difference
Total Infrastructure Index	4.312	7.411	3.099***
Education Infrastructure index	2.662	8.392	5.730***
ICT Infrastructure index	4.046	5.180	1.134
Paved roads/total surface (%)	25.306	28.429	3.122
Quality of trade and transport infrastructure	2.154	2.192	0.038
Water and Sanitation Index	43.408	47.349	3.941*
Access to Reliable Drinking Water	64.598	69.025	4.426**
Access to Improved Sanitation Facilities	32.923	32.090	-0.833

*Note: *** p<0.01, ** p<0.05, * p<0.1*

***Notes**: Group 1 comprises of middle to emerging income economies in our sample and comprises of Botswana, Kenya, Ghana, Mauritius, Nigeria and South Africa. Whilst the **Group 2** comprises of developing countries namely Eswatini, Namibia, Lesotho, Zambia, and Zimbabwe to name just the few 46 countries in our sample.*

Source: Author's compilation

Countries in our sample were financed by the Development Southern Africa Bank (DBSA), the African Development Bank (AfDB) as well as the Chinese Development Bank and other local sources of financing between the period of 1950 and 2018. It is therefore worthwhile to unpack the evolution of road and other soft infrastructure such as education and water and sanitation for the period of 2002-2018 as done in Chapters Three and Four.

Table 2.4: Summary statistics on paved roads performance (1950-1995), units in thousands

Variable		Mean	Std. Dev.	Min	Max	Observations
Paved roads	Overall	3863	8122	0	60861	N = 1166
	Between		5986	142	34307	n = 42
	Within		3865	-23389	30417	T = 27.8

Source: Author's compilation

The average network size of roads in SSA economies was 3 863 km, with some countries such as Eswatini having zero paved roads in the early part of the frequency. The countries with higher network size have 60 861 km in size.

Table 2.5: Paved roads performance of middle-to-emerging income countries in SSA (1950-1995)

Variable		Mean	Std. Dev.	Min	Max	Observations
Paved roads	Overall	6149	7876.0	6	31800	N = 228
	Between		6513.6	1224	19479	n = 7
	Within		4480.5	-11537	18470	T = 33

Source: Author's compilation

Overall trends in Table 2.5 show there is greater proportion of paved roads in kilometers among middle to emerging economies in SSA than the low to developing income countries. This trends in data supports the evidence in Table 2.5 and Table 2.6 that middle income countries overall perform better in both soft and hard infrastructure compared to low-income countries.

Table 2.6: Paved roads performance of low-to-developing income countries in SSA (1950-1995)

Variable		**Mean**	**Std. Dev.**	**Minimum**	**Maximum**	**Observations**
Paved roads	Overall	3307	8088	0	60861	N = 938
	Between		5850	142	34307	n = 35
	Within		3703	-23944	29861	T = 27

Source: Author's compilation

Table 2.6 show that on average, low developing countries during the period of 1950 to 1995 had on average 3 307 (thousands) kilometers in paved road length and this is almost half the average size of middle-income countries in our sample that comprises Mauritius, Nigeria, Botswana, Ghana, Kenya and South Africa. The evidence in Table 2.6 collaborates with trends found in both Tables 2.3, 2.4, and 2.5.

The analysis proceeds by looking at the role of colonial origin on the trajectory or historical performance on the road infrastructure. Evidence shows that there is better paved road performance for countries such as Botswana, Mauritius, Nigeria, Zambia, Kenya and Zimbabwe that has legal origin formation from the British legacy than countries such as Mozambique, DRC, Central African Republic, Senegal to name just a few that have either French, Belgium or German formation. This evidence is supported by Gwenhamo et al. (2008, 2012), Zaaruka (2012) and Letete and Sarr (2016) that countries with British colonial history perform better than countries with other source of legal origin. Our findings are robust at all levels and on average, countries with British origin outperform the other source of colonial origin as per results in Table 2.3.

2.17 Conclusion

There is significant room to improve the infrastructure situation in SSA. Investment in SSA countries is lagging vis-à-vis peers such as emerging and developing Asia as well as Latin America and the Caribbean. The region's infrastructure is perceived as being of relatively low quality. The infrastructure investment and financing gaps for SSA economies is continuously widening over time despite funds. More than their funding requirements are lying idle under mutual management funds' custody. Improving the efficiency of sizable investment programmes in the region could contribute to more solid economic growth and help achieve desired social priorities and development goals. Stronger institutions could foster more efficient public investment and also serves as a useful conduit and catalyst towards private sector participation in infrastructure investment projects. The correlation results in this chapter show a positive association between public investment efficiency and the quality of institutions, suggesting that developing stronger institutions in SSA could lead to a significant improvement in investment efficiency and possible closure of the ever-ballooning infrastructure investment and financing gaps. Moreover, IMF Managing Director observed that 40% of SSA economies' debt burden accumulation is an outcome of weak, porous and opaques institutions, which promote rent-seeking and management inefficiencies by bureaucrats. This is particularly relevant for countries with weak institutional quality, where governments may use capital spending as a vehicle for rent-seeking, leading to inefficient spending. Given the current drive for scaling up investment in SSA, the task of improving institutions quickly should become a priority.

Encouragement of Public Private Partnerships and an improvement in public investment management practices in SSA countries could significantly reduce their infrastructure gaps. While SSA presents better institutional design in the areas of national and sectoral planning, multi-year budgeting, and project management, the region has weaker regulations in the areas of central-local coordination, management of PPPs, company regulation, and monitoring of assets. SSA countries could reduce their infrastructure gaps by strengthening planning and selection of PPPs, credibility of multi-year budgeting, effectiveness of project appraisal and selection, monitoring of projects during implementation, and registration of infrastructure assets. Other measures to promote greater scrutiny of public investment projects include 1) improving the procurement process, 2) increasing data transparency and the budgeting process, 3) advancing infrastructure needs assessments to guide medium-term sectoral strategies on infrastructure and monitor progress in closing infrastructure gaps, and 4) undertaking audits and independent in-depth diagnoses of the current public investment management system in coordination with development partners. Also, the soft infrastructure dimension such as education and health, which has been conspicuously omitted must be included in analysis, since following growth models, growth is accelerated if the is complementarity between stock of capital and quality labour.

CHAPTER 3: EFFECT OF INSTITUTIONAL QUALITY ON INFRASTRUCTURE DEVELOPMENT IN SSA COUNTRIES: A STATIC AND DYNAMIC PANEL DATA THRESHOLD APPROACH

3.1 Introduction

Infrastructure access, quality and quantity have been extensively found to impact positively on inclusive economic growth and balanced development. It has also been found to enhance market interconnectedness, both regionally and globally, whose benefits accrual is more biased towards emerging and developing economies. The growth and development gains of infrastructure are manifested through production cost reduction, transport, communication and trade facilitation (Cerra et al., 2017). Infrastructure is also essential for increasing the quality of export products (Ding and Hadzi-Vaskov, 2017), it is vital for regional integration (Roland-Holst, 2009), food security (Blimpo et al., 2013), job creation (Dinkelman, 2011) and raises the chances of a surge in exports (Cerra and Woldemichael, 2017). For developing and emerging economies such as those in SSA, infrastructure deficits need to be addressed in order to avoid its hampering effect on the region's growth potential. During the construction phase, well developed and maintained infrastructure can support aggregate demand and complement other factors of production over the long term, which ultimately raises economies' productive capacity and strengthens their resilience to shocks.

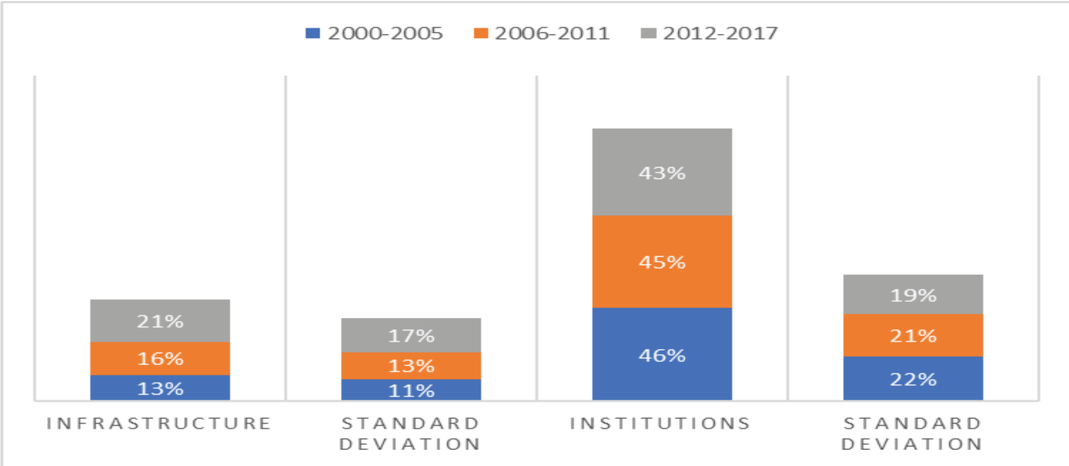
Extensive antecedent extant empirical evidence supports the relationship between infrastructure and growth (Beaton, Cebotari, and Komaromi, 2017; Calderon and Serven, 2004; International Monetary Fund, 2017). Despite all these infrastructure benefits, the SSA region has been identified as the world region with the largest infrastructure and financing gap as well as the least developed infrastructure, which might be holding back its developmental process (Ari and Toivanen, 2005, AfDB, 2018). Governments' efforts to raise funding, in many cases, have been dampened by lack of fiscal space, weak institutions and regulatory frameworks (Cerra et al., 2017). To bridge the ballooning public infrastructure and financing gap, SSA governments have tried innovative funding mechanisms, which encourage private sector participation and safeguard the fiscal sustainability but with little success. In this context, despite PPPs and other domestic and foreign private contributions to infrastructure financing being the best alternative to public spending on infrastructure, there seem to be less appetite to participate.

The mostly cited, though scantly examined, possible contributor by political economy and institutional economics' schools of thought are weak economic and political institutions (Estache & Limi, 2011). Moreover, there is dearth of literature on the role of political and economic institutions on infrastructure development, particularly optimal institutional thresholds. Due to this glaring dearth of literature and importance of infrastructure, this study sought to determine the required static and dynamic optimum economic and political institutional thresholds, which stimulate infrastructure development using a more robust sample evidence of 46 SSA countries. In addition, we assessed whether economic and political institutions act as either a catalyst or drag of infrastructure development, as we examined the size and sign of the impact of institutions' interaction with other determinants on infrastructure in the SSA region. With these unique insights, we immensely proffered practical, methodological and literature stylized contribution to the current body of knowledge in this regard using SSA economies as a laboratory.

3.1.1 Background to the Study

According to Estache (2016), in order to achieve and support poverty eradication, gather sustainable economic growth rates and close the infrastructure and financing gaps, each year, most African economies require infrastructure investment and matching maintenance expenditures as high as 15% of the GDP. Figure 3.1 portrays opposing trends of the SSA region's aggregate infrastructure development and quality of institutions with their juxtaposed associated standard deviations. These insightful average means and standard deviations for the three periods, 2000-2005, 2006-2011 and 2012-2017 are complemented by 2003-2018 yearly average trends reported in appendix Figures A3.1 and A3.2. What can be deduced from these insightful stylized facts is that the region's infrastructure development (standard deviation) is rising at a snail pace since it gained a meagre 8% (6%) over almost the past two decades. Over the same period (2000-2017), the standard deviation of infrastructure development also increased from 11% to 17%, which acts as an indicator of a rising variance in the pace at which SSA countries' infrastructure is developing. These rising variances point towards divergencies in rates of infrastructure development among SSA countries, a possible indicator of the influence of legal origins emanating from former colonisers of these respective countries. This is premised on our finding of positive and significant correlation between infrastructure performance and legal origin in Chapter Two, among SSA countries which were former British colonies that turn insignificant otherwise.

Figure 3.1: Development Indices of SSA Region's Overall Infrastructure and Institutions (2000-2017)

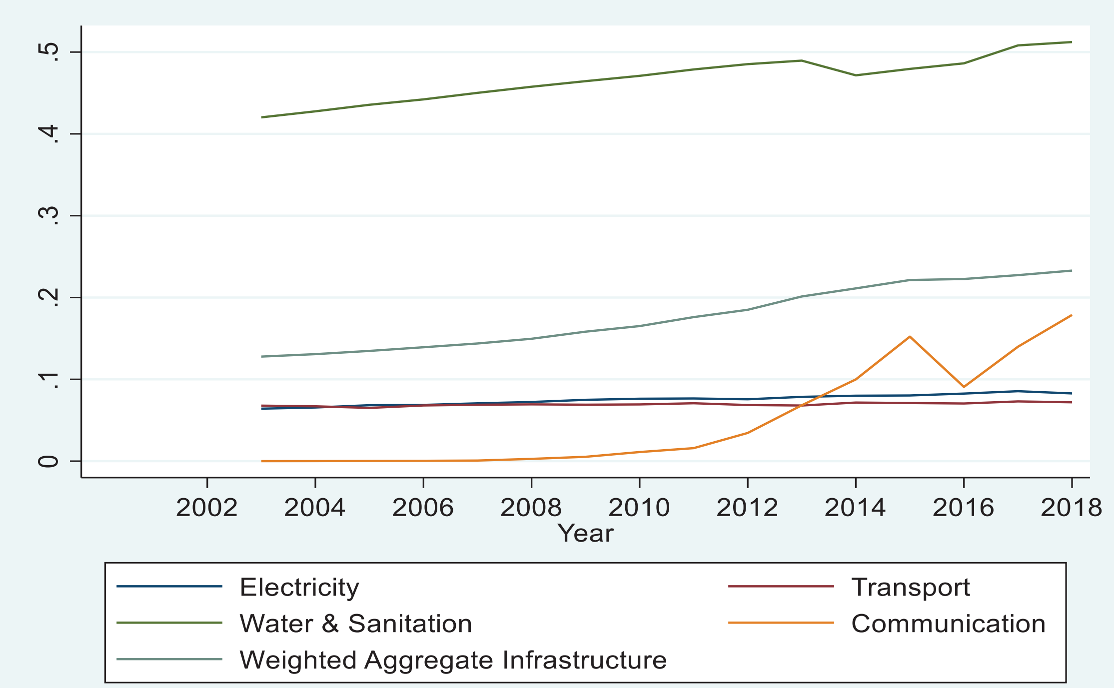


Source: African development banks (AfDB) and World Worlwide Governance indicators (WGI) Databases

This supports the arguments given by Calderon et al. (2018), AfDB (2018), Chakamera and Alagidede (2018 and Bogetić and Fedderke (2006a, b) that quality and quantity of infrastructure varies much across Africa where it declines and rises in some countries since their respective independence. From the institutional economics school of thought, the much-cited factor in the literature accountable for this marginal increase, which is below the quarter of the infrastructure requirement for the region is poor-quality institutions, which act as a drag to the propellers of infrastructure financing, development and economic growth (Acemoglu and Johnson, 2005; Acemoglu et al., 2005; Demetriades and Law, 2006). Following literature, our results also confirmed the persistent divergence nature of SSA countries infrastructure development over time.

Figure 3.1 also give a hint along this line of argument since for the period 2000-2017, the quality of SSA countries' institutions and corresponding standard deviation seemed to have both declined by 3%. In contrast to the case of infrastructure development, declining standard deviation of institutional quality is worrisome since it signifies convergence of SSA economies' institutions towards zero, a weaker side of institutional quality. Complementing these aggregated and adjusted indicators of SSA region's weighted infrastructure development and institutional quality [constructed by principal component analysis (PC1)] are their disentangled components presented in Figure 3.2 and 3.3, respectively. From Figure 3.2, indicated are marginal increases in all the four components of SSA infrastructure namely, water and sanitation, electricity, transport and communication, whose corresponding average values are 0.48, 0.08, 0.07 and 0.05. In 2003 -2018, the corresponding values of transport, water and sanitation, electricity and communication are 0.068 (0.072), 0.42 (0.51), 0.064 (0.083) and 0.00005 (0.18), indicating respective percentage increases of 6%, 21%, 30%, 6% and 3590%. The weighted aggregation of these four individual infrastructure development composite indices shows the mean overall infrastructure development of SSA countries over the period of 2003-2018 is 0.18. The mean overall infrastructure values for 2003 and 2018 are 0.13 and 0.23, showing a 77% rise.

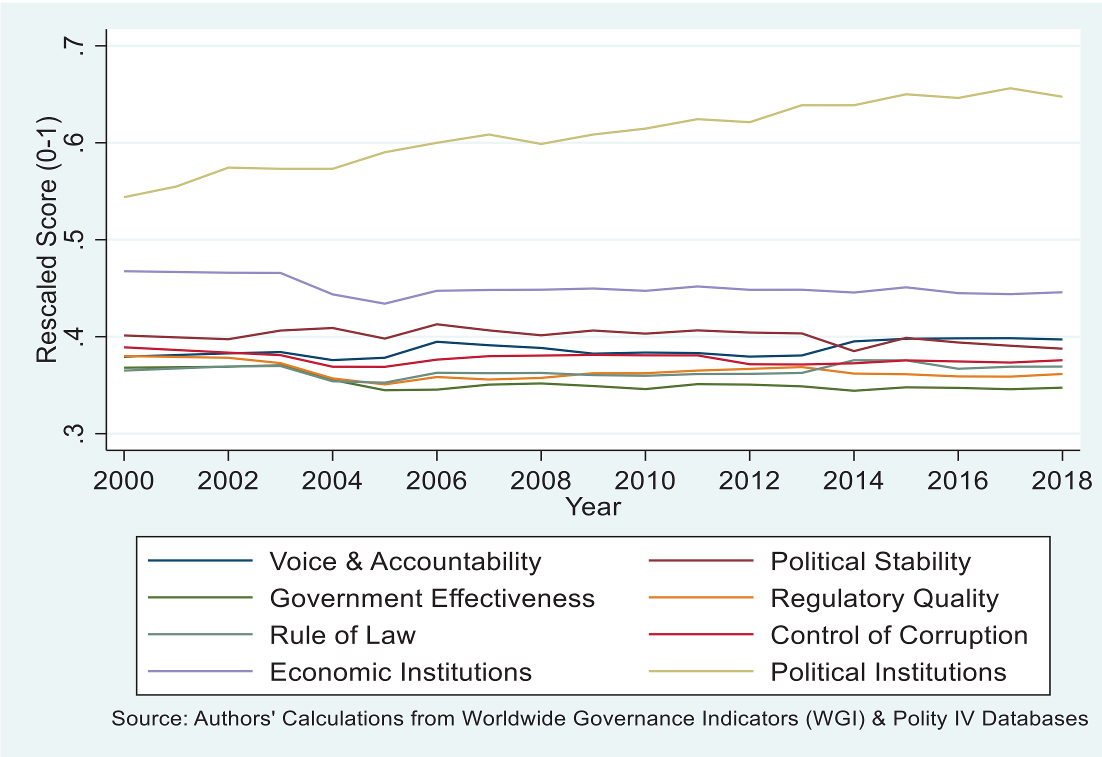
Figure 3.2: Trends of the Evolution of SSA's Infrastructure Development (2003-2018)



Source: Authors' own Calculations from African Development Bank (AfDB) Database

Institutional quality plays a vital role in terms of the infrastructure development of any country. Therefore, institutional quality must be considered to ensure that the economic development and growth takes place in the country. In their study, Foser and Briceno (2010)related the concept of institutional quality with the export of goods and infrastructure. In their study, they also stressed on the importance of institutional quality regarding infrastructure development. The results of this study show that institutional quality is greatly dependent on the infrastructure development of the country. The cumulative analysis of literature shows that institutional quality has a direct relationship with the infrastructure development. In order to improve the infrastructure of any region, it is extremely important for the respective governments and other regulatory bodies to focus on the factors of institutional quality in order to ensure that the infrastructure development is impacted in a positive manner. There is also past research, which have focused on the impact of institutional quality in the infrastructure development with respect to the financial development. The empirical results in this regard show that because of poor institutional quality in the SSA region, the financial development is impacted in a negative manner (Briceno & Shkaratan, 2010).

Figure 3.3: Trends of the Evolution of SSA's Economic and Political Institutions (2000-2018)



There are also other studies which have been carried out in specific SSA countries. For example, a study conducted by Okoi, Benjamin and Bassey (2015) was carried out mainly focusing on Nigeria. The results concluded that there is an inverse relationship between the quality of institutions and the money which is spent on infrastructure in Nigeria. This means that if the quality of institutions which work on the infrastructure projects is high, it will result in less investment on the projects because of the increase in efficiency and reduction of leakages through rent-seeking tendencies. Therefore, this study sought to examine the effect of economic and political institutions of SSA economies on their infrastructure development. Of major interest is the determination of optimum thresholds on which economic and political institutions pose a positive or negative impact on infrastructure development.

Problem Statement

From the background information, it is evident that the infrastructure development of most of the SSA countries has witnessed a slow growth over time. The aggregated and disentangled infrastructure development composite indices' growth rates are below 30% of their optimum requirement. On the other hand, both aggregated and disaggregated economic and political institutional quality indicator ranges in the poor category. Lack of infrastructure development is one of the problems strongly cited in antecedent literature, which impede economic growth, increase unemployment, reduce productivity and standards of living across the SSA region. Surprisingly, there is dearth of literature on the threshold effect of either political or economic institutional quality on infrastructure development, particularly the level beyond which institutions become a drag to infrastructure development. Thus, the major problem to be addressed through this essay is on the linkage between infrastructure development of SSA countries on the basis of static and dynamic threshold models. There are various determinants of infrastructure development in the literature but to the researcher's knowledge no study has focused on institutional quality as a driver and identifying its optimal threshold level beyond which it acts either as a catalyst or drag. The cumulative institutional quality of most of the SSA countries is quite low, which might be a contributor to its low state of infrastructure development. This essay has focused specifically on examining the impact of institutional quality on infrastructure development of SSA countries using static and dynamic models. Furthermore, the essay sought to identify optimum institutional quality thresholds at which economic and political institution pose a positive or negative effect on the SSA region's infrastructure development.

3.1.2 Aim and Objectives

The major aim of this study is to determine the optimum thresholds of the nexus between institutional quality and infrastructure development in the SSA region. As this aim is quite broad, the following specific objectives are answered in this essay:

1. To determine the static and dynamic optimal threshold levels of institutional quality that contribute towards infrastructure development in the SSA region.
2. To examine the effect of economic and political institutional quality on SSA infrastructure development.
3. To evaluate whether institutional quality acts as a catalyst or drag on the effect of financial market development (FMD), foreign direct investment (FDI), public debt and government revenue on infrastructure development of the SSA region.

3.1.3 Significance of the Study

In the current body of knowledge, there is paucity of literature on the possible linkage between institutions and infrastructure. In addition, the dynamic panel threshold modelling approach has been scantily employed in the literature. This study will be the first to apply the dynamic panel data threshold approach on more robust African data to examine the institution-infrastructure nexus using the SSA region as a laboratory. Unlike static models (see for example Cerra et al., 2017), dynamic models account for endogeneity bias. Furthermore, to the best of the researchers' knowledge, there is no study that has identified the optimum thresholds of either economic or political institutions, which stimulate the development of infrastructure. With this background, this study sought to close these identified practical, literature and methodological gaps in the extant literature. This study's output will be useful to SSA countries' government especially on identifying institutional weaknesses, which are hindering the development of their economies' infrastructure. The results will also help advocacy civil societies with information on which institutional aspects they will push for reforms to take place in order to stimulate regional infrastructure development. Lastly, the findings of this study will be useful to development financial institution as well as mutual funds managers by identifying where they can efficiently and productively allocate their funds and maximise return and shareholder value.

3.2 Related Literature

This section looks at theories and empirics that inform the linkage between infrastructure and institutions. We start by looking at the theoretical framework, where the historical evolution is contextualised to the institutions-infrastructure nexus. The theoretical expositions are followed by empirical studies that have been done so far in this regard, with the intention of identifying the uniqueness and gaps to be filled by this study. The intention is to show that institutional economics is a phenomenon to be considered in the infrastructure development debate. According to Estache (2016), institutions are a relatively recent focus of mainstream infrastructure research. Institutional economics only started to get attention in the early 1990s. Thus, mainstreaming of the concern for institutions in the technical and analytical academic and policy got recurring profiling recently in the infrastructure development literature. Except when arguing that public enterprises were failing, and that performance or management contracts were the solution, in relation to infrastructure, institutions did not appear much on radar screens (Gomez-Ibanez, 2007). Between the 1950s and 1980s, a lot of policy-oriented research focused on pricing, project evaluation and more specific technical issues published by the aid (and theory) community.[12]

3.2.1 Theoretical Framework

There are eight theoretical approaches informing the institutional effect on developing economies' infrastructure development. But this antecedent theoretical literature lacks optimal threshold dimension of institutional-quality-infrastructure nexus. This weakness in theoretical approaches forms the bases of this Chapter. These theoretical approaches are 1) the Laffont view 2) the broad public choice view 3) the spiller or transaction cost cum politics view 4) the dynamic political view, 6) the anthropological view 5) the legalistic view 7) the emerging behavioural view and 8) the empiricist view. A brief and compressive analysis on each of these various theoretical approaches is given below.

First, the Laffont school of thought posit institutions and infrastructure development linkages are anchored on incomplete markets theory and agency models. This theoretical dimension is credited to Jean-Jacques Laffont and his numerous co-authors like Martimort (1998, 1999) and

[12] For one of the earliest systematic discussions of the specific role of infrastructure in development see Hirshman (1958) and Jimenez (1995) for a stock taking survey. For a more comprehensive literature see Estache (2016)

Laffont and Meleu (2001), to mention but just a few. This view continues to be useful in policy making and academia to date, where complex institutions are characterised by multiple agency problems and there is also domination of information asymmetries. The view emphasises on incentive issues by focusing much on incentive distortionary tendencies of regulation and institutions, particularly in terms of high cost and performance contradictions visa-a-viz quality, access and affordability. Of great importance from this school of thought are the insights it brought into the interactions debate between optimal designs of regulation and various types of institutions. Under various regulatory designs, it identified institutional constraints like limited accountability, commitment, credibility, fiscal and technical capacity as major determinants. Thus, Laffont and his co-authors specialised on the internal organisation of institutions, like for example, the accountability incentive built in the delegation of functions within and across ministries and agencies[13]. Laffont, like other numerous researchers in the late 1980s and early 1990s, chronicled the value and importance of the privatization debates for developing economies but also addressed the relevance of financing options, risks, market structures and their interactions with regulatory design. The conclusion from this theory is that institutions via agency, incomplete markets and asymmetric information issues are the major hinderances to infrastructure development. That is, it validates the importance of the internal governance of institutions concerns for the multiplicity of principals and agents in organizational designs responsible for infrastructure development.

Second, the Spiller school of thought composed of authors such as Guasch and Spiller (1999), Savedoff and Spiller (1999, 2013), Spiller and Tommasi (2005)) is much anchored on how infrastructure reforms are constrained and affected by institutions particularly political ones though focusing on Latin America. This school of thought's dimension almost coincides with the infrastructure-institution policy diagnostic joint work of Laffont and Tirole which focused more on the developing countries flavour. Spiller's view was also instrumental in evaluating how transaction costs (bundling versus unbundling) are minimized by setting the production structure of the organisation at optimal level. The foundation of this school of thought is much credited to

[13] For a detailed synthesized conceptualization on Laffont school of thought and supporting empirical evidence seen Laffont's 2005 book entitled *Regulation and Development* which literature has identified as the possible best synthesised diagnostic of the incentive issues and their institutional implications for developing countries (Estache, 2016).

Williamson (1979) and to some extent derived from Coase (1992)'s views. Although Spiller's school of thought seems to focus on the effect of institutional failures on private sector investment and its disincentivizing effect on public sector commitment, his views are much closer to those of Laffont in terms of both concerns as well as to some extent in the modelling of sources of such institutional weaknesses. But on one hand, unlike Laffont's view much concerned with optimal regulation, Spiller's view is only concerned with the relevancy of rents and their sources. On the other hand, like Laffont's view, Spiller's school of thought argues that the desirable institutional mechanisms are different across countries and matched institutional initial capacity.

The main contribution of Spiller's views on infrastructure development has been its emphasis on the need to identify incentive and transaction costs issues emanating from government opportunism. Such first part opportunism, arises for example, through abusing its ability to change the rules of the game and extract quasi rents from investors and third-party opportunism through questioning by NGOs, and civil society via advocacy. Politics should, thus, be central to regulatory assessments because it defines the governance of public-private interactions. The approach is closely related to arguments made by political scientists such as Heinisz and his co-authors Bergara et al. (1998), Heinisz (2002) and Heinisz et al. (2006). Their main message is that political stability makes infrastructure investment easier and instability slows or biases investment in the sector. A closely related school of thought working on the institutions in network industries is linked to the Florence School of Regulation[14]. Its members are also anchored on the transaction costs view of the world, which can also be read as a view that points to the failure to internalize the coordination costs associated with the development of governance as suggested by Dixit (2009). However, they tend to have broader views of the issues as well as being quite effective on discussing the hybrid organizational outcomes of transactions cost in regulated industries (see for example, Shephered et al, 2006; Loas, 2012; KPMG., 2014; World Bank, 2019). They also have a stronger sense of the technical implementation details of the regulation of these sectors than what was addressed by Spiller and his co-authors. Some of them are particularly good at unbundling the characteristics of contracts and in highlighting their relevance for performance (for example, Foser & Briceno, 2016; Kandiero, 2019). Saussier,

[14] This views to a large extent could have been just as well labelled Sorbonne School of thought since much of the Florence's voices were initially anchored in Paris.

2015). Although most of their research is on OECD countries, many of their insights have broader implications. Their main conclusions are: (1) one size does not fit all when it comes to regulation and contract design; (2) details matter at all stages of the production process and (3) coordination is particularly challenging in hybrid institutional models. These observations were not unexpected and validate earlier results, but the fact that they reach them from another angle is reassuring.

Third, the legalistic view also referred to as the Shleifer view argues that the law, its origin and implementation also matters in determining infrastructure development. The importance of the legal system in shaping the performance of difference economic aspects has a long history, which dates back and starts with Coase's paper[15]. A rich and comprehensive global empirical comparative evaluation cementing the possible effects of different legal approaches on existing infrastructure across the world is credited to the early research championed by Shleifer and his various co-authors[16]. Their argument is that economic outcomes, for which infrastructure plays an integral part, are determined by legal biases since they often shape and influence laws, legal processes and dispute resolution in case of conflicts. The Shleifer school of thought's view provides insights on the distinctions between common law (French) tradition and civil law (English) tradition. Their point of contention is that compared to common law, civil law raises investment riskiness and transaction costs due to excess formalization, which cement Spiller's perspective. The Shleifer school of thought's interesting dimension and evidence has been extensively used in infrastructure discussions. Due to high investment riskiness and transactions costs associated with civil law, its outcomes are lower consistency and fairness in decisions, slower judicial proceedings, as well as more corruption. Over time the idea was turned into a legal origin theory.

Fourth is the broad public choice view, which like the views of Laffont and Spiller includes incentives as a driver of infrastructure but their main focus being the influence of politics and internal state organisation. Its main concern is that infrastructure problems are an outcome of bureaucratic and political biases and failures, which are also common in public administration literature. The state of infrastructure, according to this view, is shaped by politics, government

[15] See for example Coase (1992).
[16] Some of the co-authors in this school of thought are, Laporta, Lopezde-Silanes, Djankov and Glaeser.

internal organisation, capture risks and rent seeking. Infrastructure failures and high sector risks of massive inefficiencies and cost overruns are taken as an outcome of regulatory capture and regulatory weaknesses and loopholes, which promote the flourishment of bureaucratic rent-seeking tendencies[17].

Fifth, another crucial dimension to the institution-infrastructure theoretical relationship is the dynamic political review. It argues that the dynamic of political parties and ethnicities of leaders matters more in determining infrastructure development across the length and breadth of any given country. For example, Pork Barrel Politics and Partisan theory, which tend to argue that the relative importance of infrastructure may be used strategically to penalize or favour regions, cities or other parties. This explains why the level and /or quality of infrastructure at a country level or across regions can be impacted by changes in political majorities chronicled in the literature, for example in Mexico by Costa-i-Font (2003). The overall insight deduced from this school of thought is that improvement in infrastructure performance, stock and quality is premised on the effects of political institutions, rules, and practice of any given nation. It also points to the fact that many of the institutional challenges of the sector are not in the sector. This, in turn, implies that the first best solutions for the sector may be naïve and unsustainable if and when they ignore these higher-level constraints.

The sixth non-economic view of infrastructure sector and institutions is referred to as the Ostrom or Anthropological school of thought. It provides insights into infrastructure debate by tapping into the mostly excluded issues like rural infrastructure. Ostrom and her co-authors validate the cruciality of concerns demanding for the optimal organisation of production raised in Spiller's visions as well as Laffont's institutional internal governance issue emanating from multiplicities in organisational designs of principals and agents. Moreover, Ostrom was one of the pioneers to propose the importance of culture and social norms as drivers of key infrastructure service delivery (KPMG, 2014). Since then, the role of culture, norms and other values has enjoyed quite a broad recognition among economists[18]. The impact of anthropologists is of much value in

[17] Most widely quoted evidence on infrastructure cost overruns (see for example, Flyvbjerg (2009, 2014)) has actually been produced by the public administration literature in its efforts to detail the bureaucratic failures identified by the public choice researchers.

[18] Some of examples includes Alesina et al. (1999, 2003, 2015), Platteau (2000), Bardhan (2000), Wade (2003), Bardhan and Ray (2006). Also, some recent dimensions emanating from current literature revisit, modifications and

influencing institutional processes on ethnographic infrastructure interest ranging from public toilets to municipal roads and other lager projects are relevant to the management of consultation for instance in the preparation of projects. The design of consultations and of the matching processes explain the growing feeling of entitlement in interactions with providers, public or private, but also with all the actors associated with the infrastructure production process[19]. With this view, institutional strengthening starts when bottom-up approaches are deemed necessary though this is not something economic policy tends to internalize enough. Thus, the main message of this approach is that processes matter to institutional building, fostering infrastructure development.

The seventh theoretical perspective on institutional-infrastructure nexus is the Acemoglu-Robinson-Rodrik (ARR) school of thought. It further extends the historical/political perspective identified by Laffont and Spiller by arguing that political institutions (politics and political economy) matter in affecting status of the infrastructure sector, a sector plagued with biased and limited competition[20]. The ability to rank stakeholders in terms of their political (bargaining) power is one of the main interests in applying Acemoglu-Robinson (2012) views to infrastructure. In relation to infrastructure contracts, the AAR view is useful in identifying winners, due to institutional loopholes and lapses. The anecdotal evidence would suggest that for developing countries, the winners may have been foreign operators, the banks financing their investments and incumbent politicians when procurement and regulatory processes had been in place.[21] When reform delivered improvements in efficiency, growth in access rates, or cuts in subsidies requirements, taxpayers and users in short-term would-be winners. However, renegotiations leading to increased subsidies or higher user fees would imply longer term losses

development are often validated, by behavioural economists (see for example Torero and some of his colleagues at International Food Policy Research Institute (IFPRI)) rely much on lab and field (quasi-)experiments.

[19] Applying this school of thought's ideology, Harvey and Knox (2015, 2012) and Harvey and Knox (2011) focus on highway building in South America to show how large public infrastructural project implementations are driven by the degree and speed of state formation, by social relations, and politics. They show how local populations are concerned with the key choices, including routing, and with the distribution of benefits.

[20] This is consistent with ARR political diagnostic argument. For instance, Gomez-Ibanez (2006) already had been very effective at demonstrating how infrastructure reforms of the 1990s and early 2000s were all characterized by relatively easily identifiable winners and losers in a political sense.

[21] Various authors have documented the growing concentration of market power in international markets by former national monopolies (see for example, Bonardi (2004), Chari and Gupta (2008) and Clifton et al. (2011)).

for at least some of these players. Such losses become outcomes of their lack of power in sector specific property rights enforcements. They also reflect the capture of regulators supposed to control excesses by power-holders keen on maximizing rents. In their terminology, infrastructure performance has continued to be influenced by extractive institutions. And reforms, which AAR school refer to as ‘the privatization cum competition revolution’, have failed to turn them in inclusive institutions able to rely on competition to minimize the scope for rents.

These reforms seem to have transformed the old extractive institutions into new extractive institutions. The reasons for replacing old extractive institution with new extractive ones, according to Acemoglu and Robinson (2012), is that the reforms were revolutions that are narrow based rather than broad based. Related to this context, the heterogeneity of the sub-sector outcomes suggests that telecoms and part of the power sector (generation) have been able to benefit from increased competition to increase the number of local players, while most of the activities that had to rely on competition for the market were not much successful. It would be potentially useful to analyse with the tools of this theory why foreign actors in this game have been able to replicate their ability to join the extractive group in a wider variety of countries. For instance, Estache & Vagliasindi (2007), observed that large water deals tend to be operated by a few members of German, French and American companies present on most of the bids organized by international organizations. It would also be insightful to look with this analytical perspective into the reasons why the infrastructure reforms and policies have not always had the same impact on performance in infrastructure. And also, it would be useful to look at the extent to which the fact that different types of colonisation policies created different sets of institutions. This can help on explaining the differences in impact of these infrastructure reforms in Francophone and Anglophone Africa.

The seventh institution-infrastructure linkage theory is the Emerging Behavioural Approach, which deals with different forms of non-pecuniary or intrinsic motivations. The need to account for sources of non-rationality, for example, anchoring, framing, endowment, present, hindsight, self-serving, loss aversion, status-quo and attribution biases, in behaviour of infrastructure consumers, investors and operators in developing countries, has become an increasing concern encountered by regulators particularly when defining rules and processes. It is also increasingly becoming policy relevant in some debates, supporting the relevance of consumption and production alternatives. Moreover, it provides a better sense of the scope for nudging consumers and producers into social welfare enhancing behaviour (World Bank, 2015). One of the main early contributions of the applied research in the field is evidence on the relevance of institutions on the incidence of social context and environment for key policy decisions. As pointed out by Ceriani et al. (2009) and Clifton et al. (2011) for European consumers for instance, preference heterogeneity matters to the optimal choice of public service provision and regulation. Similar evidence has been provided for the water sector in developing countries, for instance, in the context of the willingness to pay for water storage systems (Price et al., 2016). This emphasizes the demand side of the market as a driver of the choice of institutions, including key processes in an environment in which the production and financing side tends to dominate the institutional choices. Social, cultural or other sources of differences all contribute to demand heterogeneity and this matters to public services just as much as it matters to many consumption goods. These sources thus need to be diagnosed as well.

The behavioural research evidence on social dimensions also shows that fairness matters to optimal consumption and production decision (Kahneman et al., 1986). This confirms similar conclusions reached by anthropologists (Larkin, 2013) and Harvey and Knox, 2015)). It adds that to be fair, processes matter and are easy to underemphasize or underestimate in practice when implementing policies. This has also been identified in the Laffont view in any multiple principals, multiple agents settings which are the norm in regulated industries for example Laffont and Martimort (1998, 1999). Frey et al. (2003) point to the importance of "procedural utility" in environments in which care not only on outcomes but also on procedures leading to those outcomes. Ultimately, as argued by Clifton et al. (2011), all this makes for a strong case towards empowerment of consumers. In environments in which ethnical, tribal, religious, or other historical drivers of social interactions matter, this observation is particularly relevant, and yet largely ignored in the design of infrastructure policies.

This view therefore argues for an explicit assessment of the extent to which all consumers and producers enjoy equivalent opportunities to make mostly out of structural reforms. This links back to the inclusive-exclusive dichotomization proposed by Acemoglu and Robinson (2012), to the diagnostic case made by Rodrik (2009) or by the winners and losers perspective emphasized by Gomez-Ibanez (2006) for infrastructure diagnostics. As pointed out by Clifton et al. (2011) in the case of consumers, social, cultural, and economic environments all matter and yet tend to be ignored in the design of policy. This is increasingly well documented in the context of research on energy poverty in the UK for instance. The most vulnerable tend to be at a disadvantage in their ability to make the most of increased competition and the matching increased volume of information on options.[22] In summary, this perspective on institutional design suggests that empowerment, as implemented by default, may be biased and typically regressive from the consumers' point of view. All this shows that the assessment of non-pecuniary motivations is just as important in understanding the incentives to account for when trying to influence producers, consumers, and financiers of the sector. They also impact selection and organization design. As yet, there is no unified approach for studying these issues and current body of knowledge is quite fragmentary. However, examining these issues is now a part of the mainstream agenda in economics. Lastly, the eighth view is the empiricist view to be discussed under the empirical review section. This is the institution-infrastructure linkages based running regressions of different institutional aspects on infrastructure indicators.

3.2.2 Related Empirical literature

This last view (empiricist view) regroups the research that concentrates on running regressions, most of the time on panels, to test if the creation of a specific reform, for example, the creation of a separate regulatory agency and the opening of a market to private operators makes a difference or not. These aspects are usually modelled as binary variables (yes versus no) and the outcomes are measured in one or more of few performance indicators for which long enough time series are available, though not as larger enough and rich as this study's focus on African dimension. Typically, the infrastructure quantity variables focus on access rates and network size, whereas the quality variables tend to be approximated by technical measures such as service interruption, safety incidents and maintenance costs. There are many papers focusing on various types of efficiency measures like allocative, technical, and technological but many of these actually measure labor productivity as a proxy because there is little reliable data on capital and other inputs to do better. The first generation of papers suffered from major endogeneity issues in form of omitted, mismeasurement and simultaneity biases of variables identified by some of the theories (Estache, 2016). Amongst studies that looked at drivers of infrastructure there is

[22] See for example George et al. (2011)

conspicuous absence of political and economic institutions as standalone variables. Also, many of the papers in current literature ignored cream skimming issues in the design of policies when relying on biased samples, erroneously assumed to be random. This is often what allowed a focus on the positive impacts of policies such as privatization. It ignored the "collateral damage" not picked up in the sample. For instance, looking at the impact of reform in a city is not the same as looking at the impact of that reform for a region in which rural areas are losing financing or access to scale and scope economies.

Finally, it tends to ignore the many interactions between the various characterizations of infrastructure institutions. This is quite problematic since the two dimensions may be complements in some settings and substitutes in others.[23] This is why estimates of the academic assessment of the relevance of institutions is often seen by practitioners as at best biased and at worst as irrelevant. Despite the limitations of biased representations of the pure economic trade-offs between efficiency, equity and/or financial viability of a policy, many of the contributions tend to be quite useful. The correlations they document may not be directly useful in policy evaluations, but they may help identify additional research interests to settle the debates. Much of the empirical research in this field has been produced by international organisations' staff or financed by them because of their privileged access to the required data—by the way, why is this data especially on infrastructure financing and specific institutional reform to particular sector of infrastructure, so often not public? And as data and techniques improve, the level of uncertainty on the predictability of institutional reforms' effects on specific infrastructure sector seems to be increasing. This implies that we may have been overconfident on outcomes from institutional reforms until not too long ago.

One of the main lessons of the most recent papers is that initial conditions (AAR legal origins) matter a lot more than the early empirical papers assumed. And this is hard to pick up well in multi-country and multi-year data panels. This is, in turn, makes the case for relying on case studies to complement or validate the stories emerging from the treatment of panels. This is, partially, why looking at case studies through impact evaluations has become popular but, at least in the context of infrastructure, it has its own set of problems.

[23] A typical example is the debate on the extent to which contracts are regulatory instruments needed by regulatory agencies or whether contracts and agencies are substitutes.

The first is that most of the research related on infrastructure focuses on the water and sanitation sector. In the 2015, the database of impact evaluations, infrastructure only claims 258 of them, that is, about 6% of the total, half for water and sanitation and about a quarter for ICT. There are only 10 covering the transport sector. The second is that most of these evaluations are about targeting and tools, not about institutional designs. The interest in behavioral approaches is now leading to new evaluations to cover characteristics such as norms, culture and similar dimensions linked to institutional constraints and opportunities. However, we are only at the beginning of the use of this new approach. A lot more is needed to test and validate some of the institutional characteristics the various theoretical reviews have identified as relevant in principle. Also, of much interest, where institutions are included as a driver like Cerra et al. (2017), only static models are used for empirical analysis despite their weakness on failure to account for endogeneity bias, which adversely compromises the asymptotic properties of estimators, posing serious danger on policy formulation and their effectiveness.

Moreover, to the best of our knowledge, there is no study in antecedent literature which seeks to determine the optimal thresholds at which political and economic institutions foster a positive effect on infrastructure development. To address these problems, we identified in the current literature evidence, visa viz, the current levels of average institutional quality measure, this study adopted both static and dynamic panel threshold approaches. Furthermore, Estache (2016)'s rich and comprehensive literature, which unambiguously shows that the failure of privatization models was the glaring omission of institutions in the infrastructure debate provoked us to carry out this study. Lastly, the weakness we have observed from the scantily available literature (Canning, 1998; Canning and Pedroni, 2008; Cerra et al., 2017) is either the use of physical infrastructure investment or stock as a proxy of infrastructure development. However, AfDB (2018) argued that such proxies are poor indicators of infrastructure development since they do not account for new investment and depreciation. To capture the sentiment raised by AfDB (2018), this study uses the infrastructure development data provided by AfDB which account for both new investment and depreciation.

Conclusively, the preceding overview of academic contributions leads to list of dimensions that should be expected to be of some relevance in diagnostics of institutional quality of infrastructure and other related sector. The summative list is given in the first column of Table

3.1 which is also an attempt to give some credit to the various theories and their empirical support, for their contribution to this list in the context of infrastructure. As clearly coming out and observed from a summary of the literature overview in Table 3.1, there is no specific literature that directly links overall institution, particularly political and economic to infrastructure in line with the institutional economics paradigm. In light of this literature overview and gaps identified, the next section looks at the methodology applied to this study.

Table 3.1: Summative Overview of the Main Institutional Dimensions cover by various literature

	Laffont (Agency)	Spiller (Transaction cost)	Shleifer (Legal)	Public Choice	Ostrom (Anthropology)	Behavioral	ARR (History)	Empiricists
Primary Focus								
Ownership	X	X	X	X	X	X	X	X
Re-and deregulation	X	X	X	X			X	X
Accountable regulatory autonomy	X	X		X	X			X
Contract and regulatory design	X	X		X	X	X		X
Politics	X	X	X	X	X	X	X	X
Other Focuses								
Enforcement	X	X	X	X	X			
Internal governance of agencies and government	X	X		X	X	X	X	X
Processes	X	X	X					
Technical skills and staffing	X			X	X	X		
Monitoring organisations	X	X	X	X	X		X	X
Financing of institutions		X	X	X			X	X
Legal norms								
Non-pecuniary norms	X				X	X	X	X
History			X		X		X	

Source: Estache (2016)

3.3 Empirical Econometric Methodology and Data

3.3.1 Methodology

In line with extant literature, the study utilises static (Hansen, 1999, 2000; Caner and Hansen, 2004; Demetriades and Law, 2006; Law and Habibullah, 2006; Seo and Linton, 2007; Gazdar and Cherif, 2015; Cerra et al., 2017; Law et al., 2013, 2018; Olaniyi and Oladeji, 2020a, b; Olaniyi and Adedokun, 2020) and dynamic panel data (Kourtellos et al., 2016; Seo and Shin, 2016; Yu and Phillips, 2018; Ogbaro, 2019) threshold techniques to examine the potential empirical effect of institution quality on infrastructure development in SSA. The static threshold form was pursued using the Hansen (1999, 2000) and Caner and Hansen (2004) Fixed Effect and FMOLS techniques, whereas following Kremer et al. (2013), Seo and Shin (2016), Kourtellos et al. (2016), Yu and Phillips (2016, 2018) and Ogbaro, (2019), Seo et al. (2019) the dynamic approach was accomplished based on the dynamic Panel Threshold Regression (PTR) model developed by Seo and Shin (2016), which use the first difference (FD) transformations[24].

Our approach captures both linear (FMOLS) and non-linear asymmetric (FD-GMM) effect of institution on infrastructure via use of interaction-terms and non-linear thresholds models. The estimation sample comprises of 46 countries and covers the recent period 2000-2017. Our empirical static linear (FMOLS) and non-linear (Hansen, 1999, 2000) threshold models, respectively, follow adaptations and modifications of Cerra et al. (2017)'s model, which was also based on Calderon and Serven (2010) and Agénor and Neanidis (2015). Our models are specified as follows:

$$ID_{it} = \beta_0 + \beta_1 PDGP_{i,t-1} + \beta_2 IQ_{it} + \beta_3 IQ_{it}\left(X_{it}^{j}\right) + \gamma_i X_{it} + \phi_i RD + \alpha_i + \varepsilon_{it} \qquad (3.1)$$

$$\begin{aligned} ID_{it} &= (\beta_{11} PDGP_{i,t-1} + \beta_{12} IQ_{it} + \gamma_{1i} X_{it} + \phi_i RD_{it}) I\{IQ_{it} \leq \lambda\} + \\ &(\beta_{21} PDGP_{i,t-1} + \beta_{22} IQ_{it} + \gamma_{2i} X_{it} + \phi_i RD_{it}) I\{IQ_{it} > \lambda\} + \alpha_i + \varepsilon_{it} \end{aligned} \qquad (3.2)$$

Whereas our dynamic Panel Threshold Regression (PTR) model (FD-GMM) is given as:

[24] The Seo and Shin (2016) PRT model is also known as first differences generalised method of moment (FD-GMM) since it is an amalgam of Hansen (1999) threshold and Arellano and Bond (1991) difference GMM dimensions. It is superior to the Hansen approach because it allows the regressors as well as the threshold variable to be endogenous.

$$ID_{it} = (\rho_1 ID_{i,t-1} + \beta_{11} PDGP_{i,t-1} + \beta_{12} IQ_{it} + \gamma_{1i} X_{it} + \phi RD_{it}) I\{IQ_{it} \le \lambda\} + (\rho_2 ID_{i,t-1} + \beta_{21} PDGP_{i,t-1} + \beta_{22} IQ_{it} + \gamma_{2i} X_{it} + \phi RD_{it}) I\{IQ_{it} > \lambda\} + \alpha_i + \varepsilon_{it} \quad (3.3)$$

where: ID_{it} = infrastructure development, a dependent variable; $PGDP_{i,t-1}$ = lagged per capita GDP; IQ_{it} = institutional quality measure (composite index and its disaggregated indicators), a threshold variable in this study; RD_{it} = regional dummies; X_{it} = vector of control variables; $IQ_{it}\left(X_{it}^{j}\right)$ = interaction term between *IQ* and *j* variables of interest within vector *X*; $I\{.\}$ = an indicator function; $\rho_1, \beta_{11}, \beta_{12}, \gamma_{1i}$ and $\rho_2, \beta_{21}, \beta_{22}, \gamma_{2i}$ denotes the lower and upper slope parameters for the two regimes while λ = the threshold value dividing the observation into two regimes, respectively; α_i = are unobserved fixed country effect and ε_{it} = are idiosyncratic zero mean random shocks. Following Seo and Shin (2016), we let the random error ε to be a martingale difference sequence, $E(\varepsilon_{it} | \hbar_{t-1}) = 0$, where: ε_{it} = a natural infiltration at time *t*. Thus, to allow for endogeneity of both regressors and threshold variables, we do not assume our regressors *(X)* and threshold variable (*IQ)* to be measurable with respect $\hbar_{t-1}$, such that $E(\varepsilon_{it} X_{it}) \neq 0$ and $E(\varepsilon_{it} IQ_{it}) \neq 0$. Model 3.1, 3.2 and 3.3 are estimated using a FMOLS, Hansen 1999, and Seo and Shin (2016) threshold estimators, respectively. Given the veritable weakness of the Hansen (1999)[25] model (equation 3.2) identified in the extant literature mainly being its inability to capture endogeneity or simultaneity between institutional factors and infrastructure development, the model will only be used for sensitivity or robustness checks. In this study, more reliable and valid static and dynamic results will be provided by model 3.1 (FMOLS) and 3.2 (FD-GMM), respectively.

The main motivation for our preference towards FMOLS and FD-GMM are their ability to account for simultaneity and endogeneity bias in static and dynamic modelling identified in theoretical and empirical evidence, which in our case arose due to three sources. First, if the feedback effect emanating from the bi-directional causality between infrastructure and economic growth and institutions and infrastructure is not accounted for. Second, there might be a problem

[25] For a detailed exposition of Hansen (1999) threshold analysis shortcomings, just to mention a few, see for example Caner and Hansen (2004), González et al. (2005), Fok et al. (2005), Seo and Linton (2007), Kim et al. (2008), Dang et al. (2012), Kremer et al. (2013), Ramírez-Rondán (2015) and Seo et al. (2019).

of omitted bias since some excluded variables which are captured by the white noise error might be correlated with some of the included variables, again leading to the second source of endogeneity problem, different from the one caused by the feedback effect. Evidence in antecedent literature has shown that there is feedback causation between infrastructure and economic growth, which in our models 3.1 – 3.3 is proxied by *ID* and *PGDP*, respectively. Thus, models 3.1 – 3.3 incurs endogeneity problem emanating from either feedback effect or omitted factors which must be accounted for to avoid simultaneity or omission biases from rendering the parameters from the respective models inconsistent and asymptotically inefficient and biased, causing commission of type one and two errors (Arellano and Bond, 1991; Arellano and Bover, 1995; Blundell and Bond, 1998; Wooldridge, 2002; Buck et al., 2008; Roodman, 2008; Greene, 2012; Baltagi, 2013) leading to wrong policy prescriptions.

Table 3.2: Definition of Variables, Measurement Scales and Sources

Variable	Definition	Source
	Dependent Variable	
ID/OID	Overall weighted infrastructure development composite index composed of communication (CID), transport (TID), water and sanitation (WSID), and electricity (CID)	African development Bank (AfDB) infrastructure development database
	Economic and Political Institutional Quality Measures	
OEIQ	Overall economic institutional quality (PC1: World Governance Indicators (WGI) (0 and 1 indicate weakest and strongest overall economic institutions)	World Bank, WGI
PIQ	Political institutions (Polity2) measuring state of country democracy ranging from 0-1 (0 and 1 indicate an autocratic and democratic political system, respectively.	Polity IV
PS	Political stability index rescaled between 0-1 (0 and 1 indicate weakest and strongest political stability)	World Bank, WGI
GE	Government effectiveness index ranging between 0-1 (0 and 1 indicate weakest and strongest government effectiveness)	World Bank, WGI
RQ	Regulatory quality index ranging from 0-1 (0 and 1 indicate weakest and strongest regulatory quality)	World Bank, WGI
RL	Rule of law index ranging from 0-1 (0 and 1 indicate weakest and strongest rule of law)	World Bank, WGI
CC	Control of corruption index ranging from 0-1 (0 and 1 indicate weakest and strongest control of corruption)	World Bank, WGI
	Control Variables	
LGDPG	Lagged gross domestic product growth rates which measures economic growth of a country overtime	World Bank, WDI
LO	Legal origin	Author compilation from historical events
FDI	Net foreign direct investment (FDI) inflows (% of GDP)	World Bank, IFS
FMD	Financial market development measure as credit to the private sector (% of GDP)	World Bank, WDI
PD	Public debt (% of GDP)	IMF, Historical Public Debt Database
GC	Government expenditure (% of GDP) measuring government burden	World Bank, WDI
GR	Government total revenues (% of GDP)	IMF, Government Finance Statistics
TOP	Trade openness (exports and imports as a % of GDP)	World Bank, WDI
TOT	Terms of trade	World Bank, WDI
PG	Population growth (%)	World Bank, WDI
DI	Total domestic investment (% of GDP)	World Bank, WDI

Source: Authors' own compilation

The third source of the endogeneity problem, separate from the omitted variables and bi-directional causality between explanatory variable (infrastructure) and threshold independent variable (institution) is from endogenous relationship amongst right-hand side explanatory variables, which result in simultaneity problem. Therefore, this renders other estimation techniques like ordinary Least Squares (OLS) and maximum likelihood estimation such as random effects and fixed effects inappropriate since they yield estimators, which are biased in small samples as well as inconsistent in large samples (Gujarati, 2013; Baltagi, 2013). Thus, Guru and Yadav (2019) argue for the need to control for endogeneity issue(s) arising from either of the three sources.

The FMOLS model we have used to estimate model 3.1 includes four interaction terms where institutional quality indicators are interacted with four (4) variables of interest namely; public debt (PD), financial market development (FMD), government tax revenue (GR), and foreign direct investment (FDI). Unlike the Hansen (1999, 2000) and Seo and Linton (2007) fixed effects static threshold models which treat regressors and threshold as exogenous, or Caner and Hansen (2004) who allow regressors to be endogenous but still maintain the threshold variable as exogenous, literature has copious evidence supporting the ability of FMOLS in dealing with endogeneity problem in static models (see for example, Phillips and Hansen, 1990; Shahbaz, 2009; Peia and Roszbach, 2015; Olaniyi and Oladeji, 2020b). FMOLS account for endogeneity much well and yield consistent and asymptotically efficient and unbiased long-run estimators if cointegration condition among variables exist (Phillips and Hansen, 1990; Olaniyi and Oladeji, 2020b). Thus, variables in all our FMOLS models meet the cointegrated requirement, thus, confirming robustness, validity and reliability of our estimates.

Guided by literature, the interaction term $\left(\quad \right)$

$IQ_{it} \; X_{it}^{j}$ in the linear Equation 3.1 enables us to determine the mediating effect of institutions on the role each of the five variables $\left(X_{it}^{j}\right)$ play in shaping infrastructure development of SSA countries.[26] The marginal benefit of X^jth variable on infrastructure development is given by equation 3.4 as: $$\frac{\partial \hat{ID}_{it}}{\partial X_{it}^{j}} = \hat{\gamma}_i^j + \hat{\beta}_3 IQ_{it} \tag{3.4}$$

The interpretations of mediating effect of institutional quality on the impact of each X^jth variable on infrastructure development of SSA countries depend on the estimates γ_i^j and β_3 in Equation 3.4. Preceding works in the current body of knowledge (see for example Gazdar and Cherif, 2015; Ehigiamusoe and Lean, 2019; Ehigiamusoe, 2020), Ehigiamusoe et al., 2020; Olaniyi and Oladeji, 2020a, b) have identified four possible interpretations of the two estimates as follows:

1) If both $\hat{\gamma}_i^j$ and $\hat{\beta}_3 < 0,$ it indicate the X^jth correlate acts as a drag to the development of the SSA region's infrastructure, for which the negative effect of institutional framework further cements as well as strengthens it. Therefore, this indicates X^j correlates and shows that institutions have a complementary negative effect on infrastructure of SSA countries.

2) If $\hat{\gamma}_i^j > 0$ and $\hat{\beta}_3 < 0,$ it suggest that the X^jth variable positively drives infrastructure development, but institutional quality acts as a drag that leaks out the infrastructure development benefits of the X^jth correlate. Thus, unlike in case 1, this indicates X^j correlates and in this case, institutions act as substitutes when effecting on infrastructure development of SSA countries.

3) If $\hat{\gamma}_i^j < 0$ and $\hat{\beta}_3 > 0,$ it shows that the respective X^jth variable negates, whereas institutional quality dampen the severity of negative effect of the respective X^jth correlate by plugging leakages and direct investment and funds towards infrastructure. Therefore, like in case 2, this indicates X^j correlates and, institutions act as substitutes when effecting on infrastructure development of SSA countries.

[26] For similar studies that adopt the same approach, see for example Hermes and Lensink, 2003; Gazdar and Cherif, 2015; Moradbeigi and Law, 2017; Olagbaju and Akinlo, 2018; Ehigiamusoe et al., 2019; Olaniyi and Adedokun, 2020; Saidi (2020); Olaniyi and Oladeji (2020a, b).

4) If both $\hat{\gamma}^j_i$ and $\hat{\beta}_3 > 0$, it means the respective X^jth correlate impacts positively to infrastructure development, while institutional quality have a complementarity effect by providing a conducive environment necessary for fostering infrastructure via X^j correlate. Thus, this indicates X^j correlates and, institutions have a complementary positive effect on infrastructure of SSA countries.

In light of model 4, works on institutional economic theory and evidence from extant studies have indicated that if $\hat{\gamma}^j_i$ and $\hat{\beta}_3$ are statistically significant but have opposing signs, it signals the existence of a threshold of institutional quality beyond which the respective X^jth correlate is stimulated positively by institutions, which provide a strong footing for infrastructure development (see Acemoglu and Johnson 2005; Acemoglu et al., 2005; Ehigiamusoe and Lean, 2019; Ehigiamusoe et al., 2019; Ehigiamusoe and Samsurijan, 2020; Ehigiamusoe, 2020). In tandem with the studies like Hermes and Lensink (2003), Gazdar and Cherif (2015), Moradbeigi and Law (2017), Olagbaju and Akinlo (2018), Ehigiamusoe et al. (2019, 2020), Olaniyi and Oladeji (2020a, b) and Ehigiamusoe (2020), the threshold of institutional quality is determined by setting Equation 3.4 to zero for which via algebraic simplification becomes:

$$IQ_{it} = \frac{-\hat{\gamma}^j_i}{\hat{\beta}_3} \tag{3.5}$$

In addition, the FD-GMM dynamic threshold approach we have used to estimate Equation 3.3 is superior to all other static and dynamic threshold models in existing body of knowledge whose strong, restrictive, and crucial assumption(s) is that either regressors, threshold or the transition variable(s) or both are exogenous (Seo and Shin, 2016)[27]. Our use of two-step FD-GMM technique, though it removes the country and regional effects, fill this gap by explicitly addressing an important issue on how best to simultaneously model nonlinear asymmetric dynamics and unobserved individual heterogeneity. It also deals with effects of endogeneity

[27] Examples of such static and dynamic models in current literature are Hansen (1999, 2000), Caner and Hansen (2004), González et al. (2005), Fok et al. (2005), Seo and Linton (2007), Kim et al. (2008), Dang et al. (2012), Kremer et al. (2013), Ramírez-Rondán (2015), For a more detailed and extensive survey see also Hansen (2011). Furthermore, Kourtellos et al. (2016) and Yu and Phillips (2016, 2018) tried to address the issue of endogenous threshold variable but it in the context of a single equation thus superseded by that of Seo and Shin (2016).

problem on parameter consistency, asymptotically unbiased and efficiency arising from failure to account for simultaneity and omission bias. We filled this methodological deficiency by combining and extending the approaches by Hansen (1999, 2000) and Caner and Hansen (2004) to the Arellano and Bond (1991) GMM dynamic panel data model with endogenous threshold variable and regressors. Specifically, following studies on GMM literature (for example, Holtz-Eakin et al., 1988; Arellano and Bond, 1991; Ahn and Schmidt, 1995; Arellano and Bover, 1995; Blundell and Bond, 1998; Alvarez and Arellano, 2003; Bun and Windmeijer, 2010; Hsiao and Zhang, 2015; Hayakawa, 2015; Kourtellos et al., 2016; Yu and Phillips, 2018), we consider the asymptotic properties of Seo and Shin (2016), which suit our large cross-section of 46 SSA countries with a fixed time period of 18 years (2000-2017).

3.3.2 Data and Variables

The data samples comprise institutional quality and infrastructure development as well as the threshold and control variables for the period 2000 – 2017. In the empirical models, in the case of FMOLS, there are five interaction variables used to determine threshold levels of institutional quality[28] based on Equations 3.4 and 3.5. The four (4) variables are 1) public debt (PD), 2) financial market development (FMD), 3) government tax revenue (GR) and 4) foreign direct investment (FDI). In addition, there are six control variables, which are legal origin (LO), government consumption (GC), terms of trade (TOT), domestic investment (DI), lagged gross domestic product growth rate (LGDPG) and trade openness (TO). Lastly, the dependent variable is infrastructure development.[29] The same variables are employed in the case of FD-GMM. To determine the dynamic panel data threshold effect of institutional quality on infrastructure development, we used seven (7) transition variables represented by IQ in model 3.2 and 3.3 as reported in Table 3.6 based on definitions in Table 3.2.

[28] Institutional quality was proxied separately by five worldwide governance indicators (WGI) as well as the overall score we generated combining the six WGI using Principal Component Analysis (PCA). To determines with type of institution matter most on shaping SSA infrastructure, we further categorized them into economic and political institutions. Following literature, the indicators were rescaled to scores ranging from 0-1, 0 and 1 indicating weakest and strongest institutions.

[29] In addition to our use of rescaled generated infrastructure development index using PCA, for robustness check we also include the overall infrastructure index generated by AfDB (2018) combining transport, electricity, telecommunication, water and sanitation for which results are availed upon request.

3.4 Presentation and Analysis of Empirical Results

In this section, we analyse the results estimated using the models 3.1 and 3.3. Because of the weaknesses identified in the literature of static Hansen fixed effects threshold analysis, being its failure to account for endogeneity problems arising from omission and simultaneity biases, thus we excluded its estimation results. Since the static and dynamic threshold models we employed are superior to the Hansen Fixed Effect threshold model in accounting for endogeneity and simultaneity problems, we employed the Hansen threshold model exclusively to determine the number of thresholds. Given the inability of FMOLS and FD-GMM in identifying the presence of multiple thresholds since they are designed only for a single threshold determination, Model 3.2 was exclusively used to determine whether there are multiple thresholds or not. First, we started by looking at descriptive statistics of variables used in regression analysis based on models 3.1 and 3.3. Second, we reported the diagnostic test namely, panel unit root, cointegration, threshold test and model specification test. Lastly, we presented the regression results assuming both static and dynamic panel data threshold approaches based on model 3.1 and 3.3 and determined the thresholds institutional quality and infrastructure development using dynamic FMOLS and FD-GMM techniques.

3.5 Descriptive Statistics

The descriptive statistics of variables used for regression analysis are presented in Table 3.3. Summary statistics in Table 3.3 are complemented by regional and country specifics descriptive reported in Appendix Tables A3.1 and A3.2 as well as Appendix Figures A3.1 and A3.2. Following literature, the indicators were rescaled to scores ranging from 0-1, 0 and 1 indicating the weakest and strongest institutions. In addition, overall institutional quality indicators were further categorized into economic and political institutions. With corresponding overall economic (OEIQ) and political institutions (PIQ) means (standard deviations) of 0.4498 (0.208) and 0.6083 (0.2615), economic institutions of SSA countries on average are less developed and less volatile than political ones. From disaggregated institutional quality indicators from WGI, we observed political stability (government effectiveness) to be the highest (lowest) based on both average score and volatility. On a scale of 0-100, we found SSA's overall infrastructure development (OID) to be 18%, with a standard deviation of 15%. When this is compared to respective average (standard deviation) of political and economic institutions score of 61% (26%) and 45% (21%), indicates SSA institutions are more developed than their infrastructure.

This confirms the arguments and evidence in the extant literature that the state of SSA countries' infrastructure is almost similar serve for two countries namely South Africa and Mauritius (Bogetic and Fedderke, 2006a, b; Chakamera and Alagidede, 2018; AfDB, 2018; Calderon et al., 2018), but in contrast, the quality of their institutions diverges with high volatile (EIU, 2015; World Bank, 2019). From Table 3.3, reported are the summary statistics for variables used by AfDB for generation of OID, WSID (CID) was found to have the highest (lowest) mean and volatility across countries SSA with averages and standard deviations of 47% (5%) and 19% (9%), respectively. In terms of the control variables, all expressed as a ratio of GDP with the exception of legal origin (LO), PD (TOP) has the largest (smallest) mean and standard deviation of 68.457 (1.782) 113.561 (0.758), respectively.

Table 3.3: Descriptive Statistics

Variable	Obs	Mean	Std.Dev.	Min	Max
		Infrastructure Development Measures (ID)			
OID	638	17.672	15.04	0.369	94.324
TID	638	6.939	8.938	0.38	52.651
EID	638	7.52	15.293	0	93.559
CID	638	5.007	9.144	0	76.938
WSID	638	46.749	19.259	6.04	97.56
		Economic and Political Institutional Quality Measures (IQ)			
OEID (PC1)	638	0.4498	0.208	0	1
PID	772	0.6083	0.2615	0.05	1
PS	638	0.4007	0.175	0	0.756
GE	638	0.352	0.121	0.124	0.712
RQ	638	0.363	0.121	0.052	0.726
RL	638	0.365	0.125	0.098	0.716
CC	638	0.377	0.124	0.134	0.744
		Control Variables			
LGDPG	638	4.532	5.26	-36.392	63.38
LO	638	2.087	1.531	0	7
FDI	638	3.168	14.986	-84.654	115.364
FMD	638	25.622	112.598	0.403	2564.493
PD	638	68.457	113.561	20.123	123.458
GC	638	10.145	1.234	0.563	40.675
GR	638	8.345	1.345	0.345	35.678
TOP	638	1.782	0.758	1.645	2.954
TOT	638	2.641	1.419	0.675	6.431
PG	638	2.511	0.959	-2.594	4.833
DI	638	1.998	1.327	-0.678	56.138

*Source**:** Author's own calculation*

3.5.1 Presentation and Analysis of Diagnostic Checks

Econometric literature has shown that reliability and validity of panel data estimator and thus policies informed by such estimators are premised on them having passed certain pre-and post-estimation diagnostic checks. Such diagnostic checks for panel data, especially FMOLS, includes panel unit root test, panel cointegration test, cross-sectional dependence test, panel autocorrelation. Furthermore, for us to understand the impact of institutions and other major determinants of infrastructure development in selected SSA countries in static state, we use FMOLS with interaction terms. This was motivated by its ability to provide consistent, asymptotically unbiased, and efficient estimators in the presence of omission and simultaneity problems mostly encountered in studies like ours. Unlike other approaches like pooled ordinary least squares (POLS) and maximum likelihood estimation techniques such as random effects (REM) and fixed effects (FEM) regression models, which yield inconsistent, asymptotically biased, and inefficient parameter, FMOLS account for endogeneity problems. The tests showed presence of heteroscedasticity (Hall and Pagan, 1983) and first order autocorrelation (Arellano and Bond, 1991; Woodridge, 2002; Drukker, 2003; Shehata and Sahra, 2015; Born and Breitung, 2016), which we corrected by using cluster robust standard errors. In the case of FD-GMM, we used two-step Windmeijer (2005) corrected cluster robust standard errors. Further test done and reported together with regression results were cross-sectional dependence using Friedman's (1937) test procedure, model significance using the F and Sargan/Hansen tests, presence of a single threshold (Seo and Shin, 2016) or multiple thresholds (Hansen, 1999, 2000; Caner and Hansen, 2004) tests and panel cointegration test based Kao technique.

The panel unit root tests are reported in Table 3.4 whereas all other test which unlike stationarity test, relate to the model and not variable specific, are presented as per model in Tables 3.4 and 3.5. Given the balanced panel requirement particularly for Hansen (1999, 2000, Caner and Hansen, 2004) and Seo and Shin (2016), Baltagi (2013) recommend the use of at least two panel stationarity tests. Following this recommendation above other approaches, we adopted Im, Pesaran and Shin (IPS) (2003) and Augmented Dickey and Fuller (ADF)-Fisher (Choi, 2001) approaches. Unlike other tests like Levin-Lin-chu (LLC) and Breitung, which assume homogeneity across panels via their assumption of common or group unit root process, IPS and ADF-Fisher approaches test individual unit root process, thus capturing heterogeneity across panels (Greene, 2012; Baltagi, 2013). Through the application of these two panel stationarity tests, we ensured robustness of our results. These two tests are based on the null and hypothesis that all panel are non-stationary against the alternative that at least one panel is stationary.

To guarantee consistence in our unit root test, we allowed for time trend for all the test equations since we observed that the data was trending upwards over time and used zero lags. From the results reported in Table 3.4, we found that, except for institutional factors which are consistently stationary at level, all series are stationary in first difference across the two testing models. Some few variables are found to be stationary in levels. Following econometrics literature, this divergence in levels of stationarity among our variables, justified the need to carry out panel cointegration tests to guarantee that the variables move on the same wavelength in the long run and to avoid a spurious regression scenario (Gujarati, 2008; Greene, 2012; Baltagi, 2013).

Table 3.4: Results for Panel Unit Root Tests

	Im, Pesaran and Shin (IPS)		ADF-Fisher (ADF)	
Variable	Level	First Difference	Level	First Difference
ID	1.5481	-6.636***	1.287*	5.1696***
EIQ	-4.767***	-20.282***	11.149***	50.428***
PIQ	-2.777***	-16.763***	6.527***	39.218***
PS	-5.385***	-23.751***	9.658***	62.561***
GE	-5.115***	-22.137***	9.660***	57.355***
RQ	-3.952***	-21.293***	8.449***	56.786***
RL	-4.220***	-19.413***	7.446***	48.751***
CC	-2.544***	-18.476***	7.537***	40.303***
LPGDP	-14.960***	-31.673***	33.666***	94.99***
LO	0.391	-12.587***	2.068**	29.803***
FDI	6.543	-10.559***	-4.2667	20.319***
FMD	1.722	-12.589***	-1.5041	26.254***
PD	1.9749	-11.592***	0.7025	26.1386***
GC	4.707	-18.044***	-4.1268	43.116***
GR	2.873	-14.055***	-3.3278	30.050***
TOP	-3.619***	-20.221***	6.299***	52.161***
TOT	-5.047***	-15.788***	-0.6080	21.1723***
PG	2.454	-16.820**	22.187***	12.229***
DI	3.578	-14.736***	0.369	35.526***

Note: *** p<0.01, ** p<0.05, * p<0.1. For uniformity, we used lag zero include trend for all the test.

There are three tests meant to perform cointegration test in the case of panel data, namely Kao (1999), Pedroni (1999, 2004) and Westerlund (2005). Pedroni and Westerlund tests are suitable for unbalanced panel data while Kao test performs best in the case of balanced panels. Therefore, given the nature of our data, we opted for the Kao panel cointegration test procedure and as per model, results reported in Table 3.6 show that the variables in all our models are cointegrated. The panel autocorrelation test presented as per model specification in Table 3.6 shows the presence of autocorrelation and heteroscedasticity, which forced us to correct it by using cluster robust standard errors. De Hoyos and Sarafidis (2006) argue that for panels like ours, with small time, which is less than thirty (T=15) and large cross-sections of at least thirty (N=46) must be subjected to cross-sectional dependences test. In our study, cross-sectional dependence, as stated by Robertson and Symons (2000), Anselin (2001), Pesaran (2004), and Baltagi (2013) can arise due to common shocks and unobservable factors across the SSA region affecting both institutions and infrastructural development. Amongst the three methods used to perform this test, we used Pesaran's (2004) approach, which is more suitable for balanced panel as opposed to the other two (Friedman, 1937; Frees, 1995), which are most suitable for unbalanced panels. Use of FMOLS when there are cross-sectional dependence yields inefficiency though consistent estimators since standard errors will be biases (De Hoyos and Sarafidis, 2006). From the Pesaran cross-sectional dependence test as reported in Table 3.6, we found absence of cross-sectional dependence in all our FMOLS models. This shows that our parameters are efficient and consistent, validating our policy implication derived from this study. The absence of cross-sectional dependence shows that institutional and infrastructure development issues diverge and varies that much across SSA countries, an observation also confirmed by this essay's background trends, measures of dispersion and central tendency. The significant F-statistic from our FMOLS regression models show validity (significant) of our models.

Table 3.5: Hansen (1999) Static Threshold Test (Fixed-Effect Panel Data Threshold Model)

Threshold	Sum of Squared Residuals	Mean Square Error	F-statistic	Probability value
	Overall Economic Institutional Quality (OEIQ)			
None	3.3671***	0.0026	25.386	0.0041
Single	1.9423	0.0017	1.3794	0.8945
	Political Institutional Quality (PIQ)			
None	4.9570***	0.0117	28.7164	0.0013
Single	2.9413	0.0053	2.2075	0.7126
	Political Stability (PS)			
None	3.7164***	0.0317	17.8734	0.0087
Single	2.5533	0.0462	5.7640	0.4831
	Government Effectiveness (GE)			
None	6.1283***	0.0296	21.5165	0.0038
Single	3.5274	0.0172	7.8065	0.3788
	Regulatory Quality (RQ)			
None	1.6351***	0.0418	19.3344	0.0030
Single	5.1122	0.0452	4.1653	0.5321
	Rule of Law (RL)			

None	2.4162***	0.0077	16.8999	0.0036
Single	4.7543	0.0543	6.8532	0.3712
Control of Corruption (CC)				
None	9.8582***	0.0553	22.7765	0.0032
Single	7.9541	0.0134	3.9986	0.4758

Source: Own computation using WGI and Polity IV Dataset

In addition, to circumvent the limitations of the FMOLS and FD-GMM in determining the presence of more than one threshold, we adopted the Hansen (1999) multiple threshold tests procedure whose results are reported in Table 3.5. The results show the presence of a single threshold. This validates the reliability and validity of FMOLS and FD-GMM results and support their suitability for the task of examining the static and dynamic nonlinear asymmetric threshold effect of institutional quality on SSA region's state of infrastructure development.

3.5.2 Regression Result

Static threshold panel data results for seven (7) regression models using infrastructure development as regressors and with both separate and entangled economic and political institutional quality measure(s) as well as some control variables as regressors are reported in Table 3.6. Table 3.7 reports the dynamic threshold panel (FD-GMM) data results using the same regressors but based on a dynamic panel data threshold approach. Insights from the results presented in Tables 3.6 and 3.7 are as follows. First, thresholds levels from models 1-7 reported in Tables 3.6 and 3.7 are much higher than the means observed from summary statistics in Table 3.3. Second, consistently, we observed the institutional quality threshold levels from the dynamic models in Table 3.7 to be higher than those from the static models reported in Table 3.6. This supports econometric literature arguments that when compared to dynamic threshold panel data models, threshold parameters from static models are less precise and less robust since they are mostly plagued with downward bias[30]. Third, unlike static panel threshold models, dynamic panel threshold models split the sample into lower and upper threshold regimes, making it possible to assess the differences in the impact of institutional quality on OID between the two regimes as given in Table 3.7. In line with this view, results for the two regimes in Table 3.7 show that a percentage increase in IQ triggers a higher positive effect on OID of countries in the lower regime than those whose IQ is above the threshold level.

[30] For a detailed explanation see Kremer et al. (2013), Kourtellos et al. (2016), Yu and Phillips (2016, 2018), Seo and Shin (2016) and Seo et al. (2019).

Fourth, the bulky of our sample of SSA countries' political and economic institutional quality scores are below the required thresholds[31]. This acts as an indication that in relation to the minimum required IQ thresholds, most SSA countries have weak institutions to the one expected to positively propel the regional OID. Fifth, juxtaposed to political institution (PIQ), overall economic institutions (OEIQ) have a greater positive impact on overall infrastructure development (OID). Furthermore, in the case of disaggregated institutional quality indicators from both FMOLS and FD-GMM model 1-7 results in Tables 3.6 and 3.7, it has been observed that government effectiveness (GE) and control of corruption (CC) pose the highest positive significant effects on SSA's OID.

Table 3.6: Static Panel Data Threshold Regression Results

	(1) OEIQ	(2) PS	(3) GE	(4) RQ	(5) RL	(6) CC	(7) PIQ
OEIQ	2.359***	1.211***	1.783***	1.370***	1.414***	3.730***	2.127***
PIQ	0.241*	0.327*	0.710**	1.003	2.107	0.131	0.732
PS	0.987*	0.897**	0.967***	2.104**	1.533***	2.851***	0.998**
GE	3.451**	1.631**	1.603**	2.005**	1.205*	2.109***	1.478*
RQ	0.988**	0.879*	0.966**	0.961	1.839*	4.781***	2.122
RL	0.947***	0.867	0.884	0.956***	0.659**	2.412***	1.445***
CC	3.872***	2.747**	2.216*	2.598**	5.185**	2.108**	0.923***
LPGDP	1.174***	0.428***	0.762*	0.179***	0.272***	2.106**	1.531*
LO	3.217**	2.580***	3.842***	2.709**	1.155**	3.766**	0.739*
FDI	1.528**	1.523	1.579***	0.612*	0.989**	0.944**	0.751**
FMD	1.869***	1.709***	1.774**	1.001***	0.974***	2.112**	0.038**
PD	1.137*	0.967***	1.895**	1.257***	0.517***	2.165***	0.371**
GC	-1.783***	-2.642	-1.924***	-0.911*	-0.877	-1.221***	-0.757***
GR	1.426**	0.715***	1.678*	0.782***	0.213**	1.897***	0.051*
TOP	0.972***	0.877***	1.794**	0.562***	0.678***	2.496**	0.719
TOT	1.321**	0.106	1.724**	0.723	-0.466	0.431	0.543
PG	-2.879	-1.965**	-0.945	-0.983**	-0.952***	-3.617***	0.099
DI	0.923**	0.241	2.130**	0.568**	0.719*	2.305***	0.162
FDI*IQ	-2.347***	-2.801*	-3.541***	-1.168*	-1.702**	-1.537***	-0.936*
FMD*IQ	-2.884***	-3.280**	-3.273***	-1.800***	-1.636***	-3.417***	-0.047*
PD*IQ	-1.711**	-1.756**	-3.174***	-2.213***	-0.863***	-3.475***	-0.413**
GR*IQ	-2.385**	-1.347*	-3.640**	-1.599*	-0.363*	-3.243**	0.306*
SA_Dummy	0.976***	0.634*	0.973***	0.764	0.8435*	1.254***	0.862*
WA_Dummy	1.765***	0.876**	1.892***	0.891	0.760	2.281***	1.312*
CA_Dummy	2.146***	0.965**	2.238***	1.003*	1.123**	3.542***	1.984**
EA_Dummy	3.564***	1.129**	3.629**	1.321**	2.219*	4.714***	2.146*
Institutional Quality Thresholds (From Differentiations of OID with respect to FDI, FMD, PD and GR)							
FDI	0.536	0.544	0.446	0.524	0.581	0.614	0.802
FMD	0.648	0.521	0.542	0.556	0.595	0.618	0.814
PD	0.665	0.549	0.597	0.568	0.599	0.623	0.899
GR	0.598	0.531	0.461	0.489	0.586	0.585	0.866
Observations	638	638	638	638	638	638	638

[31] The average percentage of sample of SSA countries which falls in the lower category of our threshold levels in the case of dynamic and static threshold panel data models are 88% and 81% respectively.

Overall R^2	0.564	0.747	0.570	0.529	0.485	0.636	0.742
Hausman test	32.21***	18.24***	493.60***	125.48***	150.68***	50.14***	49.36***
Wooldridge test	12.58***	47.20***	33.14***	592.83***	549.09***	12.57***	44.50***
F-Statistic	389.01***	23.41***	12.62***	28.85***	131.15***	31.75***	13.03***
Pesaran's test	1.256	50.372	6.837	33.814	23.581	12.561	16.884
Kao Coint. Test	4.418***	2.432***	3.167***	2.354***	2.887***	4.31***	2.798***
Countries	46	46	46	46	46	46	46

Note: *** p<0.01, ** p<0.05, * p<0.1.

Table 3.7: Dynamic Panel Data Threshold Regression Results

	(1) OEIQ	(2) PS	(3) GE	(4) RQ	(5) RL	(6) CC	(7) PIQ
				Lower Regime			
OEIQ	4.875***	2.112***	1.730***	3.823***	2.112***	1.730***	3.823***
PIQ	0.084*	-0.542*	-1.215**	2.124	6.833	0.084	0.542
PS	1.468*	1.292**	1.716***	4.011**	5.355***	3.755***	1.084**
GE	4.781**	3.309**	1.005*	1.333**	2.585*	2.183***	2.726*
RQ	2.917**	1.316*	0.965**	0.817	2.389*	7.968***	3.578
RL	3.222***	0.607	0.484	0.756***	0.450**	4.020***	1.885***
CC	4.544***	3.653**	20.726*	3.578**	16.885**	11.158**	5.233***
LID	0.544***	0.653**	0.241**	0.285*	0.329*	0.821**	0.486
LPGDP	0.986***	0.080***	0.016*	0.096***	0.080***	4.086**	2.875*
LO	2.241**	1.578***	13.482***	1.890**	1.113**	7.640**	0.653*
FDI	2.399	1.166	1.999***	0.863	1.760***	0.843**	0.757***
FMD	2.013***	1.243***	1.033**	0.904***	0.124***	3.072**	3.038***
PD	-1.359	-0.865***	-1.975**	-0.537***	-0.271***	-3.658***	-0.475**
GC	-0.313***	-0.432	-1.214***	-0.512*	-0.717	-1.591***	-0.557***
GR	1.316**	0.941***	1.128*	0.871***	0.111***	1.101***	0.141
TOP	1.472***	0.778***	2.926**	0.472***	0.778***	1.926**	0.485
TOT	0.819**	0.137	0.204	0.023	-0.144	0.030	0.286
PG	-4.689	-3.506***	-1.490	-1.893**	-0.979***	-5.836***	0.529
DI	1.239**	0.537	1.204**	0.727*	0.671*	1.469***	0.286
				Upper Regime			
OEIQ	0.282**	0.398*	0.119***	0.086**	0.132	0.052***	0.086**
PIQ	0.019***	0.018	0.501***	0.646	1.479***	0.019***	2.366
PS	0.013	0.316**	0.819**	1.689	2.196***	2.450	1.414
GE	0.440**	0.346*	0.923**	2.168***	0.475*	0.181**	0.366
RQ	0.156	0.486	0.875	0.086*	1.084**	5.894***	1.769
RL	2.084*	0.542	0.125	0.214	0.383	0.162	0.328
CC	1.019**	1.498***	2.705***	1.011**	3.386***	5.877***	3.544***
LID	0.157**	0.012**	0.124***	0.142	0.198**	0.156	0.160**
LPGDP	1.019***	0.018	2.050***	0.646	1.479***	2.284***	0.143
LO	1.030***	0.485*	0.425**	0.473**	0.106*	1.258**	0.227*
FDI	1.229***	0.801	0.9516***	0.4010*	1.016***	0.611	0.321
FMD	1.065***	0.919**	0.732***	0.886***	1.975***	2.062***	1.156*
PD	-1.029***	-0.311***	-1.176**	-0.336***	-0.128***	-1.895***	-0.139
GC	-0.216**	-0.117**	-1.010***	-0.376	-0.562***	-1.322**	-0.248
GR	1.028**	0.773*	0.966**	0.504	0.034	0.951**	0.306
TOP	0.369*	0.089	0.102**	0.012*	0.2749	0.698**	0.144**
TOT	0.003***	0.002	0.140***	0.823***	0.438***	0.213***	0.103**
PG	-2.123***	-1.322*	-0.640***	-0.823**	-0.438*	-0.213***	-0.103*
DI	0.803***	0.302	0.954***	0.436***	0.413***	0.963***	0.125**
Threshold	0.678***	0.584**	0.561***	0.589**	0.601***	0.627***	0.823**
Upper Regime (%)	14.493	13.851	5.314	7.488	10.465	4.781	25.259

Linearity (p-value)	<0.001	0.014	0.008	<0.001	<0.001	0.003	<0.001
Hansen J-test p-value	0.265	0.061	0.278	0.625	0.266	0.4204	0.381
Countries	46	46	46	46	46	46	46

Note: *** p<0.01, ** p<0.05, * p<0.1.

Thus, weak institutions negate OID of SSA countries. Political instability, which is more prevalent across the SSA region, also hampers the overall development of infrastructure since it destructs physical infrastructure. Ineffectiveness of SSA governments and inability to nip corruption in the bud retard both infrastructure development and financing across the region. In addition, weak institutions particularly economic institutions act as a drag which dampens the positive effect of external (FDI) as well as internal (FMD, GR and PD) sources of finance of SSA's OID. This becomes possibly the main reason causing the persistent widening of both infrastructure investment and financing gaps chronicled in Chapter One and Two of this thesis. These results confirm concerns raised in the budding Institutional Economics field of economics, which argue that SSA region's underdeveloped infrastructure and ballooning infrastructure investment and financing gaps are an outcome of weak, porous and opaques economic and political institutions (Bogetic and Fedderke, 2006a, 2006b; Calderon and Serven, 2010, Estache, 2016, Oxford Economics 2018; GIH, 2018, AfDB, 2018). It is also in line with institutional economics theories, which includes among others, 1) the Laffont view 2) the broad public choice view 3) the spiller or transaction cost cum politics view 4) the dynamic political view, 6) the anthropological view 5) the legalistic view 7) the emerging behavioural view and 8) the empiricist view.

On control variables, in both static and dynamic threshold models, LGDP, LO, FMD, GR, TOT, TOP and DI consistently positively impact OID whereas GC and PG negate it. PD carries opposing signs, that is, having a positive and negative sign in Table 3.6 and 3.7 respectively. Interestingly, interactions terms of IQ indicators with FMD, PD, GR and FDI in Table 3.6, which we also employed to derive static threshold levels, carry negative signs. This shows IQ acts as a drag which negates the positive benefits of FMD, PD, GR and FDI on OID. From development financing organisations, the drag consequences of weak institutions particularly economic ones across SSA countries manifest itself through issues such as low financial intermediation[32], high

[32] Following the arguments of the Law and Finance theory by La Porta et al. (1997, 1998, 2000) and Beck and Levine (2008), lack or low financial intermediation is an epitome of weak, porous and opaque institutions which cannot enable and sustain contract enforceability and respect of property rights.

and unstainable debt, low government revenue generation capacity and low external infrastructure finance through FDI. Therefore, the underdevelopment, inefficiency, and shallowness of the SSA financial markets can be a contributor to the underdevelopment and inadequacy of their respective infrastructure and huge financial and investment gap we observed in Chapter One and Two of this thesis. Gross domestic investment triggers a positive impact on OID. As a result, based on the condition that injections (investment) are equal to withdrawals (savings), boost the development of SSA region's infrastructure, respective countries and institutional investors must utilize trillion of dollars under management within Africa and globally through syndrication and financial systems' intermediation role. Inflation indicator variables as proxied by GDP deflator were found to pose a positive impact on hard infrastructure and in some soft infrastructure models. The possible reason is that most SSA countries are expriencing a managable rate of inflation, which most respective authorities use either through fiscal or monetary policies to stimulate economic activities of their economies.

3.6 Conclusion and Policy Recommendation/Prescription

Motivated by the least infrastructure development indicators, huge infrastructure financing and investment gaps of the SSA region when compared to all other world regions, the objective of this study was to investigate whether both aggregated and disentangled economic and political institutional quality play any role in negating the development of region's infrastructure. From the result, we observed that across the SSA region, weak institutions, particularly economic ones play a pivotal role in the underdevelopment the region's infrastructure, which might have led to the huge and ever-increasing investment and financing gaps we observed in Chapter One and Two. Among the economic institutions, government effectiveness and control of corruption are the ones which come out as top influencers of SSA countries' infrastructure development. Moreover, we observed the impact of institutional quality on infrastructure development in SSA countries and sub-regions to be higher in cases where institutional quality is below their respective optimum thresholds. Thus, SSA countries must take radical structural reform, mostly targeting economic institutions that are responsible for the promotion of a conducive environment, which incentivises and fosters not only public sector participation but also both domestic and foreign infrastructure investors. Economic institutions, which are directly responsible for contract enforcement and respect of property rights are more pertinent and require urgent structural reforms and reconfiguration. Thus, the regulating environment must encourage PPPs and participation of institutional investors who have excess and idle funds of around $100. The SSA region’s financing gap ranges between $68 and $108 billion. In light of the law and finance view, structural reforms must also target responsible enabling of financial resource pooling and allocating sectors, such as the financial system of SSA countries, to increase both their efficiency and competition so that they can improve their financial allocative efficiency and intermediation functions.

APPENDICES

Table A3.1: Summary statistics of Economic Institutional Quality for SSA Individual Countries (2000-2017)

Region/Country	Observations	Mean	Std	Min	Max
SSA	**828**	**0.450**	**0.208**	**0**	**1**
Southern Africa	252	0.576	0.232	0.092	1
West Africa	288	0.448	0.166	0.053	0.875
East Africa	126	0.404	0.157	0.125	0.777
Central Africa	162	0.292	0.139	0	0.655
Mauritius	15	0.946	0.026	0.902	1.000
Botswana	15	0.931	0.025	0.881	0.984
Cape Verde	15	0.816	0.034	0.750	0.875
South Africa	15	0.772	0.043	0.700	0.831
Namibia	15	0.770	0.023	0.731	0.838
Seychelles	15	0.749	0.041	0.683	0.823
Ghana	15	0.661	0.026	0.624	0.710
Senegal	15	0.602	0.043	0.517	0.677
Lesotho	15	0.601	0.037	0.532	0.661
Rwanda	15	0.595	0.151	0.337	0.777
Burkina Faso	15	0.546	0.029	0.499	0.587
Benin	15	0.538	0.036	0.495	0.640
Zambia	15	0.533	0.034	0.472	0.592
São Tomé and Principe	15	0.530	0.040	0.491	0.655
Malawi	15	0.523	0.034	0.469	0.575
Tanzania	15	0.514	0.020	0.473	0.555
Eswatini	15	0.512	0.032	0.436	0.563
Gambia	15	0.504	0.049	0.411	0.609
Mozambique	15	0.494	0.063	0.363	0.559
Gabon	15	0.492	0.052	0.421	0.600
Madagascar	15	0.482	0.097	0.373	0.626
Uganda	15	0.479	0.012	0.446	0.500
Mali	15	0.468	0.085	0.352	0.562
Mauritania	15	0.456	0.100	0.367	0.682
Niger	15	0.444	0.019	0.415	0.474
Kenya	15	0.435	0.028	0.397	0.485
Ethiopia	15	0.387	0.030	0.315	0.437
Togo	15	0.364	0.038	0.292	0.429
Sierra Leone	15	0.356	0.053	0.209	0.424
Cameroon	15	0.354	0.017	0.324	0.385
Côte d'Ivoire	15	0.333	0.100	0.197	0.497
Comoros	15	0.305	0.045	0.237	0.412
Congo	15	0.282	0.021	0.236	0.312
Liberia	15	0.282	0.109	0.053	0.373
Guinea	15	0.275	0.060	0.170	0.389
Angola	15	0.274	0.061	0.093	0.341
Nigeria	15	0.271	0.028	0.215	0.311
Guinea-Bissau	15	0.255	0.056	0.155	0.323
Eritrea	15	0.255	0.118	0.125	0.509
Burundi	15	0.244	0.037	0.186	0.332
Equatorial Guinea	15	0.220	0.019	0.186	0.270
Chad	15	0.217	0.051	0.136	0.349
Central African Republic	15	0.178	0.052	0.095	0.272
Zimbabwe	15	0.172	0.054	0.098	0.273
Sudan	15	0.167	0.028	0.128	0.231
DRC	15	0.110	0.033	0.000	0.149

Source: Own Calculations based on World Bank's Worldwide Governance Indicators (WGI) Database

Table A3.2: Summary statistics of Overall Infrastructure Development for SSA Individual Countries

Region/Country	Observations	Mean	Std	Min	Max
SSA	736	17.67	0.150	00.412	94.332
Southern Africa	224	27.758	21.579	3.137	94.324
West Africa	256	14.024	8.591	2.227	50.431
Central Africa	144	13.758	6.701	2.732	30.671
East Africa	112	11.081	5.802	0.369	25.604
Seychelles	15	73.315	17.261	47.432	94.324
South Africa	15	60.990	13.401	45.879	79.635
Mauritius	15	58.770	12.875	42.102	76.787
Cape Verde	15	36.896	9.772	24.899	50.431
Botswana	15	31.369	3.905	24.727	36.793
Namibia	15	26.817	1.683	24.696	28.882
Gabon	15	24.039	3.734	18.675	30.670
Gambia	15	22.725	4.170	16.639	28.612
Zimbabwe	15	22.719	1.467	20.151	24.716
São Tomé and Principe	15	22.443	3.837	16.751	27.381
Comoros	15	20.303	1.647	17.980	23.500
Eswatini	15	19.351	4.516	13.216	25.764
Senegal	15	18.238	5.362	11.522	25.965
Zambia	15	18.234	2.837	14.424	22.289
Ghana	15	18.074	6.634	10.680	28.835
Rwanda	15	17.002	2.768	13.562	20.768
Côte d'Ivoire	15	16.101	2.880	12.789	21.960
Cameroon	15	15.662	2.772	11.969	19.813
Equatorial Guinea	15	15.316	2.003	12.825	18.215
Kenya	15	15.298	6.815	7.887	25.604
Malawi	15	15.127	2.846	11.506	21.019
Uganda	15	15.090	3.883	10.469	20.622
Nigeria	15	14.497	5.157	8.609	22.365
Lesotho	15	14.354	1.107	12.832	16.008
Burundi	15	14.342	0.333	13.874	15.112
Burkina Faso	15	13.811	2.182	11.260	17.055
Angola	15	12.397	4.051	7.300	19.038
Benin	15	11.715	3.127	8.252	16.228
Congo	15	11.507	2.725	8.677	17.531
Guinea	15	11.407	2.329	8.139	14.789
Sudan	15	10.728	3.260	7.116	15.404
Mauritania	15	10.661	3.963	5.181	16.195
Liberia	15	9.731	2.471	6.741	14.485
Central African Republic	15	9.637	1.696	7.298	11.951
Guinea-Bissau	15	9.596	2.869	5.312	13.536
Togo	15	9.502	2.329	6.712	12.971
Mozambique	15	9.068	2.311	5.879	12.495
Mali	15	9.031	4.344	3.942	15.948
Tanzania	15	8.435	2.885	5.172	12.544
Sierra Leone	15	6.803	2.011	4.508	9.975
Eritrea	15	6.744	1.215	4.760	8.311
DRC	15	6.132	1.572	4.023	8.165
Madagascar	15	5.793	2.325	3.137	10.735
Chad	15	4.741	1.590	2.732	7.239
Ethiopia	15	4.261	2.955	0.369	9.699
Niger	15	4.128	1.219	2.227	5.762

Source: Own Calculations based on African Development Bank (AfDB) Infrastructure Development Database

Figure A3.1: Distribution of SSA Institutional Quality and Infrastructure Development (2000-2017)

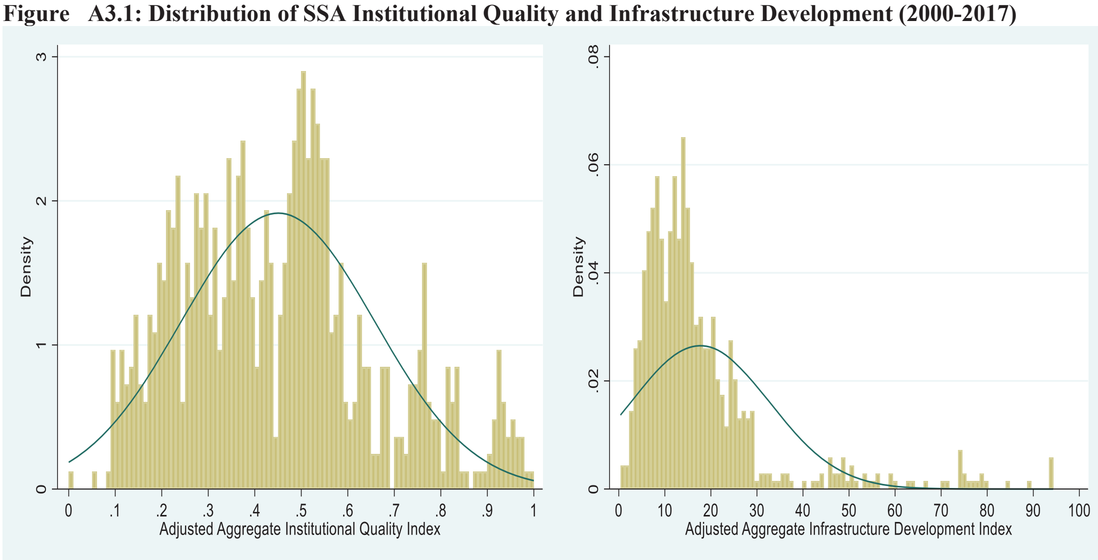
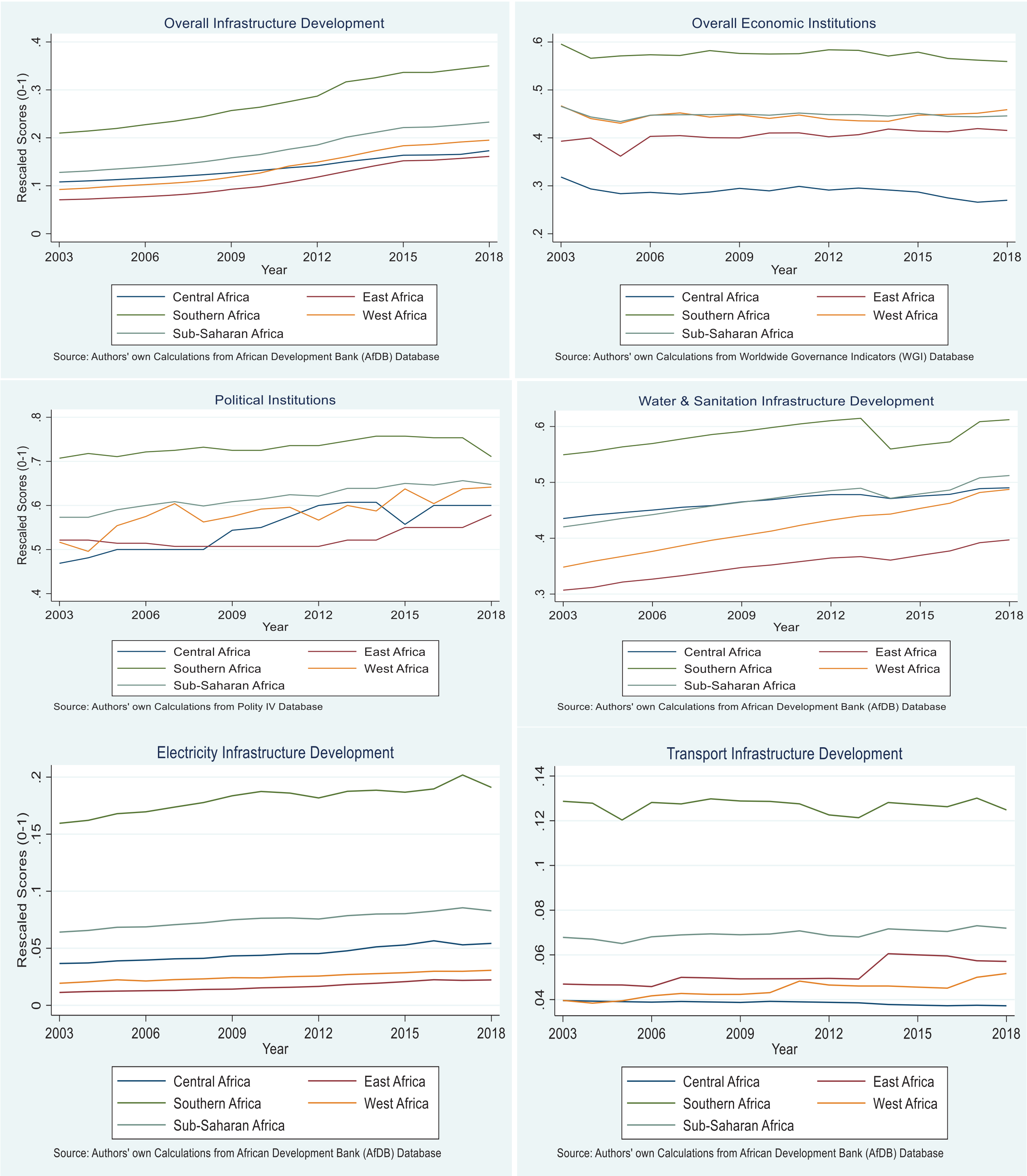
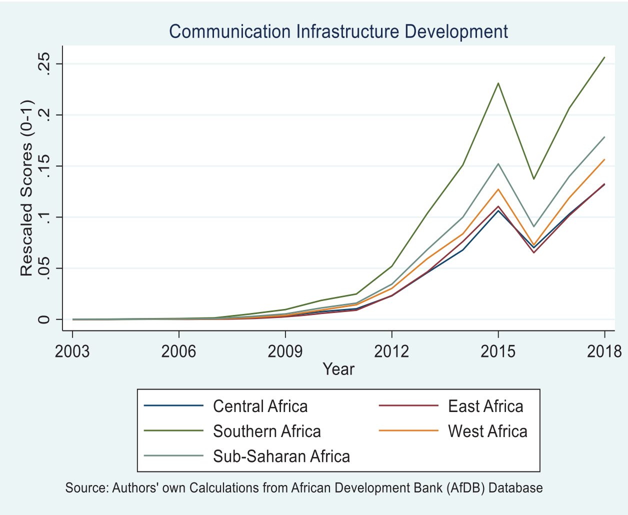
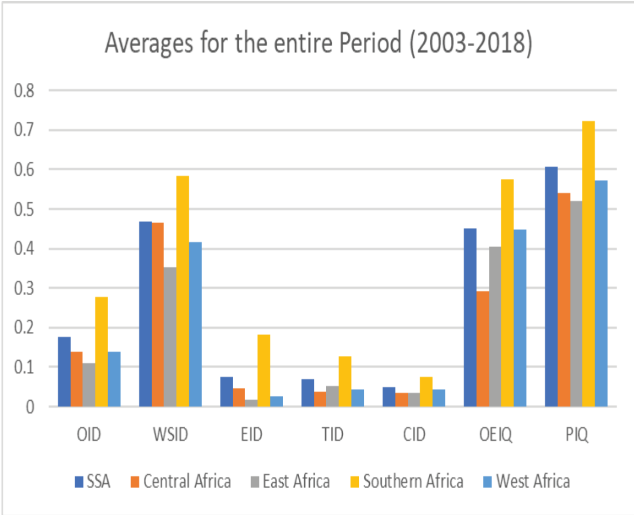


Figure A3.2: Evolution of SSA Infrastructure development and Institutions overtime (2003 -2018)




Communication Infrastructure Development
Rescaled Scores (0-1)
0
.05
.1
.15
.2
.25
2003
2006
2009
2012
2015
2018
Year
Central Africa
East Africa
Southern Africa
West Africa
Sub-Saharan Africa
Source: Authors' own Calculations from African Development Bank (AfDB) Database


Averages for the entire Period (2003-2018)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
OID
WSID
EID
TID
CID
OEIQ
PIQ
SSA
Central Africa
East Africa
Southern Africa
West Africa

CHAPTER 4: THE NEXUS BETWEEN GROWTH AND INFRASTRUCTURE IN SSA: A THRESHOLD ANALYSIS APPROACH

4.1 Introduction

Sub-Saharan Africa (SSA) enjoyed high growth rates that outpaced those of the developed countries for more than two decades. However, economic activity in the region has decelerated and that is explained by a plethora of factors, poor infrastructure being a main contributor (Calderón et al., 2018). Infrastructure is an amalgam of material, institutional and personal facilities and data, which are available to the economic agents, and which contribute to realizing the equalization of the remuneration of comparable inputs in the case of a suitable allocation of resources, that is complete integration and maximum level of economic activities (Jochimsen, 1966). Thus, infrastructure is a measure of a nation's position on the global stage and is accepted by all (Chotia and Rao, 2016). In other words, infrastructure refers collectively to roads, rail lines, electric supply, telecommunication networks, and similar public works that are required for an industrial economy, or a portion of it, to function (Oxford, 2018). Inefficient and inadequate infrastructure leads to high transaction costs, which can prevent the economy from realizing its full potential, regardless of the advancement on different fronts. Physical infrastructure covering transportation, communication and energy through its regressive and forward linkages promotes growth. Meanwhile, social infrastructure, which incorporates education and health, sewage, disposal water supply, sanitation, etc., are in the nature of primary services and have a pronounced impact on the quality of life.

Infrastructure quality and quantity have been extensively found to impact positively and linearly on economic growth and development (Aschauer 1989; World Bank, 1994; Chakamera and Alagidede, 2018; Calderón et al., 2018). Surprisingly, in the current extant literature, to the researcher's best knowledge, threshold (non-linearity) analysis of infrastructure and the effect of infrastructure access on economic growth is scant in general and non-existent specifically in the case of SSA countries and region where there is ever ballooning, and skyrocketing infrastructure investment and financing gaps witnessed in Chapters One and Two. Literature has argued that studies looking at the impact of infrastructure access and its determinants has been conspicuously absent though it is directly linked to inclusive growth, social policy, and the achievement of Millennium Development Goals MDGs) focusing on human development well-being like child mortality, universal primary education, gender equality, and malaria and HIV/AIDS (Leipziger et al., 2003; Reinert, 2011; Jakob and Edenhofer, 2014; Steckel et al., 2017). For example, Leipziger et al. (2003) found infrastructure to be associated with child health, human capital accumulation and the achievement of the Millennium Development Goals (MDGs). As a result, Leipziger et al. (2003)'s evidence was viewed as a justification why inadequate proportions, poor quality and inaccessible infrastructure across SSA countries led to the dismal performance of the region towards achievement of the MDGs by 2015. According to Bogetic and Fedderke (2006) this brought back infrastructure as the top priority of developing economies' development agenda, particularly of countries in the SSA region. This line of argument provoked us to include infrastructure access and soft infrastructure dimensions as well as the threshold analysis using SSA region as a laboratory. The SSA region serves as a fertile ground because antecedent literature evidence seems to indicate that is where the problem of underdeveloped infrastructure, gaps in respect of output, infrastructure investment and financing is more profound. As opposed to the assessment of the effects of only quantity and quality of infrastructure on economic growth, omitting the access and non-linearity dimensions, which according to Greene (2012) and Baltagi (2013) pose omission bias, this study sought to address such a common drawback in the antecedent literature by adopting the static and dynamic threshold approach and also capturing infrastructure accessibility by the SSA region's inhabitants.

Infrastructure has also been found to enhance market interconnectedness, both regionally and globally, whose benefits accrual is more biased towards emerging and developing economies based on disaggregated infrastructure components. For example, Bonfatti and Poelhekke (2017) evaluate how transport infrastructure trigger the direction of trade in developing countries. Contrary to Bonfatti and Poelhekke (2017), Wessel (2019) assess the impact of transport-mode-specific trade on different types of infrastructure. In Brazil, Bottasso et al. (2018) relates trade with port infrastructure. Therefore, the main aim of this essay is to examine effect on infrastructure on economic growth of SSA countries on the basis of a static (fixed effects) and dynamic (system GMM) panel data threshold approaches.

Infrastructure is critical for economic and social development the world over. Basically, from human beings, infrastructure plays a critical role on daily basis like the need to access clean and safe water for drinking and cooking as well as power for lighting and heating homes, roads and railways for people to get to work and provide for their families. At firm and household level, transport infrastructure as well as seaports and airports, allow people to reach the markets they need to trade their goods and services, including across international boundaries. In these ways, and many more, infrastructure is vital to quality of life, economic development, poverty alleviation and economic growth.

Economies are actually based on infrastructure and guaranteeing that everybody in the society benefits from public infrastructure assets is at the centre of many current debates. Creating more inclusive structures, networks and systems will help authorities to reduce inequality, drive productivity, increase land values and boost economic growth (Oxford Economics, 2018). It has been widely argued in the literature that adequate supply of infrastructure services in right proportions and of good quality is viewed as a key ingredient for economic growth and development especially in the case of emerging and developing countries, Africa included (Aschauer, 1989; World Bank, 1994; IMF, 2014, 2019; AfDB, 2018).

Meanwhile, poor infrastructure development particularly in the SSA region hinders economic growth (Calderon and Serven, 2010; World Bank, 2013). The role of infrastructure in economic growth has been a focal point in policy circles. For instance, the AfDB (2010, 2018) regarded the lack of infrastructure in Africa as an indication of untapped productive potential, which is also a huge investment opportunity. So long as the unmet demand for infrastructure as well as investment and financing gaps exists, it remains a key restrain on doing business in most African countries, which depresses their firms' productivity by roughly 40% (IMF, 2014; Oxford Economics, 2018; Calderón et al., 2018; AfDB, 2018). Infrastructure's role in economic development has therefore attracted a great deal of attention.

This essay of the thesis sought to empirically examine the nexus between economic growth and infrastructure in SSA economies. The next sections of the study provides background of the study, the problem statement, the contribution of this study, scope of the study as well as literature review.

4.1.2 A Brief Background on SSA Infrastructure and Economic Growth

Antecedent evidence in the literature and infrastructure expert views are consistent on the fact that infrastructure is a crucial ingredient in boosting productivity due to lower firm costs (Nadiri and Mamuneas, 1994), raising international trade flows (Limao and Venables, 2001), opening space for employment creation, reducing inequality and poverty by enabling industrialisation, particularly of developing economies (OECD, 2006; AfDB, 2013, 2018; Calderon et al., 2018) fostering economic growth world-wide and specifically in the developing countries such as the SSA region (Chakamera and Alagidede, 2018; Calderón et al., 2018). The SSA region, due to its overreliance on exports of commodities,which are not beneficiated, and value added, was the most affected region during the post-global financial crisis slowdown. Considering this, there is need to continue the growth trajectory and momentum it experienced during the period of the Africa Rising narrative, hence the need to develop its infrastructure base (IMF, 2018).

According to Oxford Economics (2018), inadequate water and sanitation infrastructure is costing Africa approximately 2% of its GDP, high transport costs add 75% to the price of African goods, and about 30 countries have chronic power outages. All-in-all, underdeveloped infrastructure has been estimated to cost at least 5% of Africa's annual GDP growth. According to the World Economic Forum (2019) report, in relation to SDG goal 8 (decent work and economic growth), least developed economies group, in which the bulk of SSA countries fall, has consistently missed the target by 7% since 2015 and by 2030 extreme poverty levels will be twice the 3% set target for goal 1. This is mainly attributed to inadequate infrastructure. Another crucial evolving consensus in the literature is that under the right circumstances, an adequate supply of infrastructure can help foster growth in the region (IMF, 2014, AfDB, 2018). The bulk of literature of literature (see for example, Aschauer, 1989; World Bank, 1994; IMF, 2014; Cerra et al. 2017) look at how an adequate supply of infrastructure services trigger economic development, but not going deeper on examining the benefits reaped from good quality and accessibility of such infrastructure stock. Above literally considering adequate supply of infrastructure in SSA, which is a quantity dimension, Chakamera and Alagidede (2018) and Calderón et al. (2018) add a second dimension namely quality. Given the paucity of studies examining growth benefits of infrastructure services, Calderón et al. (2018) hint on the need to assess the benefits of infrastructure accessibility as a standalone factor free from confounding effects by aggregating it within either quality or quantity indicators or both.

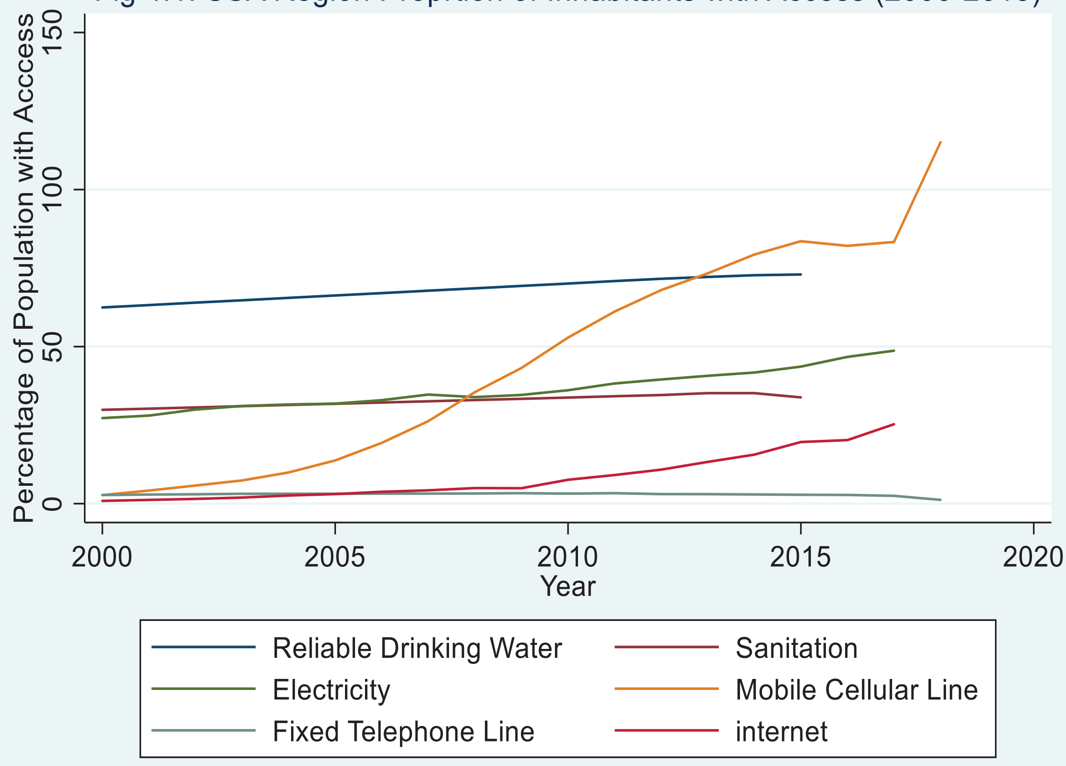
In support of equality, poverty reduction and inclusive growth via infrastructure, SDG 6 (access to water and sanitation), 7 (access to affordable and clean energy) 8 (decent work and economic growth) 9 (industry, innovation, and infrastructure) 10 (reduced inequality) and 11 (sustainable communities and cities) revolve around possible linkages between infrastructure and economic growth. Moreover, it has been argued in the literature that achievement of Millennium Development Goals MDGs), much linked to human development well-being like child mortality, universal primary education, gender equality, and malaria and HIV/AIDS eradication was hinged on adequate amount, accessibility and quality of infrastructure service (UN, 2000; Fukuda-Parr, 2012; Griggs et al., 2013; Steckel et al., 2017). This argument might be the possible reason why SSA countries recorded the least results towards the achievement of MDG targets by 2015. Also, correction of under-provision of the material foundations necessary to fulfil basic human needs through expanded access to infrastructure for, inter alia, electricity, water, sanitation, telephone, healthcare and education, should be regarded as one of the central aims of public policy (Jakob and Edenhofer, 2014). This view is consistent with a broader view in social policy of a universal entitlement to basic goods (Reinert, 2011). Therefore, SDGs and inclusive growth targets can be achieved if quality, accessible and adequate amounts of infrastructure are made available within the SSA region. Thus, this justifies why in this chapter we seek to examine the effect of infrastructure quantity, quality and access dimensions on economic growth using SSA region as a laboratory anchoring on the most omitted threshold (non-linearity) approach.

SSA, in the Oxford Economics (2018) report was ranked at the bottom of all developing regions in virtually all dimensions of infrastructure performance such as transport, energy, telecommunication, and water and sanitation. Regardless of SSA possessing approximately 30% and accommodating approximately one-seventh of the world's mineral wealth and population, respectively, on the World Economic Forum (WEF) (2019)'s 4th industrial revolution overall Global Competitiveness Index (GCI 4.0) scale of 0-100 ,it scored a paltry 46.3 against a global leader (Singapore) and world average scores of 84.8 and 60.7, respectively. Major contributors to SSA's dismal performance on a 12-pillar based overall GCI 4.0 index across all global regions are both hard and soft infrastructure based three-pillars, namely health (soft infrastructure), ICT adoption and infrastructure (hard infrastructure). Higher significant cross-regional gaps from the optimal frontier (score of 100) above the overall world gap between best-and worst-performing countries of 28 noticed in respect of the aforementioned three pillars are 38.4, 36.2 and 34.7 (WEF, 2019). From this least and much below average score, one can clearly deduce that there is a severe both hard and soft infrastructure deficiency more prevalent across SSA that needs to be dealt with as a priority if the region is to have any meaningful development. According to Calderon and Serven (2010), the region has some inherent characteristics that may facilitate the potential role of infrastructure for its economic development namely: the large number of landlocked countries, which are home to a major proportion of the region's total population (about 40 %), and the remoteness of most of the region's economies from global market centres. This supports and shows how pertinent and urgent the need to unravel how the infrastructure quantity, quality and accessibility propel economic growth using the SSA region as a laboratory.

Limao and Venables (2001); Elbadawi et al. (2006); Behar and Manners (2008) are of the view that the geographic disadvantages of most SSA countries result in high transport costs that deter intra-and-inter regional as well as international trade. Limited openness to trade is the main factor behind the stylized fact that holding other things constant, landlocked countries tend to grow slower than others (Limao and Venables, 2001). Given these drawbacks, adequate transportation and communication facilities are viewed as a breakthrough since they can help overcome these geographic disadvantages and unlock trade. If these are not dealt with, the end result will be poor infrastructure and eventually leading to slow or negative growth.

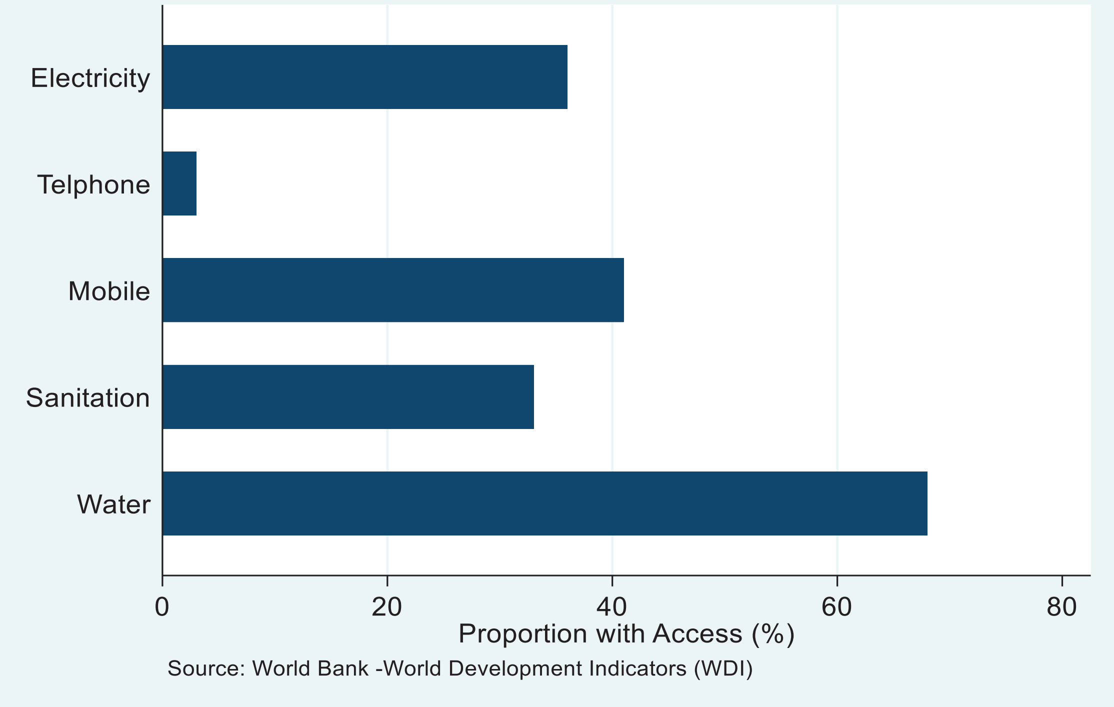
With this background, we feel the examination of the effects of infrastructure quantity (extensively covered) and quality (scantly covered) on economic growth in the extant literature, will be futile and leave a huge void if the following fundamental questions still remain unravelled: 1) Does infrastructure access positively or negatively affect economic growth? 2) What is the optimal threshold of infrastructure quantity, quality and access on economic growth? Are the thresholds maximum or minimum thresholds? Therefore, as a contribution to the existing body of knowledge, this chapter seeks to probe answers to the above yet still unanswered questions. Therefore, Figures 4.1 and 4.2 present the trends and average disaggregated infrastructure access measures for the period 2000-2018. Except in the case of drinking water, the access scores of less than 50% hint towards inaccessibility of infrastructure services by the majority of the SSA region's inhabitants, which might act as a hinderance to inclusive economic growth, poverty reduction and achievement of SDGs.

Fig 4.1: SSA Region Proprtion of Inhabitants with Access (2000-2018)



In the previous research work, a pattern can be seen where academic researchers devoted considerable effort to theoretical and empirical analysis of the contribution of infrastructure development to growth and productivity and in virtually all cases, a positive relationship emerged (Estache et al., 2002). In the early and late 2000s, more attention has also been paid to the impact of infrastructure on inequality and poverty (Estache et al., 2002; World Bank 2003, 2006; Calderon and Serven 2004, 2010). There is also an emerging consensus from the literature, which suggests that, under the right conditions, infrastructure development can play a major role in promoting economic growth and equity and, through both channels, help reduce poverty (Estache et al., 2002). However, surprisingly there is literature dearth on the optimal threshold level above which infrastructure starts to pose a positive impact on economic growth since virtually all studies in literature examine the infrastructure- growth nexus using linear models. Furthermore, such attention was devoted on physical infrastructure stock, which do not account for depreciation of the infrastructure. Also conspicuously omitted in extant literature is the infrastructure quality and access. Thus, this essay was provoked by these gaps.

Figure 4.2: Average Access in SSA Region (2000-2018)



4.1.3 Problem Statement

The background information and reports by Oxford Economics (2018), WEF (2016, 2019), Calderón et al. (2018) and AfDB (2018) have shown that Africa in general and SSA in particular face serious infrastructure deficiency, quality, performance and service accessibility, which drive policy makers and academia view it as an a hinderance to achievement of inclusive and robust regional economic growth. For example, Oxford Economics (2018) report ranked SSA at the

bottom of all developing regions in virtually all dimensions of infrastructure performance such as transport, energy, telecoms and water and sanitation. In addition, regardless of SSA possessing approximately 30% and accommodates approximately one-seventh of the world's mineral wealth and population, respectively, on the 2019 WEF's 4th industrial revolution overall Global GCI 4.0 scored a paltry 46.3% against a global leader (Singapore) and world average scores of 84.8 and 60.7, respectively. Major contributors to SSA's dismal performance on a 12-pillar based overall GCI 4.0 index across all world regions are both hard and soft infrastructure based three-pillars, namely health (soft infrastructure), ICT adoption and infrastructure (hard infrastructure). Higher significant cross-regional gaps from the optimal frontier above the overall world gap between best-and-worst-performing countries of 28 noticed in respect of the three pillars are 38.4%, 36.2% and 34.7% (WEF, 2019).

Furthermore, water and sanitation infrastructure deficiency costs Africa approximately 2% of its GDP, high transport costs add 75% to the price of African goods, and about 30 countries have chronic power outages (Oxford Economics, 2018). Overall, underdeveloped infrastructure has been estimated to cost at least 5% of Africa's annual GDP growth. AfDB (2018) further argues that the main factor holding Africa back from reaping and enjoying fruits of industrialisation is insufficient stock of productive and quality as well as inaccessible infrastructure like water, power and transport service, which allow firms to survive in industries with strong comparative and competitive advantages. That is, SSA experienced high growth rates that outpaced other world regions for more than two decades before the global financial crisis (GFC). However, post-GFC its regional economic activities decelerated due to a plethora of factors, with poor infrastructure cited as the main contributor (Calderón et al., 2018). As a result, IMF's (2018), World Economic Outlook (WEO) reported that, SSA is burdened by infrastructure challenges coupled with depressed global trade and commodity prices that may stay lower than pre-crisis levels for a long time. This increased its output gap and slowed down its long-term growth trajectory and momentum amid a plethora of other internal and external adverse operating environmental conditions. Thus, various stakeholders including experts in academic and policy circles suggests a "big push" to help the region achieve inclusive growth, escape poverty and narrow the income per capita gap vis-à-vis the rest of the developing world (Sachs et al., 2004; Collier, 2006; IMF, 2014). These calls for action are advocating for a wide array of policy agendas and interestingly, with all of them citing infrastructure development as a serious priority among drivers that can foster productivity and inclusive growth across the region.

Moreover, in relation to SDG goal 8 (decent work and economic growth), least developed economies group, in which the bulk of SSA countries fall, has consistently missed the target by 7% since 2015 and by 2030 extreme poverty level will be twice the 3% set target for goal 1 (WEF, 2019). This is mainly attributed to inadequate infrastructure. Another crucial evolving consensus in the literature is that under the right circumstances, an adequate supply of infrastructure can help foster growth in the region (IMF, 2014, AfDB, 2018). The bulk of literature (see for example, Aschauer, 1989; World Bank, 1994; IMF, 2014; Cerra et al. 2017) looks at how an adequate supply of infrastructure services trigger economic development, but not going deeper on examining the benefits reaped from good quality and accessibility of such infrastructure stock. Above literally considering adequate supply of infrastructure in SSA, which is a quantity dimension, Chakamera and Alagidede (2018) and Calderón et al. (2018) add a second dimension namely quality. Given the paucity on examining benefit on infrastructure services, Calderón et al. (2018) hint on the need to assess the benefits of infrastructure accessibility as a standalone factor free from confounding effects by compounding it within either quality or quantity indicators or both.

Literature has argued that studies looking at the impact of infrastructure access and its determinants has been conspicuously absent though it is directly linked with inclusive growth, social policy and the achievement of Millennium Development Goals MDGs) much linked to human development well-being like child mortality, universal primary education, gender equality, and malaria and HIV/AIDS (Reinert, 2011; Jakob and Edenhofer, 2014; Steckel et al., 2017). Also, literature in abundance is mostly concentrated about developed economies where infrastructure stock and quality are high, neglecting lower income countries which form the bulk of SSA countries. Given the paucity of studies examining the benefits of infrastructure services, Calderón et al. (2018) hint on the need to assess the benefits of infrastructure accessibility as a standalone factor free from confounding effects by entangling it within either quality or quantity indicators or both. Therefore, linkage of infrastructure access and threshold modelling using exclusively a more homogenous cross-country sample developing economies is scant in the current literature. This led to mind pondering questions: Is the effect of aggregate infrastructure on economic growth U or inverted U-shaped? What is the optimal threshold level in the case of SSA visa-viz current status-quo and compared to thresholds in the existing literature?

4.1.4 Study Objectives

The main objective of this essay is to examine both linear and non-linear linkages between infrastructure and Economic growth of 46 countries in the SSA region. This primary objective will be achieved through the following specific or secondary objectives:

1. To examine whether aggregate infrastructure quantity, quality and access positively or negatively affect economic growth in 46 SSA countries.

2. To evaluate if aggregate infrastructure quantity, quality and access affect economic growth of the SSA region in a linear or nonlinear fashion.

3. To find the optimal threshold levels of aggregate infrastructure quantity, quality and accessibility.

4. To ascertain whether the aggregate infrastructure quantity, quality and access thresholds are maxima or minima.

4.1.5 Study Significance

Antecedent evidence in the literature has extensively indicated that infrastructure is crucial in driving economic growth and alleviation of poverty across the globe. Also, adequate infrastructure in the form of road and railway transport system, seaports, power, airports, education, and health among others, is critical for the efficient working and integration of the economy and the rest of the world and achievement of SDGs. Dupay (2010) argued that infrastructure is responsible for "rolling out" basic power, water, sewerage, and communications services across geographical territories as public or quasi-public goods using systems of standardized services. Regardless of all these benefits posed by infrastructure on overall economic development, SSA is ranked at the bottom of all developing regions in virtually all dimensions of infrastructure performance. Surprisingly, SSA being the second largest region, which houses almost one-seventh of the world's population, has a score of 2.91 out of 7 on the infrastructure category of the World Economic Forum's (WEF's) Global Competitiveness (2016) Report. With a meagre overall infrastructure quality and performance score 46%, it was rated the least by WEF in 2019.

Despite all the slowdowns in growth, underdeveloped and deteriorating infrastructure, it is also imperative to note that Africa also has a unique opportunity to develop its infrastructure in a sustainable manner that can boost productivity and growth to catch up with world standards. Using the vast minerals and human capital that the continent has, SSA could leapfrog to new, sound infrastructure, drawing on the best innovations from all over the world. SSA can also have benefits such as increase in productivity, especially in manufacturing and service delivery if it develops adequate and efficient infrastructure. There are also multiple effects that come with infrastructure development such as the creation of more jobs, increased attractive investment opportunities as well as encouraged efficient use of natural resources (Global Infrastructure Hub (GIH), (2018)). Moreover, improved infrastructure will also contribute to social development in the areas of health and education and reduce societal inequalities through a more equitable distribution of national wealth (GIH, 2018).

4.2 Literature Review

This section looks at theoretical framework where this study is built upon and empirical studies which will enables us to identify our contribution to the body of existing literature.

4.2.1 Theoretical Framework

The theoretical connection between economic growth and infrastructure can be derived for the Solow economic growth model. There has some recent adjustment to the Solow growth model which include the human capital augmented Solow growth model, the institutions augmented Solow growth model among others. In light of these adjustment, our empirical model captured the human capital and institutions augments by incorporating the human development, that is, both health and education as per Becker (1962, 1997, 2007) and Rosen (1976) human capital theory and institutional quality variables generated using principal component analysis (PCA). For simplicity, we can use the 1956 Solow growth model which has capital, labour and technology. The assumptions which underpin the Solow model are, technological progress grows at a constant rate g, the savings ratio is constant, labour grows at a constant rate n, prices and wages are flexible, there is constant returns to scale (CRTS), there are only two factors of production, capital is flexible, there is constant returns to scale, there are only two factors of production, capital depreciate at a constant rate and the economy produce a single composite commodity. Using these assumptions, the economic output Y can be specified as:

$$Y = f[A(t), \quad K(t), L(t)] \tag{4.1}$$

where: A, K and L capture technology, capital and labour respectively, t is a measure of time. A Cobb–Douglas production function of the form:

$$Y = A_t K_t^{\alpha} L^{\beta}{}_t \tag{4.2}$$

Where α and β is capital and labour substitutability rate, respectively. Using the above the traditional Solow model the capital accumulation would be specified as:

$$\dot{k}(t) = sAk(t)^{\alpha} - (\delta + n)k(t) \tag{4.3}$$

Equation 4.3 is the key equation in the Solow model. The equation states that the rate of change of capital stock per unit of effective labour is the difference between the actual investment per unit of effective labour (*s* is the savings rate) and the break-even investment level. The break-even investment level is the amount of investment that must be done to keep *k* at its existing level. The reason why capital *k* must be kept at its existing level is that first a portion of capital depreciation and also that the quantity of effective labour is growing. Additional derivation in the Solow growth model will produce the steady state level of effective capital per work as:

$$k^{*} = \left(\frac{sA}{\delta + n}\right)^{\alpha/1-\alpha} \tag{4.4}$$

What can highly be deduced from the Solow model is the need of steady accumulation of capital which depends on the saving rate s, given that capital is depreciating overtime and that the quantity of effective labour is growing. The form of capital includes both the human capital and the physical capital. Infrastructure is another form of capital that should be maintained at- a certain level given the issue of depreciation. Thus, the Solow growth model is used to introduce the link between infrastructure and economic growth. here are also other theories like Keynesian growth theory, the Kaldor growth model among others, which can also be used to link infrastructure to economic growth.

To be more specific to the linkage between infrastructure and economic growth, this study adopts a theoretical model developed by Barro (1990) and Mankiw, Romer and Weil (1992) as an improvement over the 1956 Solow growth model and used by Canning and Pedroni (2008), and Seethepalli et al. (2008). It includes infrastructure as well as both the accumulation of human and physical capital to explain the international variation in economic growth rates across SSA countries. The model is given as:

$$Y = A_t F_t^{\alpha} K_t^{\beta} L_t^{1-\alpha-\beta} \tag{4.5}$$

where: Y is aggregate output at time t produced using infrastructure F, other capital K, labour L and state of technology A. Our assumptions for simplicity are that the savings rate, s, is constant and both capital F and K depreciate each period. Next period's infrastructure is a proportion of savings (perhaps through a tax system or by a private sector mechanism that channels investment based on private returns), so that:

$$F_{t+1} = \lambda Y_t \tag{4.6}$$

Non-infrastructure investment K is determined by:

$$K_{t+1} = (1-\lambda) s Y_t \tag{4.7}$$

Substituting the capital accumulation equations (4.6) and (4.7) into the production function (4.5) gives the equation of the evolution of per capita output as:

$$\left(Y/L\right)_{t+1} = A_{t+1} s^{\alpha} (1-\lambda)^{\alpha} \lambda^{\beta} \left(Y/L\right)_t^{\alpha+\beta} \left(L/L_{t+1}\right)^{\alpha+\beta} \tag{4.8}$$

The description of the evolution of technical progress, A_t, investment share allocated to infrastructure, λ, and the size of the labour-force, L_t. Canning and Pedroni (2008), assume that an exogenous stochastic process determines each of these three. The total factor of production A_t in log form is modelled as follows:

$$a_t = a_0 + \delta t + \mu_t \tag{4.9}$$

where: $\mu_t = \sigma t + v_t$ for which $0 \le \sigma \le 1$ and v_t is a stationary random variable with a mean of zero. Therefore, log total factor productivity depends on a constant, a_0 a trend rate of growth, $\delta \ge 0$, which we take to be zero when $\sigma = 0$, plus a random term that is stationary if $\sigma < 1$ and non-stationary if $\sigma = 1$.[33]

4.3 Related Empirical Literature

Empirical studies on the linkage between infrastructure and long-term economic growth in Africa has taken off. Ndulu (2006) chronicled the diagnostic view of the major issues in

[33] For further detail on this theoretical framework model see Canning and Pedroni (2008) and Seethepalli et al. (2008)

infrastructure for the region while Ayogu (2007) surveyed the literature on the growth and productivity effects of infrastructure development. For instance, Estache et al. (2005) estimated an augmented Solow model using pooled OLS and found that roads, power and telecommunications infrastructure (rather than water and sanitation) have a significant association with long- run growth in Africa. Other studies follow a production function approach. For instance, Ayogu (1999) estimated an infrastructure-augmented production function using regional panel data from Nigeria and found a strong association between infrastructure and output. Kamara (2006) evaluated the dynamic effects of infrastructure in an aggregate production function for a panel of African countries. Analogously, Boopen (2006) estimated the output contribution of transport infrastructure using panel data. Leaving out the access dimension, Chakamera and Alagidede (2018) examined the effect of infrastructure quantity and quality on growth of SSA countries using both linear dynamic (SGMM) and Dumitrescu and Hurlin causality approach. Assessing the growth benefits of reducing SSA region's infrastructure gap, Calderon et al. (2018) found reduction of the gap boost regional economic growth by 1.7% per annum, quantity and quality contribution by 1.2% and 0.5% per year respectively. All these studies have the following drawbacks; 1) they did not determine the minimum amount of infrastructure quality or quantity which is needed to boost growth, 2) they did not ascertain whether infrastructure quality and quantity has a U or inverted U-shaped effect on growth, 3) though infrastructure access is directly and indirectly linked to welfare issues, inclusive growth and SDGs, it was conspicuously omitted and 4) they did not look at whether infrastructure quantity, quality and access has complementarity or substitutability effect on economic growth. These issues form the basis and contribution of this study to the body of existing knowledge. Thus, this study aimed to close these gaps.

It has been critically reviewed by Eberhard et al. (2011), that there is an abundant theoretical work carried out in the field of infrastructure and economic development. However, there is a limited number of research pertaining to the region of SSA countries, which has been carried out from the perspective of infrastructure to welfare, output, and productivity despite it being the region with widest and ever ballooning infrastructure investment and financing gaps as well as inequality and poverty levels. In addition, literature that employed threshold modelling to ascertain whether the effect of infrastructure quantity, quality, and access in U-or-inverted-U-shaped using SSA region to our knowledge is non-existent. Arrow and Kurz (1970) were the first in providing a formal analysis on the effects related to the public capital on welfare and output under the alternative financing schemes. In their study, the public capital was considered as an input in the aggregate production function by Cassel, de Candia and Liberatore (2010). However, with the passage of time, the literature in the field of infrastructure development has grown significantly with further exploration on the determinants associated with the infrastructure development and consideration of productive current spending and public capital.

The nexus between the equity in resource allocation and infrastructure development has been analysed by a number of researchers (Kodongo, 2015, p. 15). However, the empirical findings associated with the infrastructure development are varied, where the consensus seems to be incipient that the development of the infrastructure in the countries plays a significant role in enhancing the economic performance and, by addition, poverty alleviation. The study of Schiffbauer (2007) identified five different channels of the infrastructure development which influences the growth and the economic performance of the country that includes, (1) factors of production within a country, (2) complement for the factors of production, (3) industrial policy tools, (4) stimuli for the accumulation of the factors and (5) the stimulus for the aggregate demand. In this essence, the study carried out by Yoo (2006) also highlighted the indirect impact of the infrastructure development by the means of total factor productivity. However, the most crucial problem in the analysis of the infrastructure-economic growth nexus is the failure on how to account for infrastructure quality and access as well as ascertaining the optimum threshold levels. The policy makers and the researchers have focused on the provision of more infrastructures rather than a better infrastructure, which is accessible by inhabitants thereby leading to inclusive growth and development of the country.

In the light of Arrow and Kurz (1970), the disentangling of the causality between the economic growth and infrastructure development is considered as another empirical concern as the direction focused on the causality between the two variables has not been clear. It has been estimated by Hagerman (2012) who revealed the feedback on the effects of infrastructure that it can be associated with the output per capital with the physical infrastructure. However, the actual effects of the infrastructure development on the economic growth and development along with the causality issues has become a centre of attention and the empirical challenge by the practitioners and the policy makers in this field.

Following Streimikiene and Kasperowicz (2016), the linkage between economic growth and development of the country is found to be relatively weaker since infrastructure stock can lead to 0.47% increase in the per capita growth and the quality development of the infrastructure can increase growth by a meagre 0.10% per year. It has also been argued by Gwilliam et al. (2008) that the studies mainly focused on the infrastructure-growth nexus using qualitative measures or strongly relying on correlation between the quality and quantity measures. These types of analysis conspicuously leave out the infrastructure access measures as a standalone variable. Moreover, it has been surprising to find that the joint influence of the aggregate index of infrastructure stock and quality is less than the influence of stock alone on growth in SSA countries. However, it is suggested that the poor infrastructure quality within the SSA region has dampen the growth effect of existing stock of infrastructure (Dabara et al., 2016).

A strand of recent studies has focused on the infrastructure development on the SSA countries. According to Ndulu (2006), it has been stated that the productivity and growth has affected the infrastructure development in the different countries. According to Kodongo (2015), the SSA region has attracted importance from the practitioners and scholars in the literature as it has reflected that the political conditions result in the effective development of the infrastructure within the countries. Moreover, the databases on the infrastructure development highlights that there is significant existence between the development of the infrastructure and the growth of the county as it contributes towards the economic development of the country (Kayizzi-Mugerwa, Anyanwu and Conceição, 2014). There are different perspectives on the infrastructure development of the SSA countries, which is one of the reasons why many practitioners and authors who have carried out research in this field have different views with respect to the performance of this region, where some of the researchers relate it to the household and the electrification of the employment activities within the countries.

In the study carried out by Yeps, Pierce and Foster (2008), the infrastructure development is simply regarded as the direct input in the production process of a country. In addition, the infrastructure could also be placed under the broader heading of the physical capital where the approach mainly assumes that the development of the infrastructure within a country can be associated with the growth in a manner that is different from the physical capital. Aizenman, Jinjarak and Park (2015) added that the theory holds a significant increase in the infrastructure stocks would mainly increase the output of the overall economy and directly inducing the economic growth of the country.

The power generation infrastructure's main role provides a tangible example of the channel. It is also regarded as the necessary input for many production processes in both products and services as it renders the marginal economic transactions (Asiedu, 2006, p. 68). In addition to the above statement, both international and South African have fewer opportunities for the investments leading to decrease in the total economic activities within the Sub-Saharan African countries.

Infrastructure may also be regarded as the complement for the input of other factors of production in two different senses (Calderón and Servén, 2010). In the first case, the cost of production may be lowered down with the improvement in the infrastructure development. However, the inadequate infrastructure system also creates a number of variable costs for the firms for which the organisations have to develop contingency plans for the failure pertaining to the infrastructure development or even building infrastructure by the government officials (Estache, Wodon and Lomas, 2014).

The inadequate transport infrastructure incurs a massive cost for the institutions who should seek alternative means of transportation for both inputs and finished goods. According to the findings of Hagerman (2012), the important contributor to the Africa's poor performance in the growth and the development of respective countries was their transport infrastructure. However, the total cost for the individual firms who are providing transport infrastructure can be relatively higher than the cost of the state provisions in relation to such infrastructure, as the latter is significant in achieving a presence of the economies of scale and scope.

4.4. Methodology and Data

4.4.1 Data Sources and Description

In this research, we collected data on the infrastructure related factors (quantity, quality and access) of 46 SSA countries for the period of 2000-2017. Four broad infrastructures dimensions we considered were electricity, roadways, telecommunication (fixed telephones plus mobile phones) water and sanitation infrastructures. We aggregated the infrastructure variables using principal components (PCA) analysis and standardized them across all SSA countries. The detailed definitions of variables and data sources is as presented in Table 4.1[34]. The method we used for aggregating infrastructure variables, namely PCA, is discussed below.

4.4.2 Principal Component Analysis (PCA)

To aggregate our infrastructure and institutional quality variables into one composite index, in light of literature, we observed PCA to be the most suitable method. For example, Karamizadeh et al. (2013) and Davo et al. (2016) state that PCA is a mostly employed multivariate approach which provides for parameter and data reduction with only highest relevant information retention capability. Thus, crucial information is extracted from the dataset by PCA and expressed in a new orthogonal variable (Rencher 2003; Abdi and Williams, 2010). Furthermore, PCA can reveal latent structures in data (Markaki, Chadjipandelis, and Tomaras, 2014). That is, it reveals patterns in data and makes it simple to analyse (see Unglert, Radic, and Jellinek, 2016; Chakamera and Alagidede; 2018; Calderón et al. 2018). Lastly, noise in the data is reduced more by PCA through selection of the maximum variation and by automatically removing small variations in the background (Karamizadeh et al. 2013). Despite these pros, PCA also has its own drawbacks. For example, given that PCA technique is pure mathematically based, if it is not carefully structured, according to Zhang et al. (2015), could generate results that have no economic implications. Therefore, we strongly believed that PCA could adequately achieve our goal. The goal of PCA in this study was to identify the principal components that provide greater explanation of the soft and hard infrastructure and institutional quality dataset. The first principal

component P_1 generation, which is a linear vector of Z original variables being standardized infrastructures and institutional factors is:

$$P_1 = w_1 Z_1 + w_2 Z_2 + w_3 Z_3 + ... + w_j Z_j \qquad (4.10)$$

[34] For the literature guidance on the variable measurement and definitions we have used see Aschauer, (1989), Chakamera and Alagidede (2018), Cerra et al. (2017) and Calderón et al. (2018). Chakamera and Alagidede (2018) differentiate growth in logs improved drinking water and sanitation which are part of measure of infrastructures quality and log of percentage of population with improved water and sanitation as measures of access though confounded in infrastructure stock (quantity). They view increase or positive growth in people with access to improved drinking water and sanitation as a rise in water and sanitation infrastructure, whereas more people with access to improves water and sanitation indicates accessibility to water and sanitation infrastructure by citizens. We follow the same measurement approach, but unlike Chakamera and Alagidede (2018) we avoid the problem caused by confounding access and quantity measures by disentangling them into their respective components.

where: $Z = Z_1, Z_2, Z_3, ..., Z_j$ are original individual j infrastructure factors as given in Table 4.1, ($w = w_1, w_2, w_3, ..., w_j$) where: w is a vector of weights defining the linear combination of original variables. Following Wold et al. (1987) and Calderon (2009), the weights are normalized by making the sum of squared values of variances optimizing weight of model 4.10 equal to 1. To ascertain the number of components to retain, we considered components which capture or explain more than 50% and whose eigenvalues, as a guideline, are larger than the average of the eigenvalues. We also looked at the scree plots, (see Appendix B4) which confirm the first guideline. The selected aggregate infrastructure indices are used in infrastructure-growth analysis based on the GMM technique. The GMM is described in detail below.

4.4.3 Methodology

4.4.3.1 The Theoretical Model – System Generalised Method of Moments (SGMM)

We used the System-GMM (SGMM) technique to examine the dynamic threshold effect of aggregate as well as disentangled infrastructure stock, quality and access on economic growth of 46 SSA countries over the period 2000 – 2017. We adopted this approach for numerous reasons. First, contrary to static models, SGMM is best suited for dynamic panel data. The second and crucial reason posed by Calderon (2009) and Loayza and Odawara (2010) is that addition to its ability to account for country-specific and unobserved time effects, SGMM can further handle endogeneity among explanatory variables. Literature has shown that there is endogeneity between infrastructure and economic growth, since theoretically, infrastructure promotes both productivity of existing resources and new created ones.[35] Thus, both output and productivity is affected positively with infrastructure. On the contrary, economic growth affects both demand and supply of infrastructure, leading possibly to overestimation of size of the impact of infrastructure on economic due to simultaneity bias if endogeneity is not accounted for (Esfahani and Ramirez, 2003). In the literature, there exists empirical evidence, which buttresses the theoretical feedback or bidirectional causality (simultaneity) between economic growth and infrastructure (see Eberts and Fogarty 1987; Perkins et al., 2005; Kularatne, 2006; Canning and Pedroni, 2008).

[35] For a details explanation and reason see Munnell (1992)

The third reason, as opposed to other estimation approaches like maximum likelihood, econometricians do not need to make strong distributional assumptions (Arellano and Bond 1991; Jogannathan et al., 2002; Hansen and West 2002; Arellano and Bover 1995). Fourth, econometric literature has proved that SGMM performs very well even in the case where included variables and residuals are conditionally heteroscedastic and serially correlated (see Hansen 1982; Arellano and Bond, 1991 Arellano and Bover (1995) and Blundell and Bond (1998), Roodman (2005). Fifth, SGMM estimators are quite efficient than other popular estimators like the two-stage least squares and Ordinary Least Squares (OLS) when auxiliary assumptions such as homoscedasticity fail (Woodridge, 2001). Sixth, although Difference GMM (DGMM) (Arellano and Bond, 1991) also have the five strengths listed, it has been theoretically proved by Arellano and Bover (1995) and Blundell and Bond (1998) that it is weaker than SGMM for the following reasons. 1) It yields inefficient estimates since it relies on lagged levels of variable which are poor instruments for first-difference equations. Therefore, the precisions of DGMM estimators are asymptotically weak. 2) In contrast, SGMM estimator eliminates this problem by using the lagged levels as instruments for first difference equations and the lagged first differences as instruments for level equations. Chakamera and Alagidede (2018) state that in econometrics, SGMM is among the most crucial and powerful advancement in the last 35 years but surprisingly with respect to its application, there is paucity usage in extant literature, particularly in the analysis of infrastructure growth nexus studies. In view of alluded strengths, we adopted the SGMM estimation technique.

4.4.3.2 The Empirical Model

Our empirical model section was in three parts. The three-tier approach was motivated by Calderon et al. (2018) proposition that the estimation of infrastructure-growth nexus must address three issues, namely, 1) multi-dimensionality of infrastructure at sectoral level, 2) increasing quantity and/or quality enhancement, though they omit enhancement of infrastructure accessibility and 3) amelioration of problem of endogeneity and reverse causality identified in the literature. First, we provided the empirical regression models which take both the linear and non-linear log-log form, whose parameters were taken as elasticities. Second, the models we used to construct aggregate infrastructure quality, quantity and access composite indices are given, together with other indices to measure quality human capital as well as institutional quality. Lastly, the approach we used to determine the optimal threshold of the effect of infrastructure, stock, quality, and access on economic growth will be provided.

We also provided a mechanism we used to determine whether our thresholds are maximum or minimum thresholds, that is, whether the effects of aggregate infrastructure stock, quality and access on SSA region's economic growth is U-or-inverted-U-shaped. Complementing the proposition by Calderon et al. (2018) our estimation, in addition to their three issues, made two additional contributions, which are 1) inclusion of the infrastructure access dimension above simply quantity and quality and 2) determination of optimal threshold of these three aspects of infrastructure to ascertain whether the impacts are U-or-inverted-U-shaped. The inclusion of the infrastructure accessibility aspect is crucial since it is directly linked and at the centre of the achievement of WHO's SDGs, and IMF and World Bank's fight of inequality towards inclusive growth objective especially in the case regions dominated by countries with lower income status like SSA, where such problems are more prevalent.

4.4.3.2.1 Empirical Regression Models

In light of the above motivations on use of SGMM estimation procedure and assertation by Greene (2012 and Baltagi (2013) that dynamic analyses are well suited for panel data, our empirical panel data model was specified as:

$$\ln \Delta G = \alpha \ln G_{i,t-1} + \beta_i' \ln F_{it} + \psi_i' \ln X_{it} + \theta_i + \sigma_t + \varepsilon_{i,t} \qquad (4.11a)$$

And alternatively,

$$\ln \Delta G = \alpha \ln G_{i,t-1} + \beta_i' \ln F_{it} + \phi_i' \ln^2 F_{it} + \psi_i' \ln X_{it} + \theta_i + \sigma_t + \varepsilon_{i,t} \qquad (4.11b)$$

where: G is GDP per capita, F is a vector of infrastructure variables, X is a vector of control variables, θ is unobserved country specific effect, ϕ is unobserved common factor, ε is white noise error term, i which ranges from 1 to 46 represent individual SSA country included in our sample and t represent time. Proxy of economic growth was derived as $\ln \Delta G_{it} = \ln\left(G_{it}/G_{i.t-1}\right) = \ln G_{it} - \ln G_{i,t-1}$. All variable used in the regressions are expressed in logarithms as reported in Table 4.1 except legal origin since it's a binary dummy variable. Infrastructure variables included are as described in Table 4.1. Aggregate infrastructure variables generated by PCA and included in our analysis are quantity measure (*lnQT*), quality *(lnQL*) and access *(lnAC)*. We used the squares of these three aggregate infrastructure measures which were used to derive the thresholds on which infrastructure impact economic growth. Furthermore, the interactions between these three aggregate infrastructure indicators were also utilized. The interactions generated provided the three high-breed aggregate infrastructure indicators, namely *lnHQA* (interaction between quantity and access), *lnHQQ* (interaction between quantity and quality) *lnHQQA* (interaction between quantity, quality and access), but their descriptions are not included in Table 4.1. The control variables used in this analysis are also reported in Table 4.1. The descriptive statistics of the variables and regression results from these models are presented in Tables 4.3, 4.4 and 4.8.

The inclusion of $G_{i,t-1}$ which makes the model dynamic as opposed to static adds more value and realism to our analyses by incorporating the momentum and inertia effects mostly accompanied by macroeconomic variables imitating business cycles for the respective included SSA economies. That is, positive (negative) economic growth in the previous year $(t-1)$ will trigger positive (negative) economic growth in the current year (t). Greene (2012) and Baltagi (2013) however argued that under such circumstances, static panel data model like fixed and random effects frameworks face a drawback that the error term ε and lagged dependent variable $G_{i,t-1}$ are usually correlated and this is more pronounced in the case of random effects model. Furthermore, endogeneity of the lagged dependent variable based on proofs and arguments given by Hansen and West (2002) might be caused by the presence of heterogeneity (country-specific effects). To counter this problem of correlation and endogeneity in the data as previously stated, we adopted a GMM approach that relies on instrumental variables, which was initially developed by Arellano and Bond (1991) and later modified by Arellano and Bover (1995) and Blundell and Bond (1998). The main reason being that extant literature has shown that for both soft and hard infrastructure there is endogeneity and reverse causality.[36] Arellano and Bond (1991) suggested that endogeneity among explanatory variables can be controlled using appropriate lags of the explanatory variables as valid instruments. Like Calderon et al. (2018), SGMM which is more robust as opposed to DGMM whose estimators are asymptotically weak, we used both internal

[36] see for example Eberts and Fogarty 1987; Perkins et al., 2005; Kularatne, 2006

and external instruments. As internal instruments to avoid weak estimators like the once produced by DGMM, we used in differences the lagged level of regressors as well as in levels, the lagged differences of regressors. In addition to internal instruments (that is, lagged levels and differences of the regressors), we also used demographic and geographic variables as external instruments. Our internal and external instruments were validated by two crucial tests namely first order residual autocorrelation (Arellano and Bond (AB), 1991) and overidentifying restriction test (Hansen and difference-Sargan tests). From these two crucial specification tests, non-rejection of the null hypotheses that there is no higher-order serial correlation of residuals in differences and that instruments and residuals are uncorrelated, validate the model making estimators from SGMM consistent and asymptotically strong (both asymptotically unbiased and consistent). Econometric literature has shown that in small samples though with slight downward bias, estimators of two-step SGMM are more asymptotically efficient and consistent than those of one-step. The bias arises because the approximation to the asymptotic standard errors does not account for the extra small-sample variation due to the use of estimated parameters in constructing the efficient weighting matrix. But the bias of the two-step SGMM estimators disappears as the sample size or the number of observations increases (that is, as either N or T or both tends to infinite) like our case where N=46 and T=18. To carter for this bias problem of SGMM estimators in small samples we adopted the correction method as proposed by Windmeijer (2005). The SGMM and model specification test results are reported in Table 4.8.

4.4.3.2.2 Aggregate Infrastructure Indices Generation

We employed PCA approach to generate three synthetic infrastructure measures captured by *F* in the regression models 4.*11a* and 4.*11b*, that is, quantity (lnQT), quality (lnQL) and access (lnAC) by taking their first principal components (PC1). The variables that make these aggregate measures are as reported in Table 4.1. We also used the same approach to generate two additional components for institutional quality (lnIQ) and quality of human capital (lnSF), which are part of control variables captured by *X* in both model *4.11a* and *4.11b*. Based on the generic PCA model 4.1, the weights (eigenvectors) of the respective specific variables we used to generate the three aggregate infrastructure measures as reported in Table 4.1 are:

$$\ln QT = 0.8824\ln QT_1 + 0.2868\ln QT_2 + 0.4324\ln QT_3 + 0.4962\ln QT_4 + 0.5282\ln QT_5 + 0.6270\ln QT_6 \quad (4.12)$$

$$\ln QL = 0.7964\ln QL_1 + 0.5695\ln \Delta QL_2 + 0.4473\ln \Delta QL + 0.7270\ln QL_3 + 0.5244\ln QL_4 + 0.3389\ln QL_5 \quad (4.13)$$

$$\ln AC = 0.8317\ln AC_1 + 0.7409\ln AC_2 + 0.5276\ln AC_3 + 0.4892\ln AC_4 + 0.4989\ln AC_5 \quad (4.14)$$

$$\ln IQ = 0.3944\ln VA + 0.3333\ln PS + 0.4815\ln GE + 0.4618\ln RQ + 0.4571\ln RL + 0.5425\ln CC \quad (4.15)$$

$$\ln SF = 0.6741\ln SF_1 + 0.6507\ln SF_2 + 0.5495\ln SF_3 \quad (4.16)$$

where: variables in equations 4.12 – 4.14 are as defined in Table 4.1. Following Chakamera and Alagidede (2018), access to improved drinking water and sanitation facilities appears in both aggregate quality and access infrastructure measure, but with different values due to different treatment. The quality measures in equation 4.13 apply logarithms on growth rate or changes in access whereas accessibility measures given in equation 4.14 use logarithms of relative figures.

That is, from equation 4.13 $\ln \Delta QL_{it} = \ln\left(QL_{it}/QL_{i,t-1}\right) = \ln QL_{it} - \ln QL_{i,t-1}$. Chakamera and Alagidede (2018) argued that positive (negative) values of $\ln \Delta QL$ show increasing (decreasing) quality of water and sanitation infrastructure. The variables used to construct the aggregate institutional quality index in equation 4.15 are voice and accountability *(VA)*, Political Stability *(PS)*, Government Effectiveness *(GE)*, Regulatory Quality *(RQ)*, Rule of Law *(RL)* and Control of Corruption *(CC).* Equation 4.16 are measures of aggregate soft infrastructure based on human capital theory (Becker, 1962; Rosen, 1976) using variables such as government health expenditure per capita (SF1), private health expenditure per capita (SF2) and secondary enrolment (SF3). Becker (1962, 1997, 2007) and Rosen (1976), argued that quality of human capital drives growth via increases in factor productivity when individual workers improve their wellness and abilities or skills, which they can accumulate through training and education.

Table 4.1: Definition of variables, Measurement Scales and Sources

Variable	Definition	Source
	Dependent Variable	
lnG	Log GDP per capita which measures economic output of a country considering the midyear population changes	World Bank, World Development indicators (WDI)
	Infrastructure Quantity (lnQT) (Principal Component Analysis (PC1)	
lnQT1	Log of electricity net production in million kilowatt-hours	Energy Information agency
lnQT2	Log of fixed telephone line per 100 people	International telecommunication Union
lnQT3	Log of mobile Cellular subscriptions per 100 people	World Bank, WDI
lnQT4	Log of proportion of populations using internet	World Bank, WDI
lnQT5	Log of fixed broadband per 100 people	World Bank, WDI
lnQT6	Log of length of road network in kilometers	International Road Federation
	Infrastructure Quality (lnQL) (Principal Component Analysis (PC1))	
lnQL1	Log of electricity losses in million kilowatt-hours	Energy Information agency
ln∆QL2	Log of % change in population proportion with improved water	WHO, UNICEF
ln∆QL3	Log of % change in population proportion with improved sanitation	WHO, UNICEF
lnQL4	Log of paved road network as a percentage of total road network	International Road Federation
lnQL5	Log of mobile quality scores (score/100) (Ibrahim Index)	Mo Ibrahim Foundation
lnQL6	Log of fixed telephone faults per 100 fixed telephone lines	International telecommunication Union
	Infrastructure Access (lnAC) (Principal Component Analysis (PC1))	
lnAC1	Log of people with access to electricity (% of population)	World Bank, WDI
lnAC2	Log of people with access to improved drinking water (% of total population)	WHO, UNICEF
lnAC3	Log of people with access to improved sanitation facilities (% of total population)	WHO, UNICEF
lnAC4	Log of people with access to fixed telephone lines (% of total population)	International telecommunication Union
lnAC5	Log of people with access to internet (% of total population)	World Bank, WDI
	Control Variables	
lnLG	Log of first lag of GDP per capita which measures economic output of a country considering the midyear population changes	World Bank, WDI
lnSF	Log of aggregate soft infrastructure (Human capital development) (PC1)	World Bank, WDI
LO	Legal origin	
lnTOT	Log of terms of trade	World Bank, WDI
lnIQ	Log of aggregate institutional quality (PC1: World Governance Indicators (WGI))	World Bank, WGI
lnGE	Log of government expenditure (% of GDP) measuring government burden	World Bank, WDI
lnFD	Log of credit to the private sector (% of GDP) (measuring financial development)	World Bank, WDI
lnTOP	Log of trade openness (export and imports as % of GDP)	World Bank, WDI
lnCPI	Log of consumer price index (measuring price stability)	World Bank, WDI
lnPOP	Log of population in millions of people	World Bank, WDI

4.4.3.3 Determination of infrastructure Threshold Analysis

One of the primary objectives of this study was to determine a threshold at which infrastructure quantity, quality and access begins to have positive or detrimental effects on economic growth of 46 SSA countries. This will afford us with a chance of being able to determine whether infrastructure quantity, quality and access have a linear or non-linear impact on economic growth. If its non-linear, it will be more useful for academicians and policymakers to ascertain the nature of the curve-linear relationship, that is, is it a U-or-inverted-U-shaped. It will also be equally important to ascertaining the optimum threshold level and determine whether it's a maxima or minima. To determine the threshold equation, we differentiated the growth equation 4.2b with respect to relevant infrastructure dimension captured by the vector of infrastructure variables (F^2) and take its antilog since it's a log-log model. That is:

$$\frac{\partial(\ln \Delta G)}{\partial(\ln F)} = \frac{\partial\left(\alpha \ln G_{i,t-1} + \beta_i^{'} \ln F_{it} \quad {}_i^{'} \quad F_{it} \quad + \phi_i \ln \quad {}_{it}^{2} + \theta_i + \psi_i + \ln X_t\right)}{\partial(\ln F)} = 0 \qquad \sigma$$

$$\beta + 2\phi \ln F = 0$$

$$\ln F = \frac{\beta}{2\phi}$$

$$F = e^{\frac{\beta}{2\phi}} \qquad (4.17)$$

where F is the respective infrastructure dimension being considered that is infrastructure quantity or quality or access. For robustness purposes only, the Hansen (1999) fixed effect threshold analysis was also performed exclusive to determining the number and log values of thresholds, assuming a static state but the regression results of such a model are not going to be reported. The reasons for not reporting the OLS and maximum likelihood (MLE) (fixed and random effects) estimation regression results and using them for analysis is the inappropriateness of their assumptions given the existence of endogeneity and reverse causality between infrastructure and economic growth given in the methodology and literature review section. The threshold values provided by the Hansen procedure will enables us to determine the size of the bias encountered when one, regardless of the problems accompanied by using static models like OLS, instrumental variables two or three stage least square or MLE in the presence of endogeneity and reverse causality. The next section looks at results presentation and their analysis.

4.5 Empirical Results

In this section, we analyse the results estimated using the models 4.11a and 4.11b. We start by looking at descriptive statistics of variables used in regression analyses based on models 411a and 4.11b, followed by those of variables employed in PCA models 4.12 – 4.16 when generating aggregate infrastructure (soft and hard) and institutions. Eigenvalues for PCA are also presented and analysed (see Appendices A4 and B4). Second, we report diagnostic tests, namely panel unit root and model specification test. Lastly, we present the regression results assuming both a linear and non-linear relationship based on model 4.11a and 4.11b and determining the thresholds of infrastructure quantity, quality and access on economic growth using the dynamic SGMM approach.

4.5.1 Principal Component Analysis (PCA)

We employed PCA to aggregate infrastructure quantity, quality and access based on different dimensions of infrastructures as given in Table 4.1. PCA was also used to derive aggregate soft infrastructure (quality of human capital) and institutional quality. We transformed all dimensions of infrastructure measures, human development and institutional quality to logarithms and standardized their means to zero to reduce biasness and distortions due to presence of outliers. The results are reported in Table 4.2. Panels A, B and C show the three main PCAs undertaken in order to construct the aggregate infrastructure quantity (stock), quality and access, respectively. Panels D and E show the PCAs for human capital development and institutional quality, respectively, which where both referred to as soft infrastructure by Kingombe (2014). Human capital development combines education and health (both public and private expenditure per capita) dimensions which in light of Becker (1962, 1997, 2007) and Rosen (1976), captures the quality aspect of human capital. Institutional quality combines information on each country's six worldwide governance indicators namely, voice and accountability, political stability, government effectiveness, regulatory quality, rule of law and control of corruption. To determine the principal components, we used the two guidelines as stated in section 4.3.2. Thus, in Table 4.1, we only selected the first principal components (PC1). PC1 is always associated with the largest eigenvalue and proportion of variance and therefore we retain them. The logic being that only PC1 for hard infrastructure (quantity, quality and access) and soft infrastructure (human capital development and institutional quality) explains or captures more than 50% and has eigenvalues greater than their respective averages. In Table 4.2, the minimum information captured is 66%, with the highest being 78% in respect of infrastructure stock and institutional quality, respectively. Therefore, the guidelines recommend that only the PC1s should be retained since they provide and capture adequate information.

Table 4.2: Eigenvalues for First Principal Components (PC1)

Variable	Eigenvalue	Component	Cumulative
Panel A: Infrastructure Quantity			
PC1	2.473	0.6569	0.6569
Panel B: Infrastructure Quality			
PC1	2.2103	0.7368	0.7368
Panel C: Infrastructure Access			
PC1	3.2216	0.6768	0.6768
Panel D: Soft Infrastructure (human development)			
PC1	2.7606	0.6901	0.6901
Panel E: Institutional Quality			
PC1	4.6618	0.777	0.777

Source: Own Computation

Complementing Table 4.2 are the eigenvectors (loadings) used in generation of these five (5) aggregate components as presented in equations 4.12 – 4.16 where all the eigenvectors of respective PC1s are positive and above 0.3, with electricity leading throughout. Based on eigenvectors, interestingly electricity dominates in the aggregate infrastructure quantity, quality and access with weights of 0.88, 0.80 and 0.83, respectively. Electricity becomes the key driving factor in all PC1s for infrastructure stock, quality and accessibility. The screen plots of PC1s of these five aggregate hard and soft infrastructure indices are graphically reported in Appendix B4.

4.5.2 Descriptive Statistics

The descriptive statistics of variables used for regression analysis are presented in Table 4.3 whereas the ones we used in PCA to generate aggregate soft and hard infrastructure measures are in Table 4.4. Due to standardization, the averages of all our aggregate infrastructure, human capital development and institutional quality measures in Table 4.3 generated by PCA are zero. Institutional quality and infrastructure quality indices have highest and lowest variation shown by their corresponding standard deviations of 2.159 and 1.215. This confirms the arguments and evidence in the extant literature that the state of SSA countries' infrastructure is almost similar, serve for two countries namely South Africa and Mauritius (Bogetic and Fedderke, 2006a, b;

Chakamera and Alagidede, 2018; AfDB, 2018; Calderon et al., 2018) but in contrast the quality of their institutions diverges and are highly volatile (EIU, 2015; World Bank, 2019).

In Table 4.4, summary statistics for variables used for generation of infrastructure quantity (lnQT) and quality (lnQL), electricity was found to have the highest mean and vary much across countries in the SSA region, with averages and standard deviations of 6.878(5.15) and 1.893(1.848), respectively. Surprising, despite weights of both net electricity production (lnQT1) and losses, (lnQT2) are highest within lnQT and lnQL but its access (lnAC1) within lnAC is very low. This acts as an indication that though electricity production (quantity) across the SSA region seems to be high, its quality is hindered by huge leakages as indicated by high losses, which justify its very low accessibility by the region's inhabitants as also confirmed by 30 SSA countries witnessing chronic blackouts (Bogetic and Fedderke, 2006a, b; Chakamera and Alagidede, 2018; AfDB, 2018; Calderon et al., 2018). This observation and evidence in the literature motivated us to include interaction terms of infrastructure quantity, quality and access (lnHQQA), quantity and quality (lnHQQ) and lastly quantity and access (lnHQA) in our infrastructure-growth nexus modelling.

Table 4.3: Descriptive Statistics of Regression Variables

Variable	Observations	Mean	Standard Deviation	Minimum	Maximum
lnQT (PC1)	633	0	1.68	-4.808	4.062
lnQT – squared	633	2.811	3.698	0	23.117
lnQL (PC1)	633	0	1.215	-3.712	2.63
lnQL – Squared	633	1.473	2.721	0	13.78
lnAC (PC1)	633	0	1.568	-4.695	4.236
lnAC – Squared	633	2.455	3.262	0	22.04
lnHQA	633	1.889	2.614	-2.14	13.642
lnHQQ	633	-1.209	2.249	-11.622	2.495
lnHQQA	633	-1.373	7.212	-48.73	12.218
lnLG	633	0.019	0.05	-0.455	0.45
lnSF (PC1)	633	0	1.551	-4.712	1.783
LO	633	2.087	1.531	0	7
lnTOT	633	-0.34	0.595	-2.821	1.398
lnIQ	633	0	2.159	-7.044	21.565
lnGE	633	4.685	0.175	3.917	5.566
lnFD (PC1)	633	2.622	0.914	-0.91	7.85
lnTOP	633	-0.462	0.571	-3.307	0.888
lnCPI	633	1.635	1.102	-3.305	6.242
lnPOP	633	15.751	1.607	11.304	19.093

First, this provides us with the chance to evaluate whether infrastructure quality and access aspects have a complementarity or substitutability relationship with quantity dimension of infrastructure when affecting growth. Second, this also enables us to determine which combination between quantity-access or quantity-quality or quantity-quality-access has the highest transmission mechanism towards boosting the SSA region's growth. Therefore, HQQA, HQQ and HQA are high-breed infrastructure interaction terms in logarithms. Among them, lnQA has a positive and highest average and lnHQQA has a negative and least mean in logs of 1.889 and -1.373 while on variation, lnHQQA and lnQQ has the highest and least standard deviation of 7.212 and 2.229, respectively. In relation to infrastructure-squared values, lnQL-squared and lnQT-squared has the least and highest average (standard deviation) of 1.472 (2.721) and 2.811 (3.698), respectively. In terms of the control variables, lnPOP (lnTOP) has the largest (smallest) mean of 15.751 (-0.462) whereas on variation, lnIQ (lnGE) has the highest (least) standard deviation of 2.159 (0.175), respectively.

Table 4.4: Descriptive Statistics of Variables used for Principal Component Analyses

Variable	Observations	Mean	Standard Deviation	Minimum	Maximum
	Aggregate Infrastructure Quantity Index				
lnQT1	633	6.878	1.893	3.076	12.423
lnQT2	633	0.06	1.444	-4.605	3.534
lnQT3	633	2.954	1.782	-3.912	5.217
lnQT4	633	1.038	1.746	-4.605	4.127
lnQT5	633	-1.816	2.01	-4.605	3.786
lnQT6	633	4.196	0.242	3.364	4.604
	Aggregate Infrastructure Quality Index				
lnQL1	633	5.15	1.848	0	10.105
lnΔQL2	633	-4.095	0.819	-7.609	-2.159
lnΔQL3	633	-3.963	1.137	-8.645	-1.174
lnQL4	633	2.964	0.829	0.405	4.605
lnQL5	633	0.771	0.149	0.241	1.166
lnQL6	633	1.609	1.534	-2.378	3.675
	Aggregate Infrastructure Access Index				
lnAC1	633	3.322	0.832	0.607	4.605
lnAC2	633	4.32	0.542	3.178	7.609
lnAC3	633	3.714	0.548	1.797	4.6
lnAC4	633	3.273	0.631	1.887	4.589
lnAC5	633	1.038	1.746	-4.605	4.127
	Aggregate Soft Infrastructure Index				
lnSF1		2.601	1.435	-1.694	6.351
lnSF2		3.015	1.066	0.355	5.729
lnSF3		1.597	1.564	-1.609	1.03
	Aggregate Institutional Quality Index				
lnVA	633	-1.03	0.488	-2.919	2.857
lnPS	633	-1.051	0.688	-6.215	3.006
lnGE	633	-1.095	0.396	-2.087	2.823
lnRQ	633	-1.075	0.451	-2.957	2.754
lnRL	633	-1.063	0.402	-2.323	2.913
lnCC	633	-1.02	0.372	-2.01	2.744

4.5.3 Stationarity Test

The panel unit root tests are reported in Table 4.5 whereas all other model specification tests, which unlike the stationarity test which is variable specific are presented as per model in Table 4.7. Given the balance nature of our panel data, Baltagi (2013) recommended the use of two suitable stationarity tests which are Im, Pesaran and Shin (IPS) (2003) and Augmented Dickey and Fuller (ADF) or Phillips and Perron (PP) Fisher (Choi, 2001) test approaches since they assume variability across panels and test the individual unit root process. Through the application of these two panel stationarity tests, we ensured robustness of our results. In light of this, we adopted the IPS and ADF-Fisher unit root tests. These two tests are based on the null and hypothesis that all panel are non-stationary against the alternative that at least one panel is stationary.

Table 4.5: Results for Panel Unit Root Tests

	Im, Pesaran and Shin (IPS)		ADF-Fisher (ADF)	
Variable	Level	First Difference	Level	First Difference
lnQT	-2.0568**	-15.0661***	11.0082***	10.3179***
lnQL	-2.3707***	-12.424***	14.4775***	16.2619***
lnAC	-1.2571	-14.2700***	7.8622***	14.5395***
lnHQA	-3.0005***	-9.6858***	8.8726***	24.1802***
lnHQQ	-0.1557	-2.8016***	1.5422*	8.4083***
lnHQQA	-8.0520***	-22.0167***	3.4845***	12.4233***
lnLG	-14.2044***	-34.6554***	10.9655***	43.167***
lnSF	-4.767***	-20.282***	11.149***	50.428***
LO	-17.4398***	-37.2502***	15.1455***	43.8689***
lnTOT	-4.8026***	-24.3091***	16.6222***	31.166***
lnIQ	-3.5491***	-20.8785***	12.8429***	23.1024***
lnGE	-2.1459**	-21.0508***	3.0255***	15.3895***
lnFD	-1.3887*	-16.1649***	3.1010***	38.0205***
lnTOP	-6.4648***	-24.0144***	14.6504***	76.1165***
lnCPI	-9.913***	-26.4536***	20.5004***	49.8494***
lnPOP	2.454	-16.820**	22.187***	12.229***

Note: *** p<0.01, ** p<0.05, * p<0.1. For uniformity, we used lag zero include trend for all the test.

To guarantee consistence in our unit root tests, we allowed for time trend for all test equations since we observed that the data was trending upwards over time and used lag zero. From the results reported in Table 4.5, we find that, except for lnAC, lnHQQ and lnPOP (only in the case of IPS) there is consistent stationarity at level. In addition, all series are stationary in first difference across all the two testing models. Some few variables are found to be stationary in levels. These stationarity tests confirm the suitability of our use of a dynamic model (SGMM) (Greene, 2012).

4.5.4 Presentation and Analyses of key findings

The Hansen (1999) threshold test results in Table 4.6 do not reject the null hypothesis that there is a single threshold in the case of institutional stock (quantity) and access whereas only in the case of infrastructure quality the test support linearity since it rejects non-linearity in favour of a linear effect on economic growth. These static results are also confirmed by the dynamic model results reported in Table 4.8 where aggregate infrastructure quantity and access have a statistically significant U-shaped non-linear effects on economic growth, since their linear and squared coefficients are statistically significant. Though infrastructure quality shows an inverted U-shaped relationship with growth, the negative coefficient of its squared coefficient is statistically insignificant confirming a linear effect. Given that our SGMM model takes a log-log form, by applying the approach stated in equation 4.17, from result reported in model 5 of Table 4.8, we find respective optimum thresholds of infrastructure quantity, access and quality to be 59.64%, 70.82% and 47.39%. Thus, SSA infrastructure can positively affect its regional growth if its infrastructure stock financing is at least 60% of its infrastructure stock requirements and around 71% of its inhabitants have access to such infrastructure especially electricity which have the highest weights in PCA models 4.12 – 4.14 and improved as well as reliable water based on equation 4.14.

Table 4.6: Hansen (1999) Static Threshold Test (Fixed-Effect Panel Threshold Model)

Threshold	Sum of Squared Residuals	Mean Square Error	F-statistic	Probability value
Aggregate Infrastructure Quantity (Stock) Index				
Single	2.8782	0.0053	23.5765	0.0078
Double	2.7551	0.0034	4.8065	0.6758
Aggregate Infrastructure Quality Index				
Single	3.2351	0.0418	6.5765	0.4833
Double	3.1456	0.0452	3.65	0.8126
Aggregate Infrastructure Access Index				
Single	1.4762	0.0097	28.9054	0.0049
Double	1.3743	0.0154	7.5632	0.3712

According to report by Oxford Economics (2018), if the SSA region, which constitutes the greater part of Africa operates at its full potential capacity or at par with other continents of the world, its infrastructure needs are approximately $6 trillion ($240 billion per year). Furthermore, in 2018, AfDB approximated SSA's immediate infrastructure requirement based on its current (actual) production level to be between \$130 – 170 billion per year, with a financing gap ranging between \$68 and \$108 billion. Therefore, the possible reason for Africa lagging behind might be its infrastructure stock which is much below the minimum required threshold level of around 60% of its requirement and accessibility rates of infrastructure services of less 71% of the region's inhabitants, especially of electricity, roads and reliable safe drinking water. Evidence of infrastructure quantity, quality and access for SSA countries reported by Bogetic and Fedderke, (2006a, b) are far much lower than the minimum threshold we find to stimulates growth of the SSA region[37]. Our evidence supports arguments raised in the literature that inadequate amount of infrastructure coupled by its poor quality and inaccessibility and/or unavailability causes the SSA region to incur higher opportunity costs in terms of forgone regional economic growth (Bogetic and Fedderke, 2006a, b; Chakamera and Alagidede, 2018; AfDB, 2018; Calderoni et al., 2018). This has directly and indirectly negatively affected human welfare via access and quality of basic service like electricity, water and sanitation, worsening health and human capital accumulation outcomes (Leipziger et al. 2003; Bogetic and Fedderke, 2006a, b) which further negate inclusive growth.

Table 4.7: Hansen Infrastructure Threshold Estimates at 95% Confidence Level

Variable	Threshold	Lower Bound	Upper Bound
Infrastructure Quantity	3.6344	3.3321	3.9468
Infrastructure Quality	2.9897	2.7412	3.2468
Infrastructure Access	3.8738	3.5515	4.2068

The Hansen (1999) fixed effect threshold model estimates and their upper and lower bounds in logarithms are reported in Table 4.7. Taking the antilogarithms of the values in Table 4.7 gave the relative values of the thresholds (lower and upper bounds) of infrastructure quantity, quality and access of 38% (28% and 52%), 20% (16% and 28%) and 45% (35% and 67%). All the values of threshold estimated from the static (Hansen fixed effects) model are lower than those from the dynamic SGMM model. This confirms arguments raised in literature that the use of static models to assess the thresholds estimates of the infrastructure-growth nexus yields

[37] For a more detailed analysis of specific components of SSA infrastructure quantity, quality and access such as electricity, transportation, water and sanitation, telecommunication see Bogetic and Fedderke (2006a, b) and Calderon et al. (2018)

inconsistent and asymptotically biased and inefficient estimators due to presence of endogeneity and reverse causality between infrastructure and growth (see for example, Eberts and Fogarty 1987; Munnell, 1992; Perkins et al., 2005; Kularatne, 2006; Seethepalli et al., 2008; Canning and Pedroni, 2008). This is also in support of econometric proofs that use estimation method such as OLS, MLE, IV, 2SLS or 3SLS in the presence of endogeneity or reverse causality cause estimator obtained to lose their large sample properties of good estimators, namely consistency, asymptotically unbiasedness and efficiency (see Hansen 1982; Arellano and Bond, 1991; Arellano and Bover, 1995; Blundell and Bond, 1998; Greene, 2012; Baltagi, 2013).

Results for models 1 – 3 in Table 4.8 show that the SSA region's economic growth has an inelastic response to infrastructure quantity, quality and access separately, where a unit increase in respective infrastructure raises growth by 45%, 23% and 36%. These growth rates change marginally though in different direction depending on the infrastructure measure, when the three are combined in a linear fashion in model 4. Of much interest is the interactive effect in logs of infrastructure quantity with access (HQA), quantity with quality (HQQ) and quantity with both quality and access (HQQA) reported in model 6, 7 and 8, respectively. They indicate the interaction terms positively drive economic growth more than individual effects. The impact of a unit increases in lnHQA, lnHQQ and lnHQQA raises economic growth of SSA countries by 49%, 58% and 68%, respectively. This shows that combining all the aspects of infrastructure provides the most desirable results for the SSA region, thus the conspicuous omission of the access dimension of infrastructure by most studies in literature underestimates the true economic growth benefits of infrastructure. Our results confirm the argument in literature that reduction in the growth trajectory of the SSA region in recent years is an epitome of a combination of inadequate proportions of infrastructure coupled by poor quality and inaccessibility of infrastructure services by the region's inhabitants, particularly electricity, water and road networks (Calderon et al., 2018; AfDB, 2018, World Bank, 2018).

Table 4.8: Infrastructure-Growth Nexus Dynamic Regression Results

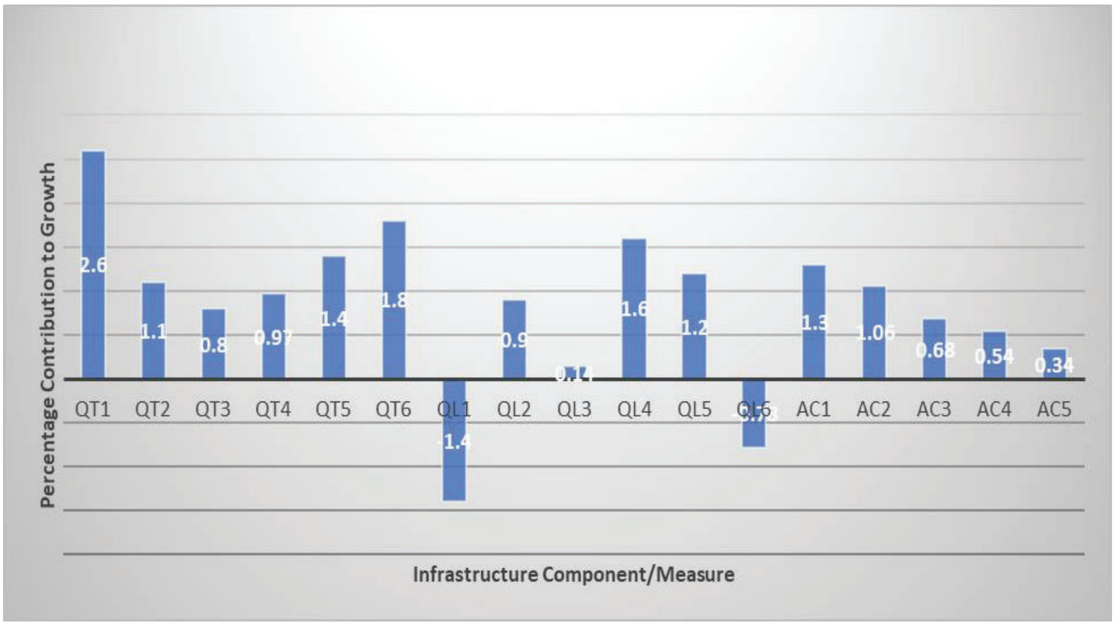
Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Aggregate Infrastructure Development and Access Indicators from Principal Component Analysis								
lnQT	0.4518***			0.3972***	-0.1758**			
	(0 .1171)			(0.0644)	(0.0789)			
lnQT – squared					0.0215***			
					(0.0112)			
lnQL		0.2295**		0.3282**	0.1853***			
		(0.103)		(0.161)	(0.0602)			
lnQL – squared					-0.01518			
					(0.0869)			
lnAC			0.3592***	0.2726**	-0.0835**			
			(0.1096)	(0.126)	(0.0411)			
lnAC – squared					0.0098***			
					(0.0023)			
lnHQA						0.4876***		
						(0.07638)		
lnHQQ							0.5756**	
							(0.2563)	
lnHQQA								0.6455***
								(0.1798)
Regression Control Variables								
1st Lag lnG	0.1812***	0.0502***	0.646	0.0982***	0.1131***	0.1011**	0.0749***	0.1749***
	(0.014)	(0.0159)	(0.466)	(0 .0312)	(0.0334)	(0.0484)	(0.0218)	(0.05863)
lnSF	0.5351**	0.2625***	0.5131***	0.1453***	0.1570**	0.3426**	0.4219***	0.3367***
	(0.2413)	(0.0729)	(0.2331)	(0.0312)	(0.0623)	(0.1461)	(0.1221)	(0.5573)
LO	-0.2369***	-0.2837**	-0.3664**	-0.2641**	-0.1487**	-0.2452**	-0.1934**	-0.3156
	(0.0698)	(0.1175)	(0.1558)	(0.1083)	(0.05966	(0.1126)	(0.07981)	(0.1306)
lnTOT	0.2071**	0.1765**	0.2049***	0.0869**	0.1871**	0.1232**	0.2543***	0.1567***
	(0.1014)	(0.0861)	(0.0706)	(0.037)	(0.0864)	(0.0554)	(0.0674)	(0.03263)
lnIQ	0.3377***	0.4376***	0.283***	0.5384***	0.3493***	0.2972***	0.4459**	0.3192***
	(0.07233)	(0.0807)	(0.0371)	(0.0631)	(0.0373)	(0.1503)	(0.1968)	(0.06954)
lnGE	-0.7723*	-0.6502**	-0.6257***	-0.2529*	-0.588***	-0.554***	-0.593**	-0.5965**
	(0.3975)	(0.3232)	(0.144)	(0.141)	(0.1407)	(0.1979)	(0.2001)	(0.2754)
lnFD	0.4131**	0.6408	0.1078	0.6591***	0.6884***	0.4322***	0.5685***	0.3565**
	(0.1645)	(0.8231)	(0.0831)	(0.0412)	(0.07132)	(0.14647)	(0.1005)	(0.1513)
lnTOP	0.0289**	0.08567	0.0504	0.0551*	0.1087**	0.1837	0.05833	0.04152
	(0.0136)	(0.3319)	(0.0631)	(0.0321)	(0.04761)	(0.2223)	(0.1052)	(0.0326)
lnCPI	-0.0152**	-0.0246**	-0.1264*	-0.0657**	-0.1123**	0.0896***	-0.0345**	-0.0956**
	(0.0068)	(0.0122)	(0.0648)	(0.0329)	(0.0462)	(0.0141)	(0.0159)	(0.04113)
lnPOP	0.0152***	0.0367**	0.0032**	0.1134***	0.1543***	0.0845**	0.1064***	0.1298**
	(0.0024)	(0.0185)	(0.0015)	(0.0321)	(0.0239)	(0.0419)	(0.0157)	(0.0652)
Constant	3.1158***	2.4751**	3.1420***	9.659**	2.9104***	2.2762**	3.637**	5.785**
	(0.7563)	(1.2116)	(0.769)	(4.838)	(0.6902)	(0.9955)	(1.6869)	(2.8482)
Observations	633	633	633	633	633	633	633	633
Countries	46	46	46	46	46	46	46	46
Specification Tests (p-values)								
AB 1st order Autocorrelation	(<0.001)	(<0.001)	(<0.001)	(<0.001)	(<0.001)	(<0.001)	(<0.001)	(<0.001)
AB 2nd order Autocorrelation	(0.306)	(0.311)	(0.231)	(0.181)	(0.111)	(0.141)	(0.336)	(0.317)
Hansen J-test	(0.593)	(0.498)	(0.409)	(0.565)	(0.528)	(0.573)	(0.416)	(0.464)
Difference-Sargan Tests[38]	(0.536)	(0.445)	(0.516)	(0.634)	(0.631)	(0.676)	(0.664)	(0.601)
F-statistic	(<0.001)	(<0.001)	(<0.001)	(<0.001)	(<0.001)	(<0.001)	(<0.001)	(<0.001)

Note: *** p<0.01, ** p<0.05, * p<0.1, denotes statistical significance at the 1%, 5% and10% levels, respectively. In parentheses are cluster robust standard errors computed as recommended by Windmeijer (2005) using small-Sample correction based to twostep System Generalized methods of Moments. We include country effects and time effects dummies. AB represents Arellano and Bond (1991) model specification test for autocorrelation.

[38] The difference-Sargan test was for the validation of all instruments for level equations.

To evaluate the economic growth benefits of closing the SSA region's infrastructure gap relative to the word average benchmark of each infrastructure sector, we followed the procedure done by Calderon and Serven (2010) and Calderon et al. (2018). Figure 4.3 depicts the sizes of the economic growth benefits of each component of infrastructure quantity, quality and access of closing the gap in terms of quantity and quality of infrastructure relative to the median of the world (excluding SSA) for each infrastructure sector. For instance, growth per capita for the SSA region would increase by 14.25% per annum if it were to close the gap with the regional median of each infrastructure indicator. Narrowing the quantity infrastructure gap would deliver higher growth per capita by 8.67% per year, followed by increasing infrastructure accessibility of inhabitants which boosts growth by 3.92% per annum and lastly catching up in terms of quality will raise growth by 1.66% per year. The contribution of infrastructure stock, quality and access to the total growth per capita of 14.25% is presented by the pie chart in Figure 4.4. Though our findings are higher, these results support evidence found by Calderon et al. (2018) that closing the SSA region's infrastructure gap relative to the world average benchmark will raise regional growth by 1.7%, quantity and quality contributing 1.2% and 0.5% per annum, respectively.

Figure 4.3: Growth Benefits of Narrowing the Gap visa vis World Median in Infrastructure (% per year)

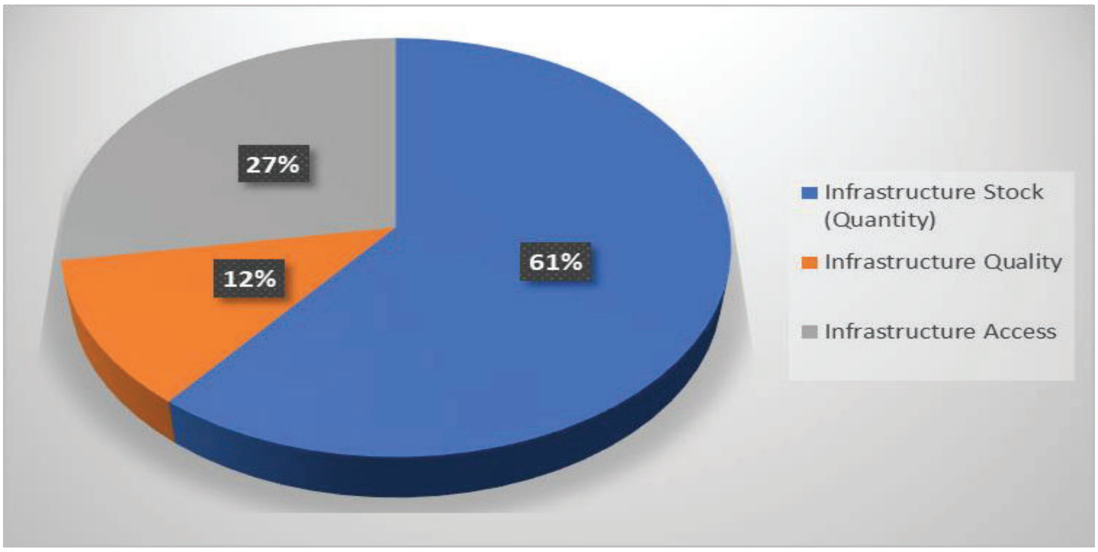


Note: The coefficient estimates are taken from Model 5 of Table 4.7 (Calderon and Serven 2010, Calderon et at., 2018)

Disentangling infrastructure quantity (QT), from Figure 4.3, we observed that the largest growth benefits are obtained by narrowing the gap in electric power (QT1), which will raise growth of

SSA region higher by 2.6%, followed by road networks, which will increase it further by 1.8% per year. In terms of quality, improving road quality, reduction of electric power losses, and improving mobile quality provides the largest first, second and third benefits to regional growth of 1.6%, 1.4% and 1.2%, respectively. Finally, on the accessibility of infrastructure services, the growth benefits of reducing the infrastructure gap in electricity and reliable water access which drive regional growth higher by 1.3% and 1.06% per annum, respectively. Our observation that electricity and road quality contribute more to the impact of infrastructure quantity and quality also support Calderon et al.'s (2018) evidence but ours goes an extra mile by showing that accessibility of electricity and water have an even much higher economic growth benefit than quality. Thus, the omission of the accessibility dimension normally plagued by studies in the existing body of knowledge might have led to omission variable bias, which might have compromised their estimators posing a possible danger on the reliability of results and policies from such results.

Figure 4.4: Infrastructure Components Contribution to total growth benefit through narrowing the Gap



4.6. Conclusion

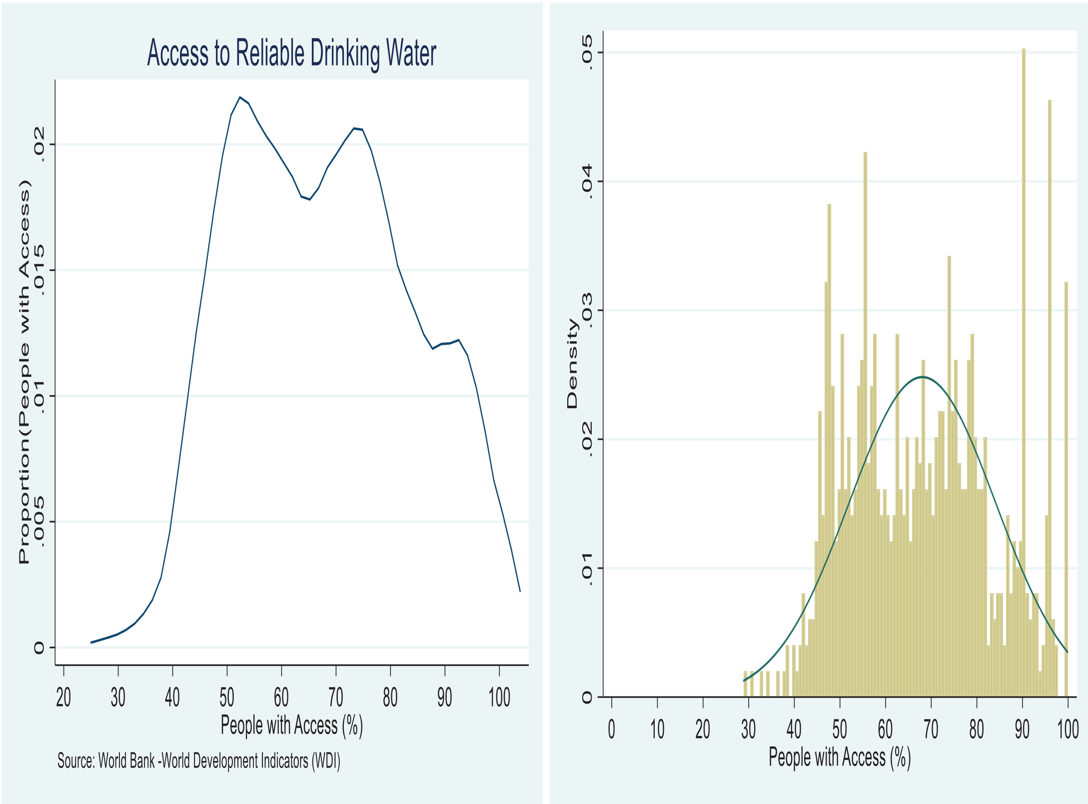
The main aim of the study was in five fold. First, to examine whether aggregate infrastructure quantity, quality and access positively or negatively affects economic growth of SSA countries. Second, to evaluate if aggregate infrastructure quantity, quality and access affects economic growth of the SSA region in a linear or non-linear fashion. Third, to find the optimal thresholds levels of aggregate infrastructure quantity, quality and accessibility. Fourth, to ascertain whether the aggregate infrastructure quantity, quality and access thresholds are maxima or minima. Lastly, to determine whether the three dimensions of infrastructure act as complements or substitutes when driving growth of SSA countries.

On the first objective we observed that the infrastructure quantity, quality and access have positive effect on economic growth of the SSA region, with quantity on the top followed by access and lastly quality. Furthermore, combining the three infrastructure aspects yields more economic growth benefits than their individual effect. This shows that the three infrastructure dimensions act as complements as opposed to substitutability, answering the fifth objective. Best economic growth benefits will accrue to the SSA region when quantity dimension of infrastructure is combining or interacting with both quality and accessibility, followed by quantity and quality and lastly quantity and access. Except in the case of infrastructure quality, the non-linear model better explains the infrastructure-economic growth nexus in the case of the SSA region since in the case of both quantity and access, the linear and squared coefficients are significant. The linear coefficients are negative and squared ones are positive, which indicates the impact of infrastructure quantity and access on economic growth is U-shaped an indication that the thresholds are minima whereas that of quality is linear. We find the minimum thresholds at which infrastructure quantity and access to be 60% and 71%, respectively. Furthermore, relative to the world average benchmark (excluding SSA), we found that the economic growth benefit of 14.25% per annum accrues to the SSA region if it closes its overall infrastructure gap. In a more granular form, closing the quantity infrastructure gap would deliver higher economic growth benefit of 8.67% per year, followed by increasing infrastructure accessibility of 3.92% per annum and lastly catching up in terms of quality will raise economic growth by 1.66% per year. We found major contributors to be electricity power, road network and improved drinking water.

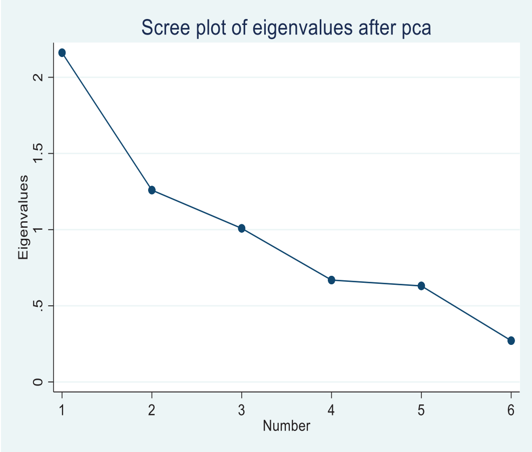
These observations demand African governments, development financial institutions (DFIs) and private sector across the globe to devote financial resources toward infrastructure investment in the SSA region for it to reach its economic growth potential. For example, AfDB (2018) showed that globally, institutional investors such as sovereign wealth funds, pension funds, and insurance companies have more than $100 trillion in assets under management. A small fraction of these excess global savings and low-yield resources would be enough to plug Africa's financing gap and finance productive and profitable infrastructure. But to crowd-in the private sector to participate and efficiently bring these excess funds into infrastructure investment, there is need for a conducive environment, with well-designed policies, laws and regulations which facilitate PPPs and respect of contracts and property rights. With proper cost recovery, appropriate risk allocation and investor protection, PPPs can drive essential infrastructure quantity, quality and improve its accessibility in constrained government budgets, which constitute the bulk of countries in the SSA region.

Appendices

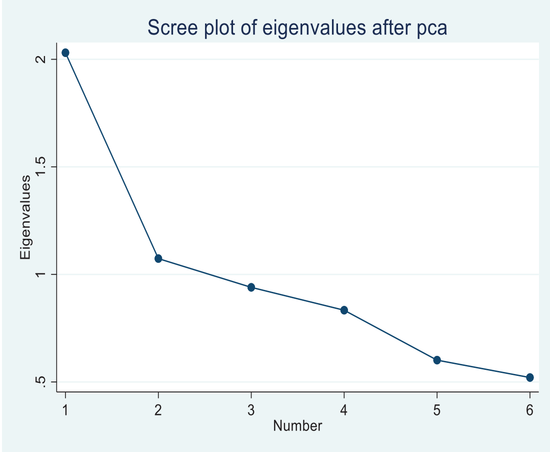
Appendix A4: Distribution of Access to reliable Drinking Water



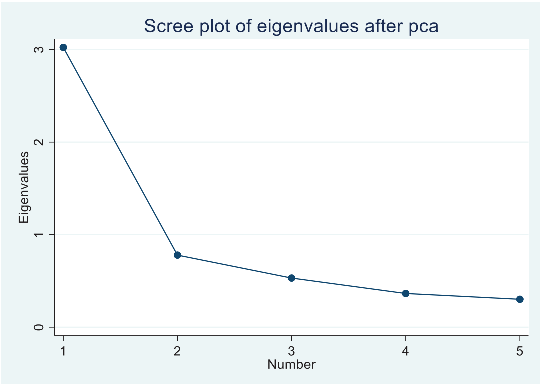
Appendix B4: Screen Plots of Principal Component Analyses of Infrastructure and Institutional Indices



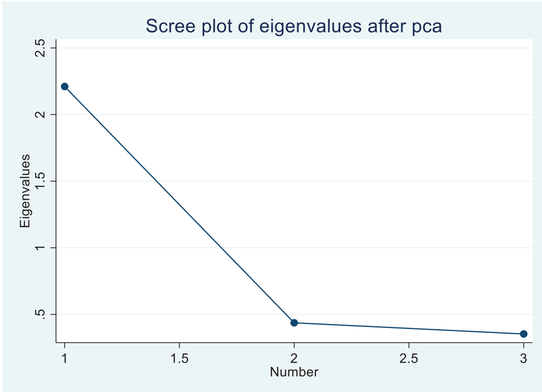
(a) Aggregate Infrastructure Quantity



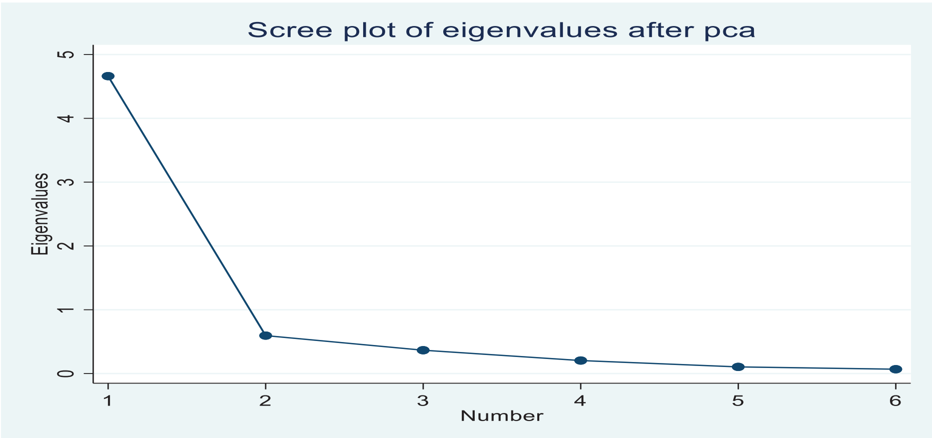
b) Aggregate Infrastructure Quality



c) Aggregate Infrastructure Access Index



d) Aggregate Soft Infrastructure Index



e) Aggregate Institution Quality Index

CHAPTER 5: CONCLUSION AND POLICY INSIGHTS

5.1 Introduction

The importance of infrastructure as an antidote to challenges encountered by micro and macro-sectors of the economy and world inhabitants cannot be overemphasized. There has been an exponential growth in both theoretical and empirical work focusing on the symbiotic intertwined linkages between the infrastructure and institutions as integral parts of poverty eradication, achievement of SDGs and inclusive economic growth particularly for developing economies. Much attention was devoted to developed economies, especially USA and Europe as well as emerging Asian countries like China, Taiwan and Singapore. Despite abundant evidence of weak institutions, retarding economic growth and ballooning infrastructure investment and financing gaps, there is a dearth of literature in developing economies especially with an African flavour on provision of solutions to the questions: How have infrastructure investment and financial deficiencies evolved over time across the SSA region? What is the threshold effect of both aggregated and disentangled economic and political institutional quality on infrastructure development of SSA region? To what extent does infrastructure impact economic growth of SSA countries. Therefore, the three essays of this thesis sought to fill these three gaps in the literature. Each of the three questions was answered by a standalone essay, with further granulated specific objectives.

The first essay (Chapter Two) chronicled the evolution of SSA region's gaps in infrastructure needs and financing. Through this essay, we observed that SSA region's infrastructure investment and financing gaps are widening and ballooning over time across the four infrastructure types considered in this thesis. We also found evidence of positive and significant correlation between infrastructure quality and institutional quality among a sub-sample of former British colonies in the SSA region, which turn to be weak and insignificant in case of other former colonies. The result points towards the influence of the legal origins on the infrastructure development in SSA region. Of interest, also, is the observation that the SSA region's debt is approaching unsustainable levels for which 40% of this debt burden is as a result of leakages through bureaucrats' rent-seeking and managerial inefficiency tendencies necessitated by porous, opaque and weak institutions. This serves as a possible reason why the infrastructure investment and financing gaps for SSA economies is continuously widening over time despite funds exceeding their funding requirements are lying idle under mutual management funds' custody, which the region is failing to take advantage of and capitalise through their use to close the gaps.

The second essay (Chapter Three) was motivated by the conspicuous antecedent literature dearth on the institution-infrastructure nexus. Its main thrust was on estimating the static and dynamic threshold level of institutional quality that will ensure stimulation of infrastructure development through efficient use of public debt (PD), government (GR) financial sector funds (FMD) and services as well as crowd-in foreign direct investment (FDI) inflows in a panel of 46 Sub-Saharan African region between 2000 and 2017. To ascertain the robustness of results, we employed a Hansen fixed effects threshold approach, Fully Modified Ordinary Least Squares (FMOLS) static models and Seo and Shin (2016) and Seo et al. (2019) recent theorized dynamic panel threshold regression approaches as informed by the New Institutional Economics theory. Due to its prominence in recent econometric literature, the estimation dwell on nonlinear asymmetric static and dynamic modeling. The dynamic panel data threshold model was estimated using the Seo and Shin (2016) theoretical first differenced Generalized Method of Moments (FD-GMM) estimation technique as operationalized by Seo et al. (2019). Though it varies with the aspect of economic and political institutional quality measure and whether entangled or disaggregated, overall, the results reveal that the effect of institutional quality on infrastructure development is non-linear with thresholds ranging between 45 – 90% in the static case and 56 – 82% in the dynamic case. This provides support for the use of a threshold regression model, with institutional quality serving as the threshold variable. Further probing was done using PD, FMD, GR and FDI as additional transition variables. In terms of the threshold level, the findings show that the index of institutional quality that will ensure the efficient use of infrastructure in stimulating growth is 0.61. The study also found that, on average, most countries in the region are operating below this threshold level, hence their huge infrastructural investment and financing gaps were underdevelopment as observed in Chapter Two. The conclusion that is drawn from the analysis is that poor institutional quality is one of the factors hampering development of infrastructure of the SSA regional countries. Coupled with huge debt burden, low institutional quality also hinders efficient allocation of fund by financial institutions towards infrastructure development and reduction of FDI inflow to the SSA regional economies. Legal origin has also been found to play a pivotal role in shaping SSA region's state of infrastructure development. The major strength of this study is that the methodology employed for the threshold analysis is exhaustive, since it encompasses both static and dynamic panel data models developed for single and multiple threshold(s) value(s).

Weak political institutions have been found to be a major drag to SSA's infrastructure development.

Essay three (Chapter 4) examined the non-linear threshold effect of infrastructure, quantity, quality and access on economic growth using a rich and robust sample of 46 SSA countries. The study was provoked by the observation that the SSA region, despite its largest infrastructure investment and financing gaps, also scored the least on all infrastructure aspects across the globe. Furthermore, the economic growth of SSA economies stalled post the global financial crisis and inequality and poverty trends were on an upward trajectory. From antecedent literature we identified the following drawbacks; 1) they did not determine the minimum amount of infrastructure quality or quantity which is needed to boost growth, 2) they did not ascertain whether infrastructure quality and quantity has a U or inverted U-shaped effect on growth, 3) though infrastructure access is directly and indirectly linked to welfare issues, inclusive growth and SDGs, it was conspicuously omitted and 4) they did not look at whether infrastructure quantity, quality and access has complementarity or substitutability effect on growth. These issues formed the basis and contribution of this study to the body of existing knowledge. Thus, this study sought to close these gaps by employing a static model (Hansen fixed effects) and dynamic model (System Generalized Methods of Moments (SGMM). We found that, first, the infrastructure quantity, quality and access have positive effect on growth of the SSA region, with quantity on the top followed by access and lastly quality. Second, the three infrastructure dimensions act as complements as opposed to substitutability since combining the three infrastructure aspects yields more growth benefits than their individual effect. Third, infrastructure quantity and quality have a non-linear U-shaped effect on economic growth of SSA with optimum minima thresholds levels of 60% and 71% respectively, while that of infrastructure quality is linear. Best growth benefits will accrue to the SSA region when quantity dimension of infrastructure is combining or interacting with both quality and accessibility, followed by quantity and quality and lastly quantity and access. Fourth, relative to the world average benchmark (excluding SSA), the growth benefit of 14.25% per annum accrues to the SSA region if it closes its overall infrastructure gap. Closing the quantity infrastructure gap would deliver higher growth benefit of 8.67% per year, followed by increasing infrastructure accessibility of 3.92% per annum and lastly, catching up in terms of quality will raise growth by 1.66% per year. We observed major contributors to be electricity power, road networks and improved drinking water.

5.2 Policy Insights

Numerous policy insights arose from this thesis. First, to close the infrastructure investment and financing gaps, relevant authorities of SSA countries must create strong institutions through implementation of radical structural reforms which crowd-in and promote private sector participation in infrastructure projects. Such created strong institutions must be able to work as firewalls against leakages and opportunity cost incurred by SSA economies due to rent-seeking and managerial inefficiencies by bureaucrats. Created enabling political and economic institutions must be able to crowd-in participation of domestic and foreign infrastructure investors as well and public-private synergies through PPPs. With proper cost recovery, appropriate risk allocation and investor protection, PPPs can drive essential infrastructure quantity, quality and improve its accessibility in constrained government budgets, which constitute the bulk of countries in the SSA region. SSA governments, development financial institutions (DFIs) and private sectors across the globe like sovereign wealth funds, pension funds, and insurance companies must devote financial resources towards infrastructure investment in the SSA region for it to reach its growth potential. But to crowd-in the private sector to participate and efficiently bring funds into infrastructure investment, there is need for a conducive environment, with well-designed policies, laws and regulations which facilitate PPPs and respect of contracts and property rights.

Second, given the complementarity between infrastructure stock and human capital, there is need to massively invest in soft infrastructure such as education and health care, which seem to be declining and falling below its required level. Third, given SSA countries' infrastructure quantity, and access current level are below optimum thresholds required to positively stimulate economic growth, African authorities must thrive to achieve the minimum thresholds of 60% and 71%, respectively. This will enable the region to start enjoying the growth benefits of infrastructure and moving in the right track towards achievement of SDGs. Forth, to reduce infrastructures induced inequalities, SSA authorities must improve the quantity, quality and accessibilities across the width and breadth of the country, especially in rural areas by reforming their political economy and political institutions. This is based on our observation that political institutions like ethnicity, tribe and political party affiliations to leaders have a role to play on the skewed distribution, quantity, quality and accessibility of institutions especially in African economies.

5.3 Suggestion for Further Study

The issues examined in this thesis are still at an embryonic stage, especially the role of institutions on infrastructure development and economic growth. Furthermore, the use of dynamic threshold modelling is scant in the infrastructure-institutions-growth trilogy, particularly in the field of Institutional Economic Theory. Literature, in the current body of knowledge, which explicitly dwells on institutional economics as a budding field of economics is sparse (Estache, 2016). Such literature needs to be exported to regions of developing economies, especially to Africa where social and economic challenges like infrastructure, poverty, inequality and unbalanced economic growth and development are highly prevalent. Given the aforementioned, the following issues not adequately addressed in this thesis require further investigation:

1. We observed infrastructure investment and financing gaps to be increasing over time on virtually all four infrastructure sectors we looked at in essay one. However, we did not thoroughly investigate the factors causing such gaps per sector.
2. We assessed the long run effect of economic and political institutions on overall infrastructure development at regional level. We did not however, do this investigation using more granular dataset, that is, at country and sub-regional level. Given that we observed that legal origin matter on the quality of infrastructure and institutions, thus, the result might vary by country as well as by sub-region considered namely, West Africa, Sothern Africa, Central Africa and East Africa.
3. We used threshold models to achieve two of our three main objectives, namely, institution-infrastructure and infrastructure-growth nexuses. It will also be interesting to examine the asymmetric infrastructure-institution-growth trilogy using both short and long run parameter, employing the Non-linear Autoregressive Distributed lag (NARDL).

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