INFRASTRUCTURAL DEVELOPMENT AND ECONOMIC GROWTH IN SUB-SAHARAN AFRICA

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(PG13/03/011)

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May, 2024.

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A Thesis Submitted to

The Department of Economics, College of Business and Social Sciences in partial Fulfilment of the requirements for the Award of Doctor of Philosophy (Ph.D.) Degree in Economics of Crawford of University.

May, 2024.

AUTHORIZATION TO COPY

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INFRASTRUCTURAL DEVELOPMENT AND ECONOMIC GROWTH IN SUB-SAHARAN AFRICA

DEGREE: Ph.D. ECONOMICS

YEAR: 2024

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DEDICATION

This Thesis is dedicated to God Almighty, the one who has the final say; the giver of wisdom knowledge and understanding.

ACKNOWLEDGEMENTS

I really appreciate God for the opportunity given me to start and complete this study, even when my health totally broke down and I was almost confirmed dead. But His mercy brought me back to life. Lord, I owe you my all. My sincere appreciation goes to my supervisor, Professor Olufemi Saibu Mubi, Department of Economics, University of Lagos (Akoka), Lagos. I shall forever treasure your kindness and resilience in ensuring that I completed this work despite all the challenges and unforeseen circumstances of life. I am indebted to my co-supervisor, Dr. Adeleke Oyende who doubled as the HOD then, for all his efforts to see the work to a logical conclusion. I appreciate the efforts of the programme coordinator, Professor (Mrs.) Comfort Moradeke Amire. I sincerely thank Professor Joseph MacIver for his moral and scholarly piece of advice he offered me regarding the necessity for me to be courageous at every stage of this work. Dr Ogunwa Samuel and Dr.(Mrs) Cecilia Adu were very strong pillars behind me. I cannot forget the encouragement volunteered by Professor Ngwama Justice, Dr. Esuh Ossai-igwe Lucky,Dr. Eleboda Samuel and other members of the academic staff of Crawford University as well as Dr. Jimoh Saka of the Department of Economics, Lagos State University. I am full of gratitude for all your efforts.

Dr Agbabiaka I salute you, you were a source of comfort when things were really challenging. Associate Professor Enilolobo of Bells University, thank you for your contribution to this work. I thank all my spiritual fathers and mothers for their sincere prayers, particularly my biological mother,Mrs Idoko Abeni Achimugu . Rev and Mrs Igbeboh and all my siblings, you all deserve my sincere appreciation.

I am very grateful to members of staff of the Department of Economics in particular Dr. (Mrs) Popogbe for her valuable contributions towards the success of this work I also extend my appreciation to the Deans of Post Graduate School (both present and past), Professor Gabriel Adeola and Profesors Adewole Adeola and all the non-academic members of the University I also appreciate the love and prayers of all the members of the University Chapel. I specially appreciate the Apostolic Faith Mission for creating this avenue for spiritual and human development. I also thank the University Management under the leadership of the Vice Chancellor, Professor Reuben Jiya Kolo and Professor Isaac Rotimi Ajayi (formal V.C). I want to salute the courage of all my classmates during class work: Dr. Agbabiaka Kamar. Dr. Felix Ojo, Dr. (Barr.) Oluwalogbo Ogunseye, Dr. Omoare Emmanuel, Dr Taiwo Oyeneye and Dr.Kehinde Oyeneye. My respect and appreciation goes to the Nigerian Air Force via the Director of Defense, AVM. Kassimu Andersen of the Nigerian Defense Head Quarters Abuja for your financial, moral and logistic support to use the aircraft during the short down period to meet up with examination schedule. My mentor in this field of study, Reverend Emmanuel Moh (an economist per excellence) a member of Apostolic faith Church West, East and Central Africa (WECA) board of trustee thank you sir, Professor Kayode Oje Daddy, thank you for the discipline you instill in me. Reverend and Mrs.Umarudeen Olowosile, Reverend Samuel Maiye, Reverend and Mrs. Festus Oyeniyi Ajayi, thanks for all your prayers and support. As the only lady among eight able men, I felt secured. Finally, I am very grateful to my niece Faithfulness Usumine Igbeboh who sacrificed her comfort with her well to do parents to assist me, all the way from Kogi State at the age of 11yrs. You are God-sent.

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ABSTRACT

This study examined the relationship between infrastructural development and economic growth in Sub-saharan Arica (SSA) Countries, using electricity, education, health, and information communication technology to measure economic growth in this region. The study also examined the causal link between the variables that will influence economic growth in SSA countries because the impact of infrastructure on economic growth in Africa is still not clear as some scholars argued that it impact is not significant, other scholars posited that it is significant to developed economies alone.

The study employed descriptive and panel econometric procedure to analyses the date collected. The study utilised annual secondary data, spanning from 1990 to 2021 encompassing ten strategically selected countries grouped into landlocked (Central African Republic, Ethiopia, Zimbabwe & Congo, Sudan), costal (Nigeria, Mozambique, Gabon & Senegal) and insular (Mauritius). *The data for the analysis were sourced from World Bank Development indicator (WBDI), Journals, data were also sourced from AIDB, World development indicators (WDI) and Worldwide Governance indicators (WGI), Data selected were analysed using tables, graphs, panel autoregressive distribution lag, fully modified ordinary least square and Dumitrescu & Hurlin and Granger causality test.*

This study therefore discovered that SSA's economic development significantly depended on functional infrastructure provision thus suggesting that government needs to formulate and implement sustainable policy strategies that encompass diverse infrastructural components to promote economic growth in SSA. The study also concludes that there is spiral effects and reverse causation which implies that promoting infrastructure development stimulates economic growth and higher growth also consequently leads to better infrastructure development.

The study recommends that Policymakers should adopt an integrated approach to development planning, recognizing the interdependencies among sectors. Comprehensive strategies that synchronies investments in electricity, education, health, and information communication technology can create a synergistic effect that will foster sustainable and inclusive economic growth in SSA countries the interconnected relationships between economic growth and various infrastructure components in the various geographical areas studied be put into consideration to foster sustainable and inclusive economic growth in SSA countries.

CHAPTER ONE

INTRODUCTION

1.1. Background to the Study

Economic growth is one of the most important factors in the global economy, despite the criticism that the level and rate of economic growth do not always translate to the well-being of a population and its living standard. According to Lukasz (2014), economic growth remains the primary measure of prosperity of a nation, even when it undermined the production from the informal market, changes in the amount of time spent on work, and negative processes associated with economic activities. The determinants of economic growth have been the emphasis of research over the years. Recent economic growth is associated with sustainability, that is, economic growth and development has to meet present needs without the risk that future generations will not meet their needs.

Research on infrastructural development has witnessed increased interest from scholars in recent times. Some have expressed support for the impact of infrastructure on economic growth. Similarly, policy makers and governments in various countries, mostly in Africa have recognised the need to evolve and implement policies that will increase investments in basic infrastructures, as a means of boosting economic performance on a sustainable basis. Unfortunate, Africa's shares of developed infrastructures has remained dismal compared to other regions of the world according to these economics scholars (Davidmac, Ekeocha, Jonathan, Ogbuabor & Anthony, 2021).

Economic growth in sub-Saharan (SSA) Africa has improved in recent years compared to what it used to be a few years back. The impact of infrastructure on economic growth in Africa is still not clear as some scholars argued that its impact is not significant, other scholars posited that it is significant to developing economies alone. Some scholar further argued that it does not impact on the standard of living of the common man in Sub-Saharan African countries; that the growth is numerical and it is not making the kind of developmental impact that will justify the figures, as access to basic needs are still very low compared to other developing regions (Odongo & Ojah, 2016). Economic growth means a sustained economic improvement in productivity which can only happen in an environment where the level of technology, man power development; in terms of education, healthcare, accommodation, security and life expectancy ratio, is high. Countries must pay attention to maintenance of political and stable macroeconomic objectives that will create a favourable environment for businesses that will attract investors; provide adequate human capital, functioning financial market, and infrastructure. In view of the foregoing analysis, infrastructure must be given the right attention to achieve a reasonable economic growth rate.

Akeju, Olusanjo, and Akode (2022) also argued that economic growth and performance vary across the African regions. East Africa recorded the highest growth rate of 5.5 percent in 2019 while Southern Africa stood at 0.3 percent, alluding to a decline in structural transformation and increasing unemployment, in contrast North, Central, and West Africa had GDP growth rates of 4.0, and 3.6 percent, respectively. In 2020, estimated GDP growth rate for Africa was negative except for the East African region, which stood at 0.7 per cent. This is because countries in East Africa responded swiftly to the Covid-19 pandemic, including enforcing lockdown protocols and devising alternative survival measures while in lockdown. Nevertheless, South Africa had the highest negative growth rate of 7 per cent as it was hit hard by the Covid-19 outbreak. (Akeju, Olusanjo, and Akode 2022)

Chengete and Alagidede (2018) argued that infrastructure is an important input in any productive economy in the world; because S it is one of the pillars of economic change in an economy. Economic growth is stimulated by adequate infrastructural development, which is mostly caused by improvements in the quantity and quality of the factors of production that a country has access to, like land, labour, capital and enterprise. An economy will begin to experience decline if the quantity and quality of any of the factors of production fall. The recognition of infrastructure as a driver of economic growth is a long-standing history that can be traced back to Rostow's growth theory. Some authors (like Rubin 1991 in Chengete and Alagidede, 2018) posited that electricity is a 'core' infrastructural component.

However, nations that have developed their infrastructure will most time record higher and better quality of economic growth and development than those that have failed to do so (Egbo, 2018). When an economy is developed infrastructural wise, it will improve the quantity and quality of land resources, quantity and quality of human resources, quantity and quality of capital resources, and people tend to participate and share the benefits of economic growth. For example, investments in infrastructure in sub-Saharan Africa are currently insufficient to bridge the infrastructural gap that will guarantee the quality and quantity of growth demanded globally.

Pieterse & Hyman (2014) posited that many developing countries that proactively seek to improve socio-economic development requires additional infrastructural investments. The World Economic Forum (2012) estimates that the infrastructure gap was US$ 1 trillion per annum. This represents the difference between the annual need of US$ 3.55 trillion and actual spending of US$ 2.5 trillion The current estimate of global infrastructure need is 4% of global GDP or US$ 4 trillion per year (Estache & Garsous, 2012). sThe study the estimate for developing countries is much higher at 15% of their GDP. Ultimately, developing countries require approximately US$ 1.5 trillion. To meet up with these challenges.

Estache and Garsous (2012) argued that Sub-Sahara Africa is facing a critical shortage of infrastructure that constitutes a bottleneck to its socioeconomic development. For there to be a sustainable growth in Sub-Saharan Africa, it will be necessary for the governments of this region to make a concerted effort in developing feeder roads and transmission lines that connect rural communities to national grids. This will enhance the free flow of movement to enable individuals, households, rural communities, and businesses alike to embark on income generating activities in the region.

The importance of electricity supply in enhancing economic activities and improving the standard of living of people in any country and cannot be over emphasized. Without stable electricity, health and welfare will be threatened. Sectors such as agriculture, industry, health, household, and banking, for example, are virtually dependent on electricity to be more efficient in their services delivery. Virtually all economic activities depend on reliable electricity supply to function. The electricity crisis in Sub-Saharan Africa has worsened in recent years, in spite of the efforts made to construct new electric power plants and transmission networks. The gap is still wide between the present trend of investments and the actual needs of electricity infrastructure (Egbo, 2018).

There have been a lot of ongoing reforms going on in various countries to solve the problem of generation and distribution in the power sector. Early in 2000, a regional strategy was launched seeking to reinforce these reforms, to exploit domestic primary energy resources, and to improve the electricity interconnections among the national grids. The aim is to build up a West African Power Pool (WAPP), the objectives of which are defined as follows: to enhance cooperation among African countries for developing electricity infrastructures, promote investment in the sector and improve electric system reliability. In light of this, many countries are interacting within their regions and borders to trade in electricity to ease the burden of their economies and make things work smoothly. The aim has been to enhance the security of supply and reduce costs, as liberalized and integrated markets allow relatively free cross-border flows, to enhance competition in power generation and supply, and offer more choices to consumers. Regional markets are gaining more importance, as these bring additional benefits to the grid integration. The creation of a regional electricity market requires the harmonization of market rules so that electricity can flow freely in response to market-based price signals (Parisio & Pelagatti, 2019).

Eisen and Mormann (2018) proposed a legal framework under which anyone, anytime, anywhere, can trade electricity in any amount with anyone at a reasonable price. That study also proposed an ecosystem in which electricity can be transformed from a basic service into a widely traded commodity. It was pointed out that Sub-Saharan region's energy sector is plagued with unreliable, extremely expensive power supply, low rate of access to power and the inability to recover high cost of producing electricity on the part of the suppliers. The study argued that it is due to inadequate planning which often led to reliance on emergency rental plants, which further increases cost of production, to the effect that demand for electricity is higher than the supply in this side of the world. Hence, the government of this region should encourage regional integration that will foster agreements that would be beneficial to all parties that are involved to make this commodity affordable and available in conducive environment.

Bagnoli, Bertomeu-Sanchez, Estache, and Vagliasindi (2021) argued that insufficient power generation capacity limits economic growth in Ghana, and inadequate infrastructure facilities has contributed to high transaction cost of doing business in most sub-Saharan African countries. These resulted in the lowest level of productivity of all low-income countries, which made them the least competitive economies in the world. According to (Egbo, 2018) if there is adequate infrastructure, African firms could achieve productivity gains of up to 40 per cent.

1.2 Statement of the Problem

Decades of economic stagnation and declining standard of living have made Sub-Saharan Africa the poorest region in the world, despite its recovery since the 1990s world economic crisis. Africa is faced with weak economic activities that cannot withstand the pressing needs of her population. Poor infrastructural development, high debt profiles, extreme poverty at all level, diseases and starvation due to poor nutrition, weak institution due to weak human development, and poor educational system which is linked to poor funding of basic infrastructures. The effects of it are insecurity, societal unrest and weak performance of the whole economic. These negative occurrences attracted scholars to devote a lot of research theoretically to finding the link between infrastructural development and economic growth and productivity, dated back to the time of Aschauer in 1993. The provision of adequate infrastructure services in other regions has long been viewed by academicians and policy makers as a key ingredient for economic growth. In terms of performance, SSA ranked at the bottom of all developing regions due to inadequate infrastructure. It has been argued by scholars that infrastructure in Africa is lagging behind not only because of financial or technical constraints but for the inability to embrace new business models to enhance integrated regional corridors, functional urban-rural agglomeration and dynamic evolving value chains, with associate infrastructure services that will propel human development. For example, the rate of electricity supply in Sub-Saharan Africa is substantially lower than what it should be, considering the levels of income and the electric grid footprint of the region. Limited access to electricity, good roads, healthcare and education impose significant constraints on modern economic activities and quality of life, as well as adoption of new technologies in various sectors such as education, agriculture, finance, health and manufacturing. Most of the social sector depend on electricity to perform credibly, households and firms endure several hours a day without access to power, and a lot of children are out of school and high rate of premature death across board. Insecurity and social unrest are on the high due to the astronomical cost of living. Even in instances where power is available, blackouts are prevalent, thereby limiting end users' potential utilisation of the facility.

Most of these problems are blamed on inadequate supply of electricity, poor education, poor health services, poor information system and poor road network system, among others. It was argued in previous studies that if adequate supply of infrastructure can stimulate employment and income generating activities in the developed economies, then Africa can build assets through micro/small sized production activities such as a fashion design if given the same opportunity. The amount of investment that will enhance this development in SSA has not received wide investigation that will bring about meaningful development that may take this region out of abject poverty.

This work, therefore, seeks to examine the effect of infrastructure deficit on economic growth in sub-Saharan Africa countries with emphasis on electricity supply and other infrastructural facilities; education, health, information, and communication technology, which make this study different from other studies. As most studies focuses on all the infrastructural facilities and all Africa regions, this study focused on ten Sub-Saharan countries that are strategically grouped according to their geographical location to better understand the problem of infrastructural development in these areas. This unique selection helped to understand the dynamic relationship of these basic infrastructures that others relates with in an organized system.

1.3 Research Questions

i. To What extent does electricity infrastructure affect economic growth in Sub-Saharan Africa countries?
ii. What is the effect of health infrastructure expenditure on economic growth in Sub-Saharan Africa countries?
iii. How does education infrastructure expenditure impact economic growth in Sub-

Saharan Africa?

iv. To what extent does information and communication technology infrastructure impact economic growth in Sub-Saharan Africa countries?

v. What is the causal relationship between infrastructural development and economic growth in Sub-Saharan Africa countries?

1.4 Objective of the Study

The broad objective of this study is to examine the relationship between infrastructural developments on economic growth in Sub-Saharan Africa countries. The specific objectives

are to:

i. examine the effects of electricity infrastructure on economic growth in Sub-Saharan Africa Countries ii. analyze the effect of health infrastructure expenditure on economic growth in Sub-

Sahara Africa Countries; iii. explore the impact of educational infrastructure expenditure on economic growth in

Sub-Saharan Africa Countries; iv. examine the impact of information and communication technology infrastructure on economic growth in Sub-Saharan Africa countries.

v. determine the causal relationship between infrastructure development and economic growth in Sub-Saharan Africa countries.

1.5. Statement of Hypotheses

The following hypotheses were tested

H01: Electricity infrastructure does not have an effect on economic growth in Sub-Sahara Africa countries.

H02: Expenditure on health infrastructure does not have an effect on economic growth in SubSahara Africa countries.

H03: Expenditure on education infrastructure does not impact economic growth in SubSaharan Africa countries.

H04: Information and communication technology does not have an impact on economic growth in Sub-Saharan Africa countries.

H05: There is no causal relationship between infrastructural development and economic growth in Sub-Saharan Africa countries.

1.6. Justification for the Study

Globally, infrastructure is deemed as critical to economic growth. Stable electricity supply and adequate healthcare will enhance human welfare. Virtually all economic activities depend on adequate infrastructure to function effectively. Inadequate access to basic infrastructure will impose significant constraints on modern economic activities. Though, there has been a significant increase in economic growth in the last decade, yet it has not improved people's access to infrastructure in this part of the world. A lot of investment and policies put in place are not yielding the desired result. A lot of scholars and policy makers blame this on insufficient infrastructure. Hence the reason for a more informative research that will give a comprehensive ideas that SSA countries can base their policy proposal, to achieve better out come from developmental purpose.

This study will examine effects of infrastructure on some selected Countries in SSA and come up with a lasting solution that will lead to increase in productivity that would enhance the Countries income, which will lead to social welfare for all. This study will also open the eyes of policy makers to the real issue affecting the economy as regards infrastructure. Investors will be informed on where to invest in this sector. It will also contribute to the body of knowledge. Two high-quality studies that analyze the effect of electricity infrastructure on economic performance, at a highly aggregated level within a country, are identified. Urrunaga and Aparicio (2012) investigated the relationship between electricity consumption and economic growth by using ARDL bounds testing approach and VECMs in Cameroon, Cote d'Ivoire, Congo, Ethiopia, Gabon, Ghana, Guatemala, Kenya, Senegal, Togo and Zambia, for the period 1970–2010. The ARDL results showed that there is a co-integration relation between electricity consumption and economic growth in ten of the eleven countries, this also informed the choice of this study measurement instrument. Davidmac *et al.* (2022), also examined the effects of both aggregate and disaggregated infrastructure development Indices (such as transport, electricity ICT, and water and sanitation infrastructure indices) on economic performance in Africa. The study established that both aggregate and disaggregated infrastructural development Indices impact positively on GDP per Capita growth in Africa, this is also in lie with the study results Davidmac et al. (2022) posited that infrastructure development has a significant impact on GDP per capita growth in Africa. This was also in line with the findings of other recent studies in extant literature. Like (Fayissa & Nsiah, 2013;

Calderon, Cantu, & Chuhan-Pole, 2018; Ehigiamusoe, 2021), as this study has also discovered. Empirical literature on the effects of infrastructure focuses on its long-run contribution to the level or growth rate of aggregate income or productivity. Odongo and Ojah (2016) study found a positive long-run relationship between infrastructure and economic growth. Kumo (2012), using South African data, confirms strong bi-directional causality between infrastructure investment and economic growth. These flagged issues inform our variable measurement and choice of econometric used to analyse this study.

1.7. Scope of the Study

To achieve the stated objectives, this study will cover 10 Sub-Saharan Africa Countries, based on similar constraints, geographical locations, and the availability of data. These countries are grouped into three; landlocked, coastal, and insular. For landlocked (Central African Republic, Ethiopia, Zimbabwe & Congo, Sudan), for costal (Nigeria, Mozambique, Gabon & Senegal) for insular (Mauritius).Data were collected for 30yrs spanning through 1990 to 2021.This done to enable the researcher to manage the available resource and time allotted to this study. The above countries were selected to represent others because most Africa countries have similar economic challenges.

1.8. Operational Definition of Terms

Electricity supply: The quantity of electricity available to the consumers **Electricity consumption:** It is the actual consumption per person.

Infrastructure: This refers to the physical and organizational structures needed for the efficient functioning of the economy, such as roads, ports, and communication networks.

CHAPTER TWO

LITERATURE REVIEW

2.0 This chapter discusses the concepts, theories and gap in the literature as it relate to the study.

2.1 Conceptual Review

2.2 Infrastructure, Facilities and Maintenance

Infrastructure is given a variety of interpretations. Researchers describe infrastructure according to the objective of their works. Stupak (2018) also mentioned that infrastructure could be described in several ways depending on the policy discussion. Gurara, Klyuev, Mwase and Presbitero (2018) categorized infrastructure into: hard infrastructure (transport (ports, roads and railways); Energy (electricity generation, electrical grids, gas and oil pipelines); telecommunications (telephone and internet); and, basic utilities (water supply, hospitals and health clinics, schools, irrigation *et cetera*.) and soft infrastructure (non-tangibles supporting the development and operation of hard infrastructure, such as policy, regulatory, and institutional frameworks; governance mechanisms; systems and procedures; social networks; transparency and accountability of financing and procurement systems). Social infrastructure also facilitates investment in human capital that ensures better utilization by some of the physical capital stock of the economy, thereby raising the productivity of the workforce. An increase in the supply of capital – a higher capital to labour ratio, which enables a given number of workers to produce more output per capita. It also enhances the quality of life of the populace by empowering them economically, politically, and socially, with the attendant positive effects on efficient use of national resources and on poverty alleviation. (Fedderke and Garlick in

Streatfeild, 2018) also identified five channels through which infrastructure influences economic growth: as a complement to other production factors; a factor of production; a tool of industrial policy; a stimulus to factor accumulation and a stimulus to aggregate demand. In this regard, Bronzini and Piselli (2009) also relate the indirect impact of infrastructure through total factor productivity. Moussa, Syed, Caglič and Malcolm (2018) takes a broader look at infrastructure to show that the problem in Africa is not power but poverty. It was upheld that reliability, affordability, and coordination are the missing links between making utilities viable and expanding the consumer base. Reliability and affordability go hand in glove, but blackouts and brownouts are common in Africa. They authors argued that if the supply of electricity is reliable, it would persuade consumers that electricity is a service worth paying for, and more consumers would bring down the cost of producing electricity.

One school of thought regards infrastructure as part of a country's physical stock of capital and, therefore, a factor of production (Aschauer, 1993; Gramlich, 1994). Proponents of this school argued that infrastructure stock changes impact national output and directly induce economic growth. The second viewpoint is that infrastructure complements other factors of production: the argument here is that infrastructure may improve total factor productivity by lowering input costs or by expanding the production frontier or the set of profitable investment opportunities (Barro, 1990). According to the third school of thought, infrastructure is believed to stimulate the accumulation of factors of production. Advocates of this view argue that accumulation and productivity of a factor (labour) is incentivised by infrastructure (educational and health facilities and roads to access those facilities) (Fedderke & Garlick, 2008). In this case, infrastructure indirectly affects economic growth.

Furthermore, it has also been argued that infrastructure investment can affect economic growth by stimulating aggregate demand or by directing industrial policy toward a desired path.

Kodongo and Ojah (2016), align with these latter views on the nature of relations between infrastructure and economic growth. This view is particularly germane for less developed regions, such as SSA, where traditional antecedents of economic growth are dominant. According to Trisnowati, Hadiwidjaja, and Nurvita (2021), hard infrastructure is essential to running an industrialized, modern economy. The "soft" infrastructure comprises non-tangible infrastructure: institutional systems, policy and regulatory, governance mechanisms, social networks security, and other institutions that are essential to the well-being of an economy. This infrastructure supports the operation and development of physical infrastructure. Many sub-Saharan African countries have made progress in improving their infrastructure, but results have been mixed across sectors and country groups.

The African Infrastructure Development Index (AIDI) 2021 shows some overall progress between 2000 and 2010 with the most rapid progress in sub-Saharan African low-income countries and fragile countries lagging behind. Improvements in the overall index were mostly driven by enhancements in information communications technology while electricity production stagnated, and transport development has been limited.

Palei (2015) advocated that economists distinguish between infrastructure capital and physical infrastructure. According to the study, the main elements of physical infrastructure are transport, water, telecommunication, and energy infrastructure. Whyte *et al.* (2020) posited that results from the analysis of different approaches to infrastructure help to state that infrastructure are facilities and systems that are the basis for society's prosperity, provided by governments for public use, which can be distinguished as soft and hard. They also argued that infrastructure is essential for the economy and society and treated it as core infrastructure. Literature had proposed several plausible theoretical explanations of infrastructure's impacts on economic growth. Electricity is seen as a major player that drives economic growth.
Akinlo & Apanisile (2014a). Posited that SSA exhibits the lowest level of productivity of all low-income countries and is among the least competitive economies in the world. If there is adequate infrastructure, African firms could achieve productivity gains of up to 40 per cent. In

Liberia, more than half of connected households report that they never have electricity. Sierra Leone and Uganda also have severe reliability challenges, with more than 30 per cent reporting never having electricity despite being connected to the grid. In some countries—including Burundi, Ghana, Guinea, Liberia, Nigeria, and Zimbabwe—more than half of connected households reported receiving electricity less than 50 per cent of the time in 2014 (Egbo, 2018).

Despite the wide range of theoretical studies on the relationship between infrastructure and economic growth, studies in Africa have not offered a strong consensus. Some studies agreed that the relationship is heterogeneous and mostly dependent on countries' infrastructural types and periods under investigation. Other studies report positive relationships between infrastructure development and economic growth in Africa, while other strands of studies did not find any relationship between infrastructure and economic growth in Africa (African economic outlook, 2018)

2.1.2 Access to Infrastructure

Infrastructure drives growth and vice versa through the need for more infrastructure as an economy grows. Chengete and Alagidede (2018) reported that unreliable, insufficient, and costly infrastructure across the African continent has arguably been the damaging weakness to higher and more inclusive growth and socio-economic development of the region. The level of infrastructure stock has hampered rather than assisted growth and development. For SubSaharan Africa (SSA) to develop and industrialise in a viable manner, there is a need to address the challenge of infrastructure in the region. Theoretically, it is possible to accept that infrastructure can extend the productive capacity of a region by both facilitating the productivity of existing resources and increasing the resources.

According to the study, infrastructure development may influence output and productivity, and on the other hand, economic growth can also influence the supply and demand for infrastructure. In general, massive infrastructure investment is required to improve access. It was also reported that only 5% of Africans have access to water due to unevenly distributed water resources. Household welfare is said to improve when they have access to affordable infrastructure services for consumption purposes. According to Kirkpatrick, Parker and Zhang

(2006), the potential contribution of infrastructure to economic growth has not been fully realized due to the high rate of poverty in SSA countries.

2.1.3 Education and ICT Infrastructure

Human resources have been an important factor in modern economic growth. Economic growth does not depend on the mere seize of human resources but on their efficiency.

Information and communication technology (ICT) has created a global village as people in different places can communicate with others across the world. It is a key factor in the present and future development of all industries. It is influencing every aspect of human endeavours. As the world is changing, ICT is the driving force behind it. It has impacted education, banking, transport, logistics, and all aspects of business engagement.

ICT has transformed and impacted tremediousely on human existence. A lot of research works have been conducted on how ICT had impacted the world economies over the years, but less has been documented about the situation in Africa in particular and Sub-Saharan Africa in general (Kouladoum, 2023). Studies show that digital infrastructure enhanced the level of economic growth irrespective of whether the countries belong to the lower, middle, and upper income groups. ICT has enhanced living standards, welfare externalities, and financial development in developing countries, according to various researchers. Despite rapid expansion in the use of mobile phones and mobile technology applications in Africa, internet penetration—a lifeline for modern trade, communication and technology applications in almost all sectors have been extremely slow in the past decade on access to infrastructure for selected regions worldwide (African Economic Outlook, 2018).

Information technology “evolved in the 1970s. Its basic concept, however, can be traced to the World War II alliance of the military and industry in the development of electronics, computer and information theory Information and communication technologies for development, which refer to the application of information and communication technologies (ICT) towards social, economic, and political development, with a particular emphasis on helping poor and marginalized people and communities. ICT for development is grounded in the notions of

“development, growth, progress and globalization, and is often interpreted as the use of technology to deliver a greater good.

2.1.4 Infrastructure Development and Economic Growth in Sub-Saharan Africa

Given that infrastructure development is inextricably linked to economic growth, (Foster & Briceño-Garmendia, 2010); Calderon and Serven 2008, Estache & Vagliasindi, 2007) all argued that infrastructure deficiency within an economy will limit socio-economic development. Insufficient power generation capacity has been identified as a huge limitation to economic growth prospects of Ghana. They also posit that poor transportation facilities, resulting in a high cost of bringing goods to the market, have been a significant constraint on growth in the agriculture sector in sub-Saharan Africa. Though similar to other regions in the world, sub-Sahara Africa exhibits a negative impact on income inequality and a positive longrun relationship between growth and increased infrastructure stock and improved quality of service.

The African Infrastructure Development Index (AIDI), developed by AfDB in 2013, is a weighted average of nine indicators of infrastructure covering four key components which are: electricity, transport, information and communication technology (ICT), and water and sanitation. Although the index emphasizes measures of infrastructure “bulk”, it also captures some aspects of infrastructure “quality”. For instance, bulk of transport infrastructure is captured through total road network in km (per square km of exploitable land area), while transport infrastructure quality is addressed through total paved roads (km per 10,000 inhabitants). Water and sanitation are covered only through quality measures: improved water source and improved sanitation facilities (both as percentage of population with access) while electricity and ICT are only represented through bulk measures. Hence, the need for this study.

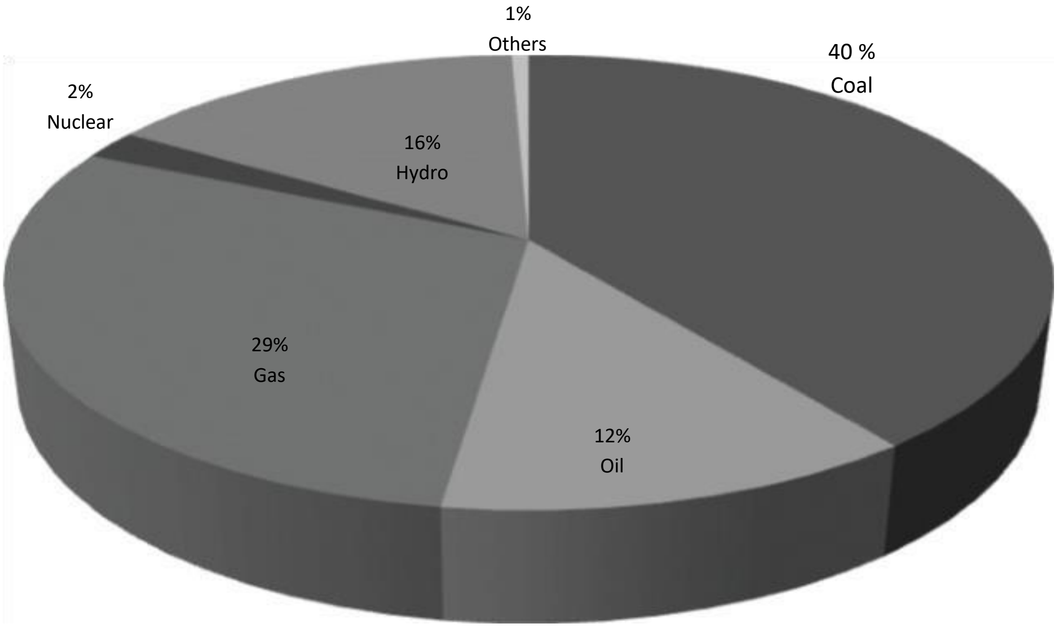
2.1.4 Electricity and Generation

Electricity is an important element that enhances economic activities and improves the standard of living in any part of the world. The world is going digital, and it level of energy requirement is increasing on a daily bases, and so Africa cannot afford to be left behind in this race. All the productive sectors and services sectors need adequate, constant, and reliable power to operate efficiently. Konkel (2014) emphasized the importance of electricity as a booster of economic growth that enhances the activities and welfare of the citizens. It has been pointed out that the important input is grossly inadequate and had, therefore, positioned the region as the poorest in the world.

Total installed capacity of electricity in Sub-Saharan. Africa is just 68 gig watts for 48 countries, the Energy portal (2018). Production is way behind the actual demand, and so the shortfall between supply and demand of electricity remained a major obstacle to sustainable economic growth. Electricity and power infrastructure and systems are a combination of human and physical resources used to create, transmit, transform, and distribute electrical power in places around the world specifics. Each regional power grid is different, but the same general principles apply to all of these critical infrastructure and systems worldwide.

This system can be broken into production, transmission, and distribution subsystems, each of which has different needs and requirements. The production subsystem is the network of power generation facilities that produce the actual power. Once it is produced, electricity is transmitted along high-voltage transmission lines, which are optimized for transmitting power over long distances (Kodongo & Ojah, 2016). As it approaches its final destination, the electricity moves through a transformer where it is reduced to a safer voltage to be distributed to its final destination. All of this happens in the blink of an eye, with power being consumed almost as soon as it is produced. While storage technology continues to improve, current highcapacity options involve some level of unacceptable loss in the storage and retrieval of electricity. The production subsystem is the network of power generation facilities that produce the actual power. Once it is produced, electricity is transmitted along high-voltage transmission lines, which are optimized for transmitting power over long distances.

Power Generation in Africa.



Sources: Akinlo and Apanisile (2014a).

Southern Africa has improved installed grid generation capacity than the rest of sub-Saharan Africa, with the total of 58 GW, 80% is in South Africa. 85% of its generation capacity is from coal and the rest from oil distillate (6%), hydropower (5%), and nuclear (4%). It is the only African country with nuclear power plants (with a capacity of about 2 GW). The average cost of grid generation across Southern Africa was about $55 per MWh, because of the high use of low-cost coal and hydropower (IEA, 2014). West Africa's grid generation capacity is estimated at about 20 GW. Of this capacity, more than 50% is gas generation (mostly in Nigeria), about 30% is oil distillate, and about 20% is hydropower. Some countries, like

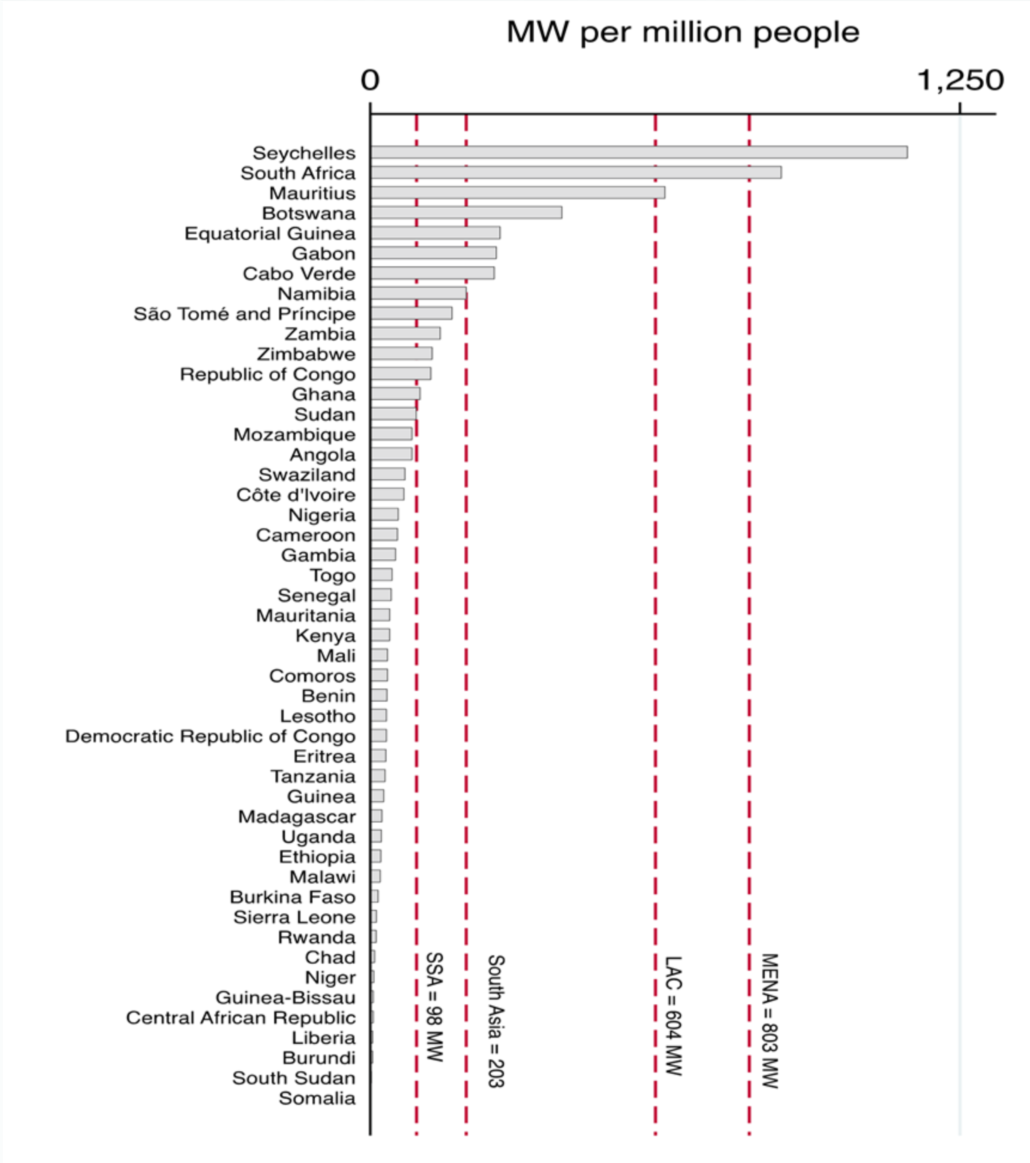
Benin, Burkina Faso, and Niger, import most of their electricity. The average cost of generation was about $140 per

MWh, owing to dependence on gas and oil generation (International Energy Agency (IEA), 2014). East Africa has grid generation capacity of about 8 GW, 50% of which comes from hydropower, 45% from oil distillate, and the rest from geothermal and gas. About 250 MW of geothermal resources lie mainly in Kenya.

The average cost of generation was $110 per MWh, despite the region's inexpensive hydropower generation, owing to the high use of expensive oil generation plants (IEA, 2014). Central Africa has the lowest grid generation capacity in sub-Saharan Africa, at 4 GW, composed mainly of 65% hydropower, 15% gas, and 20% oil distillate. The average cost of generation was around $95 per MWh, owing to the low cost of hydropower (IEA, 2014). "Africa power problems are deeply rooted, and concerted effort will be required to resolve them. Chief among those problems are the underdevelopment of the region's energy resources, the high costs of power, the unreliability of power supplies, the region's vulnerability to high oil prices, and the exacerbating effect of drought and conflict. We will deal briefly with each of these issues in turn" (Anton & Inman, 2008). When put in a graphical picture as viewed by Streatfeild (2018), the gap in capacity building is still very low and all efforts put in place by the government of this region is not justified. Looking at the graph below, one can see clearly the SSA still lagging behind. Seychelles, South Africa and Mauritius which are doing better in term of install capacity per population size.

LAC refers to Latin America and Caribbean and MENA refers to the Middle East and North America.

Figure 1. Installed capacity by population size (MW per million people).



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Source: Trimble et al., "Financial Viability of Electricity Sectors," 2015, 85–86. LAC refers to E. J. Streatfeild (2018)

2.1.5 Electricity Transmission and Supply

Streatfeild (2018) reports that Sub-Saharan Africa (SSA) has a lower supply of electricity than any other region in the world, evidence from satellite images depicting the region's relative lack of nighttime lights. All efforts put by the government of this region have not yielded the desired goal, which they argued is due to poor system management. Electricity transmission is the interstates highway of electricity delivery. It refers to the part of electricity delivery that moves bulk electricity from the generation sites to a long distance sub-stations closer to areas of demand by consumers. This is possible with the use of poles /towers carrying many wires over long distances. It is with the help of these and other related equipment that the power is stepped down for domestic consumption. SSA lacks adequate transformer and even poles to enjoy the available power (Whyte et al., 2020). Electricity supply is lower, and costs are higher in sub-Saharan Africa (SSA) than in any other world region. While several SSA countries have sought to address this issue through cross-border trade and investment in domestic infrastructure, these efforts have been greatly impeded by the high degree of systems inadequacy. Ironically, electricity tariffs are too low to recover utilities cost.

Several studies have established the fact that almost one billion people currently live without electricity, worldwide, out of which approximately 600 million reside in SSA. Surveys of households in 22 SSA countries show that just one-third of the population uses electricity. Income levels and geographic location seem to be key determinants of electricity use, as electricity consumers tend to be urban and comparatively better off. A report from the World

Bank states that low levels of electricity supply have harmed the region's economy. Threequarters of SSA firms experience power outages and reportedly lost an average of 8.3 per cent of their annual sales as a result. Due to the unreliability of electricity supply across the region, half of SSA firms own a backup generator, Carter and Musa (2017).

Generators typically supply one-quarter of these firms' total electricity, despite an operating cost that can be up to 10 times higher than that of on-grid electricity supplied by utility. The World Bank also estimated that it may take up to $60 billion in annual investments to address this rising electricity demand and ageing infrastructure. SSA's total installed electric power capacity is 100 gigawatts, or 98 MW per million people, far lower than in any other region of the world. CDC group (2016). By comparison, India has approximately 300 MW of installed capacity per million people, Latin America and the Caribbean have an average of 604 MW per million people, and the Middle East and North Africa have an average of 803 MW per million people. It is the quality of transmission infrastructure networks that determines the ability of any power delivery system to perform credibly well. There is a gap in SSA.

Table 1. Showing supply of electricity in some Regions 2017

Place	Power installed capacity	POPULATION
India	300MW	Per million people
SSA	100MW	Per million people
Latin American	604 MW	Per million people
Middle East and North Africa	803MW	Per million people

Author computation with data from Streatfeild (2018).

Looking at the above figure, one will conclude that SSA is still very far from other regions in terms of electricity supply. The fuel mix use in generating electricity in SSA is supposed to be cheaper when it is compared with other regions, because Coal accounts for 49 percent of production, large hydropower 20 percent, and natural gas 16 percent. Inadequate infrastructure and its maintenance, poor management, and systems planning, among other factors, make generation costs in SSA higher than in any other world region. Not only is utility-supplied electricity more expensive in SSA, but it is also in short supply. The fuel mix used to generate electricity in SSA is relatively inexpensive. Worldwide, coal, hydropower, and natural gas power plants offer some of the cheapest electricity production, and such plants largely comprise SSA's installed capacity:

Table 2. Showing energy mixed SSA 2017

S/N	FUEL TYPE	Percentage
1	Coal	49%
2	Hydropower	20%
3	Natural gas	16%

Author computation with data from   Streatfeild (2018).

Coal accounts for 49 percent of production, large hydropower for 20 percent, and natural gas for 16 percent. However, due to lack of infrastructure maintenance, poor management, and systems planning, among other factors, generation costs in SSA are higher than in any other world region.

However, firms in the region rely mostly on generators to fill the gap. The rates of generator use are very high for firms in South Sudan, Liberia, Chad, the Republic of Congo and Nigeria; firms in these countries use backup generators to supply at least 40 percent of their electricity needs, even though doing so, as noted earlier, can increase their electricity expenditures per kilowatt-hour (kWh) up to 10-fold. By contrast, backup generator use is comparatively low in several SSA countries with low GDP per capita, implying that high generator prices may limit demand in those markets (Streatfeild, 2018). System losses in sub-Saharan Africa are double the world average. These include technical losses from poorly maintained transmission and distribution networks and commercial losses from low revenue collection. Transmission and distribution losses are estimated at 18% across the region, when

South Africa is excluded (IEA, 2014). These losses increase the generation capacity that is required to meet load, making centralized generation uneconomical, exposing power companies to large financial risks, and increasing end-user tariffs.

The importance of electricity supply in enhancing economic activities and improving the standard of living of people in any country is indispensable and cannot be overemphasized. Sectors such as agriculture, industrial, health, household, and banking, for example, are virtually depending on electricity to be more efficient in their services. The capacity of subSaharan Africa to generate power is much lower than any other region of the world and has been stagnant for about three decades. This, in turn, has widened the gap between sub-Saharan African countries and the rest of the world. It is clear that Africa has the least power generation capacity among all the regions, despite the huge and rapid growing population in Africa that need more access to power supply; it requires more generation of power so as to meet the demand of the people. Estache and Garsous (2012) concluded that power or energy production presents the largest infrastructure gap for Africa, requiring nearly 40% to 60% of infrastructure investment.

Electricity access in Africa is hindered by the financial capability of utilities to meet supply and the ability of households to pay (Trimble, Kojima, Perez & Mohammadzadeh, 2016). In a well-functioning market, supply and demand converge at a price that satisfies producers and consumers. However, regulatory policies for electricity vary throughout the region, affecting supply. Some countries have separated production and transmission and allow independent power producers; other countries have state-owned monopolies. Independent power producers operate in 18 African countries, accounting for 13 percent of the region’s total generation capacity, and more countries are considering taking advantage of private sector investment to expand electricity supply

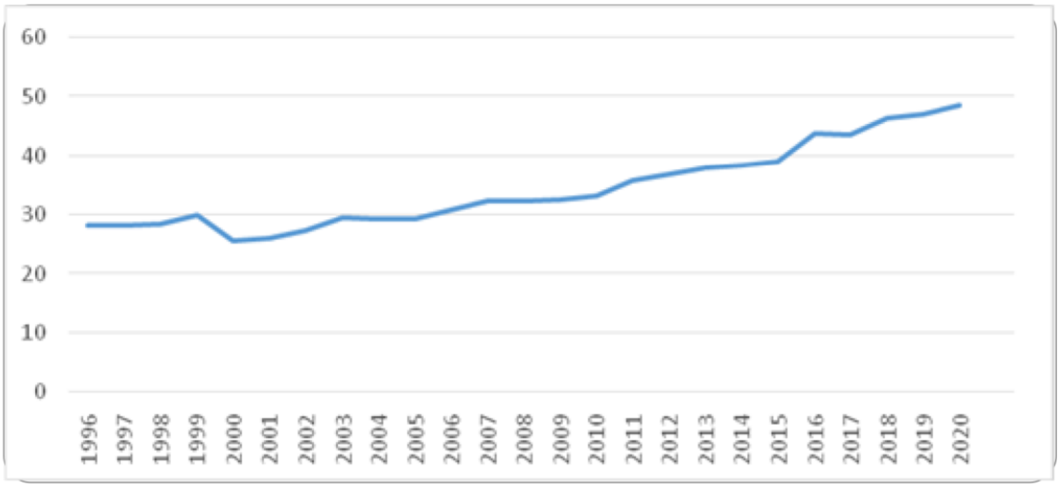
Eberhard, Gratwick, Morella, and Antmann (2017) opined that demand is affected by high costs, but poorly targeted subsidies are negatively affecting maintenance and investment (IMF 2013). If electricity markets function efficiently, it will facilitate private investment, and more countries could quicken the pace of electrification, as in Ghana, which has enacted some reforms to its electricity sector (World Bank 2017). Fixing this dysfunction of electricity markets will require improving the regulatory environment in most of the poorest performers in Africa, facing low electricity access. It is first necessary to find out the load requirement of the area where electricity is to be distributed. This depends on the nature of the area, the population of the town or village under consideration, the density of the population of the town or village population, the standard of living of the people in the locality, industrial development in the area and the cost of electric power.

Eberhard and Shkaratan (2012) opined that 93% of Africa's economically viable hydropower potential remains unexploited. Africa has the potential to generate 937 terawatts-hours (TWh) per year, constituting one-tenth of the world's total. Also, Africa is endowed with abundant solar and wind renewable energy resources, which could be harvested for growth. Experiences elsewhere suggest that the center-piece of successful electrification rollout is preparation and implementation of a national electrification strategy addressing a systematic and coordinated manner of the institutional, technical, and financial aspects involved in electrification A recent study (World Bank, 2017) finds that only half of 35 countries in Africa have officially approved electrification plans. Adequate regulatory framework will also help attract investment to fill the gap where public funding falls short. Electrification plays a crucial role in creating opportunities for income-generating activities. Though electricity is contributing to job creation and rising incomes, the overwhelming majority of the population can not afford meaningful usage with their current level of income.

Aligning electrification roll-out with job creation is also a crucial way to attract more investment and improve the financial viability of the sector, and take advantage of recent technological advances in off-grid solutions to strategically promote productive uses, especially in rural areas. This objective can be achieved through the adoption of cost-effective solar solutions that can provide sufficient capacity and reliability to support income-generating activities, such as off-season farming, value-added agro-processing, and promoting other small businesses (for example, hairdressers, eating establishments, tailors, and others).

Chinwuko (2011) argued that the distribution system is an important part of the total electric supply system, and it provides the final link between a utility's bulk transmission system and its ultimate customers (consumers). It has been reported in many technical publications that over eighty percent [80%] of all customer interruptions occur due to failures in the distribution systems. The problem of distribution system planning consists of determining the optimum numbers and locations of the distribution substations and the optimum way of connecting the load nodes to these sub-stations through the interconnection of feeders. There is a need to plot a load curve to give a clear view of what it takes to supply electricity in these areas. The load curve is a plot showing the variation of load with respect to time. The load curve of a locality indicates cyclic variation. Load curves are useful for both generation and distribution planning and enable station engineers to study the pattern of variation of demand. Load curves help to select the size and number of distribution units and to create the operating schedule of the distribution network. The yearly load curve shows load variation during the year, which is derived from monthly load curves.

Fig 1: Chart showing Electricity Supply in Sub-Sahara Africa Between 1996-2020



Source: Adopted from Alma, Mindaugasand and Vida (2022)

The average per capita electricity consumption in sub-Saharan Africa (excluding South Africa) is just 153 kWh/year. This is one-fourth of the consumption in India and just 6% of the global average. Uninterrupted power supply is crucial for the future growth rate of Africa. Achieving this will entail improving existing electricity supply channels and diversifying the sources of supply, especially in countries that rely heavily on hydro power. Ogudipe (2013) also employed lightning density as an instrument for power outages. In their results, they found that power outages lead to a reduction in the average annual growth of GDP in sub-Saharan Africa.

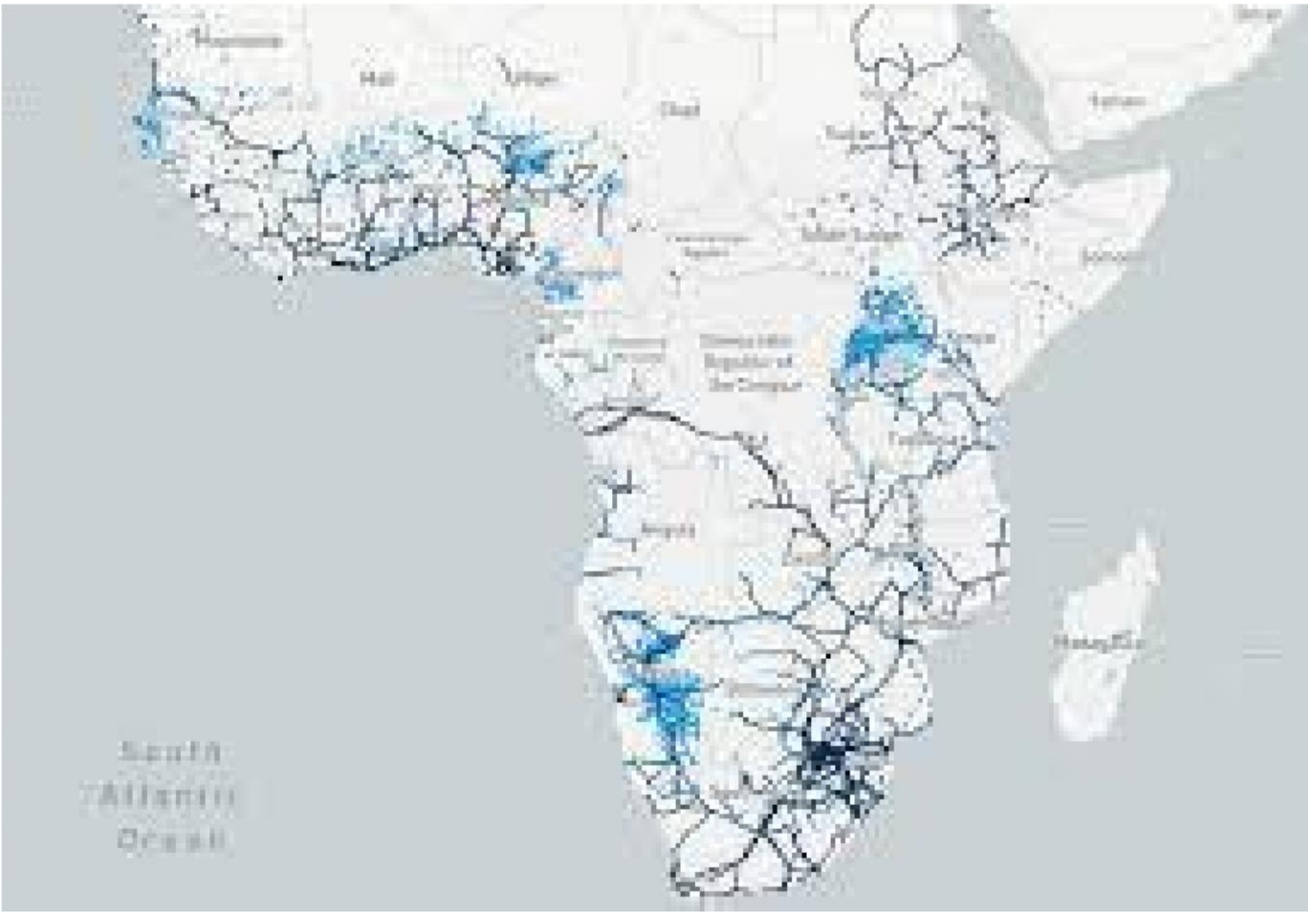
Blimpo, Postepska, and Xu (2020) argued that sustained progress in electricity access will need to go hand in hand with job creation and income generation. Productive uses of electricity enhance firms' and households' ability to pay. High capacity and reliable electricity are needed for productive uses that generate economic impact and financial benefits for the utility. Technological progress may soon give room to off-grid electricity systems, particularly those that can be powered by efficient motors, to provide enough electrical capacity for productive uses at a significantly lower cost. Off-grid systems would provide an opportunity for many African countries to leap-frog economic development, particularly in rural areas.

Even though alleviation of demand constraints will increase uptake, a large share of the population still cannot afford to connect or use a reasonable amount of electricity, let alone purchase appliances that can help generate income. Accordingly, it is essential to think beyond uptake and promote productive use through the provision of reliable electricity with adequate capacity.

Electrification plays a crucial role in creating opportunities for income-generating activities. Without electricity contributing to job creation and rising incomes, the overwhelming majority of the population cannot afford meaningful usage with their current level of income. Aligning electrification roll-out with job creation is also a crucial way to attract more investment and improve the financial viability of the sector (Blimpo *et al., 2020*).

The cost of electricity in Africa is the highest in the world, yet regulated tariffs are often below cost-recovery levels, contributing to reliability challenges. The maintenance and investment needed to provide reliable services are constrained. In 25 of the 29 countries in Africa with recent data, less than one-third of firms have reliable access to electricity. Demand and supply constraints to electricity access are interlinked. However, a significant share of the access gap can be explained by demand factors that vary in importance across countries. An analysis of 31 countries in Africa, carried out by Blimpo et al. (2020), reveals that pure demand-related factors account for about two-fifths of the access gap, with significant variations across countries and sub regions. Demand considerations account for 56 percent of the overall constraint in lower-middle-income countries, compared with 30 percent in low-income countries, where infrastructure development lags further behind.

Electrification is a long-term investment that lays the foundation for development. Countries that have the financial capacity plans and roll out electrification without delay.



Map showing transmission grids in SSA. Adopted from Western Counties history Britannica .com

2.1.6 Electricity Pricing and Consumption

The consumption sector has been getting electricity in lesser quantity in recent years, despite the fact that generation has been rising. The widening gap between electricity generation and consumption elucidates electricity losses in the form of line losses during transmission and distribution of electric power and unmetered electricity supply, i.e., theft. Sub-Saharan Africa has high income and wealth inequality (IEA, 2014), which results in vast differences in consumers' desire and willingness to pay for electricity. The cost of electricity also varies widely within the region, with South Africa and Zambia being among the lowest and Djibouti and Gabon being among the highest. Even among people who are connected to the grid, there are disparities in consumption. Despite being connected to the grid, some people cannot afford to consume electricity and thus cannot make use of modern energy services. They may also suffer disproportionately higher levels of service interruption, with no ability to depend on expensive on-site diesel generators like wealthier people in the same region. Avila, Carvallo, Shaw, and Kammen (2017). There are large differences and imbalances in world energy consumption, and there is a strong spatial correlation between socio-economic growth and per capita electricity consumption. Changes in economic structure will have a major impact on electricity demand and supply. China is in a period of rapid economic development, and research on the supply and demand stage of the domestic energy system is ongoing there. (Moussa et al., 2018).

Efficient mechanisms in price settings for different players of the market hold a very central position for a competitive power market. It is quite important to transfer the benefits of market competitiveness to all the players, including consumers. Failing to establish such an effective pricing system may entail less responsive consumption and supply variables, which are necessary for better functioning of the market competitiveness. Lack of an effective pricing mechanism may also discourage investors from investing in generation, distribution, and transmission networks, required to coordinate the flourishing market demand with supply.

However, according to the latest 'RISE' (Regulatory Indicators for Sustainable Energy) (2016) report, 17 out of 35 African countries do not have any officially approved electrification plan. An adequate regulatory framework will be needed to attract investment in all areas of the sector (generation, transmission infrastructure, distribution, and operational management) to fill the gap where public funding falls short. The private sector is needed to fill the investment gaps. Such investments could also target complementary factors that will help translate electrification into rising incomes and jobs. Potential complementary factors include a deepening of the financial sector or enhanced infrastructure, such as roads linking large cities and connecting communities to markets and large urban centres. Avila et al. (2017) reported that the cost of electricity shapes the services people use and their demand for electricity. If electricity is costly, households will use it only to access services that are highly necessary, that require just little amounts of energy, and that can only be provided by electricity. As a result, the services any household is willing to access are related to the generation technology that determines the price of electricity.

An analysis of 31 countries in Africa (Blimpo et al., 2018) reveals that pure demand-related factors account for about two-fifths of the access gap, with significant variations across countries and sub regions. Demand considerations account for 56 percent of the overall constraint in lower-middle-income countries, compared with 30 percent in low-income countries, where infrastructure development lags further behind. To make electricity expansion financially viable and to encourage investment, uptake and utilization need to be higher. For example, if all households living within range of the electrical grid were connected to the grid, access rates would be well over 60 percent, on average, in Africa and nearly double the current rate in many countries.

Why are these households not connected, and what kind of incentives would get them connected? This situation underscores the need for a deeper understanding of demand-side constraints to uptake. Low uptake is affected by the maximum amount people are willing to pay. For example, when households in Rwanda were offered three price and payment options, 88 percent did not accept any of the options. When disaggregating the results by social and economic status, using a wide range of variables, uptake was low nearly across the board.

Similarly, willingness to pay in Liberia fell from 90 percent to 60 percent when the connection charges moved from zero to US$10; it fell to about 10 percent when the proposed connection charges exceeded US$50.

Blimpo et al. (2018) explained that uptake is not always feasible for consumers because they face multiple constraints. Framing the demand for electricity in Africa from the standpoint of basic consumer theory helps organize potential constraints to uptake under three related categories: (1) price, (2) household income, and (3) the expected benefit from electricity uptake. Connection charges and the process of getting connected are critical entry point barriers that suggest an important policy lever for higher uptake, but they are often not fully understood. Connection charges are, on average, high relative to the level of income in most countries. As evident from 10 countries in Africa, focusing on recently connected households, 3 factors play out: (1) the connection requirement and process are often standard and not designed to alleviate the constraints that the poor face; (2) the process entails long waiting times, often exceeding 10 weeks; and (3) although the cost of connection is often thought of as fixed, there are significant variations across households within the same country when wiring and transaction costs are considered. The variation tends to be regressive, thus exacerbating affordability for the poor (Blimpo et al., 2018).

Although the level of income matters for uptake, income flow and predictability are tied to households' willingness to connect to electricity services. A recurring payment of even a small amount can constitute a major problem for households that generate their income on an irregular basis. Prepaid meters can play a crucial role in circumventing this constraint. Flexible mechanisms for bill payment, mirroring income fluctuations, could further address this issue. Electricity connection via conventional AC (alternating current) supply requires minimum building standards that many existing houses do not meet. There are technologies, such as ready boards, that make it possible to connect even substandard houses. Coordination between regulators in the housing and electricity sectors can help ensure that the requirements for building permits conform to the standards required for electrical connection.

2.1.7 Economic Growth

Economic growth is described as an increase in the total national income of a country. Pietak (2014) reported that the classical economists expressed that the determinants of economic growth are investments and improvement in productive capacity. In addition, the neo-classical highlighted three factors of economic growth as land, labour, and capital. The greater the utilization of these economic growth factors, the greater the economic growth. The main works of economic growth emerged in the twentieth century from the bullionism and mercantilism but remained unexplored; but was held that the wealth of a nation remain the endowed natural resources. The Physiocrats followed the mercantilists. The Physiocrats opined that agriculture is the sector of the economy which produces the 'pure' product. It was the Physiocrat Quesnay who created the economic table that described socio-economic relations, showing the essence of the pure product. The words "laissez faire, laissez passer (let me work, let me go ahead) which was spoken in one of the meetings of Physiocrats led to economic liberalism.

Pietak (2014) expressed that Sala-i-Martin (2001) distinguished factors that determine growth as: accumulation of physical capital, human capital, and education, diversity of institutions favourable to the economy, and free mobility of capital, technology, ideas, foreign investment and the free flow of information. Pietak (2014) further expressed that Solow (1957) narrowed economic growth factors to technical development while Sala- Martin (2001) pointed to several factors. There is a common assertion on elements that determine growth among the classical such as production by Smith and Ricando, sharing the "Law of markets" by Jean-Baptiste Say.

Marx presented the role of supply in the process of economic growth, but disagreed with Smith and Ricardo on Say's "Law of markets". Malthus presented the role of effective demand in the process of economic growth thus. Sharing the views of Keynes.

2.20 **Models of Economic Growth**

Models of economic growth are based on classification and aggregation of the causes of economic growth. Models of economic growth holds that depreciation rates for capital and population growth are both exogenous. Models using the savings rate can be divided into two groups. The first model takes savings rate as exogenous an example is the Harrod-Domar model, models using the production function AK, and the neoclassical models of Solow and Uzawa. In the second model, savings rate is taken as endogenous an example is neoclassical model of Ramsey, and the models of Kaldor and Pasinetti, being models set on the scientific achievements of Keynes. Models can further be divided based on capital ratio, an example is the Harrod-Domar and the AK models which assume constant value. Models can change overtime this example is the ratio of capital/production in neoclassical models.

Economic growth models can further be divided based on the criterion of time; the long- term model and the short-term model. Long-term models are models employed in determining the path of sustainable growth. Long-term models are characterized with a pattern on how the economy should grow. In short-term models, purpose is to identify the possibility of having the level of actual production approach the level of potential production. The scientific achievement of Keynes is an example of short-term model.

Harrod-Domar Model.

The Harrod-Domar model sought possibility for sustainable growth by extending the short term Keynesian model that takes the assumption of instability of the capitalist economy. In this model, growth can become sustainable when equality exists among three growth rates. These growth rates are actual growth rate, guaranteed growth rate, and natural growth rate.

The equality in these growth rates is referred to by Harrod as the "golden age". This is the condition of the full utilization of capital and labour. This condition is difficult to fulfill because it requires equalization of savings which depends on household and investment in the hands of the capitalists. The model stressed the necessity of investment in the economy. This is inadequate in SSA countries as they are regarded as poor economy. This showed that there is no mechanism to balance these three growth rates, thus, rate of growth with full employment becomes impossible and hence the need for adequate infrastructural facilities that will create the enabling environment for investors and at the end a more productive economy that will encourage economic growth even in SSA countries.

2.21 **The Nexus between Electricity Supply and Economic Growth in Sub-Saharan Africa**

The importance of electricity in enhancing economic activities and improving the standard of living of people in any country is indispensable and cannot be overemphasized. Sectors such as agriculture, industrial, health, household and banking, for example, are virtually depending on electricity to be more efficient in their services. Akinlo and Apanisile (2014) studied the impact of electricity on economic growth on 30 Sub-Saharan Africa countries using data of twenty year, panel data was used for the analysis. The result shows that electricity consumption has a positive and significant impact on economic growth.

Inadequate provision of electricity services has long been regarded to be a major obstacle to economic growth in SSA, this situation has forced many people, industries and enterprises to rely on alternative source of power such as expensive diesel power generator, in order to meet the demand of their customers. 1

According to Akinlo and Apanisile (2014), the worst hit people are the rural populace and the urban poor who have lost their businesses and enterprises due to power failure, as they could not secure alternative means of power supply. This has increased the rate of unemployment in SSA. There is a link between electricity supply and poverty, if the rate of unemployment is higher it will always have a negative impact on the standard of living which will also affect the level of productivity that will impact on economic growth. Manufacturing enterprises' experience of power outages in sub-Saharan Africa is on average 56 days per year, while a typical power security standard in the United States is one day in ten years. In comparing subSaharan Africa to other regions of the world, the capacity of sub-Saharan Africa to generate power is much lower than any other region of the world and has been stagnant for about three decades. The average per capita electricity consumption in sub-Saharan Africa (excluding South Africa) is just 153 kWh/year. This is one-fourth of the consumption in India and just 6% of the global average. Nearly 600 million people in Africa do not have access to electricity. According to them, at 68 GW, the entire generation capacity of the 48 countries of Sub-Saharan Africa is not more than that of Spain. Furthermore, if South Africa is excluded, the total falls to a mere 28 GW, equivalent to the installed capacity of Argentina. As much as 25% of the 28 GW of installed capacity is not currently available for generation, owing to a variety of causes, including ageing plants and lack of maintenance. Ironically, sub-Saharan African countries are endowed with various sources of electricity such as water. This adversely affects productivity and regional economic growth.

In spite of the fact that Sub-Saharan Africa has witnessed significant increased economic growth over some years, there has been no significant improvement in the people’s access to electricity. Akinlo and Apanisile (2014) pointed out that African countries face regular and frequent blackouts due to insufficient generating capacity, especially at peak load; weak infrastructure; minimal expansion of generation and transmission facilities; unreliable supplies; and increasing costs of fossil fuels. These adversely affect productivity and regional economic growth. An increasingly common response to the energy crisis has been the short-term lease of emergency power generators, which is not only expensive but also impacts the sustainable development of the region. In addition, the African electricity grids lack interconnections, which would facilitate network management and have a positive impact on electricity distribution and availability. For Sub-Saharan Africa (SSA) to develop and industrialize in a viable manner, there is a need to address the challenge of infrastructure in the region. Electrification in Africa needs to focus on enhancing the economic capabilities of communities as the best way to achieve faster and sustainable development progress, while at the same time addressing broad challenges (including affordability, low consumption, and financial viability of utilities) and ensuring equitable provision between urban and rural areas. Rapid progress in electrification requires that governments rethink their strategies for the sector, based on the key fundamental principles discussed as well as being conscious of key trends that may affect electrification rollout.

Table 4. Comparing electricity generation in regions of SSA. E.g. Central Africa. East Africa, West Africa, Southern Africa, in production of electricity % of megawatt. 2016

Regions in SSA	Electricity Generation by grid	Cost of Generation ($)
Central Africa	4GW	$95 per MWh
East Africa	8GW	$110 per MWh
West Africa	20GW	$140 per MWh
Southern Africa	58 GW	$55 per MWh

Author’s computation Data from (Avila, Carvallo, Shaw & Kammen (2017)

Southern Africa has more installed grid generation capacity than the rest of sub-Saharan Africa. 80% of total generation is in South Africa alone (58GW). West Africa’s grid generation capacity is estimated at about 20 GW. Of this capacity, East Africa has grid generation capacity of about 8 GW and Central Africa has the lowest grid generation capacity in sub-Saharan Africa, The cost of generation is lower in Southern Africa where they have the largest generation capacity and higher in those places where generation is lower. This is due to their generation mix. Southern Africa generates with low-cost coal and hydropower, while West Africa depends on expensive gas and oil for generations (Avila et al., 2017).

Sub-Saharan Africa faces an electricity gap in two senses: a mismatch between supply and demand in grid-connected regions and a lack of access in off-grid regions. Closing sub-Saharan Africa's electricity gap is a multidimensional challenge with important implications for how to frame the region's energy problem as a whole. Sub-Saharan Africa has high income and wealth inequality (IEA, 2014). The African electricity grids lack interconnections, which would facilitate network management and have a positive impact on electricity distribution and availability. Despite being connected to the grid, some people cannot afford to consume electricity and thus cannot make use of modern energy services which has a negative effect on their income generation.

Demand and supply constraints to electricity access are interlinked. However, a significant share of the access gap can be explained by demand factors that vary across countries. An analysis of 31 countries in Africa (Blimpo, Postepska, and Xu, 2018) reveals that pure demandrelated factors account for about two-fifths of the access gap, with significant variations across countries and sub-regions. Demand considerations account for 56 percent of the overall constraint in lower-middle-income countries, compared with 30 percent in low-income countries, where infrastructure development lags further behind. To make electricity expansion financially viable and to encourage investment, uptake and utilization need to be higher. For example, if all households living within range of the electrical grid were connected to the grid, access rates would be well over 60 percent, on average, in Africa and nearly double the current rate in many countries. Why are these households not connected, and what kind of incentives would get them connected? This situation underscores the need for a deeper understanding of demand-side constraints to uptake.

Low uptake is affected by the maximum amount people are willing to pay. For example, when households in Rwanda were offered three price and payment options, 88 percent did not accept any of the options. When disaggregating the results by social and economic status using a wide range of variables, uptake was low nearly across the board. Similarly, willingness to pay in

Liberia fell from 90 percent to 60 percent when the connection charges moved from zero to US$10; it fell to about 10 percent when the proposed connection charges exceeded US$50.

Uptake is not always feasible for consumers because they face multiple constraints. Framing the demand for electricity in Africa from the standpoint of basic consumer theory helps organize potential constraints to uptake under three related categories: (1) price, (2) household income, and (3) the expected benefit from electricity uptake. Sustained progress in electricity access will need to go hand in hand with job creation and income generation. Productive uses of electricity enhance firms' and households' ability to pay. High capacity and reliable electricity are needed for productive uses that generate economic impact and financial benefits for the utility. Technological progress may soon allow off-grid electricity systems, particularly those that can be powered by efficient motors, to provide enough electrical capacity for productive uses at a significantly lower cost. Off-grid systems would provide an opportunity for many African countries to leapfrog economic development, particularly in rural areas. Even though alleviation of demand constraints will increase uptake, a large share of the population still cannot afford to connect or use a reasonable amount of electricity, let alone purchase appliances that can help generate income. Accordingly, it is essential to think beyond uptake and promote productive use through the provision of reliable electricity with adequate capacity. Electrification plays a crucial role in creating opportunities for income-generating activities. Without electricity contributing to job creation and rising incomes, the overwhelming majority of the population cannot afford meaningful usage with their current level of income. Aligning electrification rollout to job creation is also a crucial way to attract more investment and improve the financial viability of the sector.

According to Elburz, Nijkamp, and Pels (2017), reliable electricity can contribute to increasing uptake. Reliability of electricity is positively associated with uptake across and within countries. Countries with high uptake of electricity also tend to have a higher level of reliability and vice versa. Investment to address reliability should be given higher priority because poor quality poses a significant constraint on economic impact as well. The quality of services may be worse than what is perceived and differences in the level of quality mirror income inequality. Without adequate quality, the economic impact of electricity will be significantly constrained even when all complementary factors are in place. Low economic impact caused by inadequate quality will also contribute to keeping demand and uptake low. This effect is also true for offgrid electricity solutions, where capacity, durability, and reliability are crucial to household uptake. Impact is affected by reliability.

Analysis of firm data indicates that for every percentage point increase in the frequency of electricity outages experienced by firms, output declines by 3.3 percent. Similarly, the effect on firms' revenue is nontrivial: a percentage point increase in outage frequency results in a 2.7 percent loss in firm revenue. Countries in Africa could increase tax revenues by more than 4 percent per year solely by resolving issues related to the reliability of electricity. The provision of quality infrastructure services, such as reliable electricity, is a mechanism through which governments in developing countries can enhance tax revenues. Evidence suggests that connection to the grid can potentially signal government's commitment to the provision of social infrastructure and services and thereby reinforce the sense of an implicit fiscal pact between citizens and their governments. The impact of the reliability of electricity on taxation occurs through two channels: the effect on citizens' incentive to pay taxes, and tax revenue losses caused by the negative impact of outages on the productive sectors of the economy.

2.22 Influence of Infrastructure and Electricity Supply on Economic Growth

The contribution of infrastructure to economic growth has been established by earlier literatures (Baita et al., 2020; Ekeocha, Ekeocha, Malaolu & Oduh, 2012), with additional literature on the symmetric effect of physical infrastructure on poverty and inequality (Calderón and Servén, 2008) argued that existing literature on the relationship between infrastructure and economic growth is not conclusive. Elburz, Nijkamp and Pels (2017) and Timilsina, Hochman, and Song (2020) concluded that there is no relationship between infrastructure investment and economic output using data on industrialized economies, particularly in North America, and Timilsina et al. (2020) reviewed a large body of literature and concluded that no consensus existed on the impact of infrastructure investment on economic growth, while others like Chakamera and Alagidede (2018) and Kodongo and Ojah (2016) found causality with differences in results associated with the use of variant methodological differences, infrastructure measurement, and variations in regional characteristics and density (Elburz et al., 2017; Timilsina et al., 2020). Some existing studies show a strong positive relationship between infrastructure development and economic growth. Press, USA (Kurniasih, 2020; Samir & Mefteh, 2020), whereas others find a mildly positive relationship, claiming it is not a sufficient condition for development (Timilsina, Stern, and Das, 2021). Akinlo and Apanisile (2016) describe public infrastructure as the following: physical installment like highways and roads, airports, telecommunication facilities, water supply system, electricity, waste treatment facilities, as part of residents' consumption bundles that augment capital and labour which are input in the production processes. (Ayogu, as cited in Odongo and Ojah 2016), argued that access to infrastructure promotes human development and better quality of life that will impact sustainable economic growth.

The relationship between infrastructure and economic growth has been intensively discussed by scholars in different fields. This is to show that it is important in any growing economy. Researchers have utilized various approaches based on their objectives. Kumo (2012) gave four approaches to explain the mechanism of infrastructure that contribute to economic growth: production functi0on approach, cost-function approach, growth –model approach, and causal relationship approach. These can be pointers to identify how infrastructure can boost economic growth. Based on the production function approach, infrastructure is one of the production factors that directly contribute to the production process and its outcomes. Secondly, infrastructure complements other production factors, and its improvement can reduce the cost of production. For example, road improvement can reduce the cost of production logistics. Thirdly, infrastructure can stimulate multi-factor productivity since it provides facilities for other production factors, for example, human capital development.

Moreover, investment in infrastructure can enhance aggregate demand as a result of increased construction expenditure and maintenance operation. According to Kumo (2012), the development of infrastructure can influence industrial policy since the government may distribute investments to specific infrastructure projects, which may affect private-sector investment decisions. Torisi (2009) used a causal relationship approach based on the Vector Auto regression (VAR) model, and the Granger causality test concluded that infrastructure development and economic growth can affect each other. IT can boost economic growth at any level of the economy (micro, regional, or national). Infrastructure alone cannot guarantee the desired economic growth, but it can create an atmosphere that can encourage growth. However, most of these infrastructures are interrelated and depend on each other to function effectively. Most of these infrastructures depend on an adequate supply of electricity to function. Information communication technology needs power, power is used to operate water pumps, good transport systems pave ways for more connectivity of electricity to large consumers, and it can reduce the cost of doing business.

The administration of transportation, energy, and water supply are serviced by the ICT system (Kallal, Haddaji & Ftiti, 2021). New infrastructure development can even reduce unemployment. Investment in infrastructure can increase total fixed capital and directly impact GDP growth. Infrastructure investments are said to be usually directed to infrastructure construction or overhaul, leading to increased demand for construction workers and rising overall employment levels (Meersman and Nazemzadeh, 2017). Scholars have argued that the provision of adequate and quality infrastructure promotes trade and commerce that is capable of alleviating poverty in SSA. Infrastructure deficits are seen as a constraint to traditional antecedents of economic growth. As important as infrastructure is to boosting economic growth, SSA is still lagging behind in its required level that will support the desired production, that will support the require development, that will reduce poverty to a bearable level. Investment in transport infrastructure increases connectivity, and at the long run, leads to economic activities that can simulate increased resource flow, which will enhance market acceptability, which will encourage innovations and technological progress. Wang, Lim, Zhang, Zhao, and Lee (2020) submitted that an increase in connectivity can impact cost by reducing it, which leads to improvement in productivity and efficient use of recourses. It can also promote industrial agglomeration that leads to technological spillover and raises competition and economies of scale, which may positively influence energy and other resource efficiency. On the other hand, energy efficiency can directly depend on energy infrastructure conditions. Its improvement will reduce energy losses. This will reduce its consumption and even increase its price. Azevedo (2014) argued that energy consumption by the households and business sector can boost GDP and reduce energy prices that will generate savings in all sector, which can become investments in other innovations that can reduce cost and encourage savings. Energy infrastructure is often considered essential among other critical infrastructure types because all economic activities depend on energy.

Insecurity, Corruption, Maintenance Culture, and National Debt

According to Akeju et al. (2022), the contribution of infrastructure to economic growth has been established by earlier literature (Baita et al., 2020; Ekeocha, et al., 2012) with additional literature on the symmetric effect of physical infrastructure on poverty and inequality. The nonavailability of reliable electricity supply in SSA reportedly undermines the region's economic performance. Electricity reliability (as defined by countries' "Quality of Electricity Supply" score) is closely and positively correlated with GDP per capita, and electricity reliability in many SSA countries is relatively low. Managers of manufacturing firms in SSA are more likely to highlight electricity shortages as their biggest production constraint.than managers in other world regions. Azevedo (2014) estimates that power outages are associated with an average loss of 5 percent of firm sales across SSA. The extent of lost sales varies across the region: lost sales rates are particularly high in the Central African Republic, Ghana, and Nigeria, while Eritrea, Liberia, and Rwanda have some of the lowest loss rates among countries at their income level. Similarly, the World Bank Enterprise Survey reports that exporting firms in SSA countries that experience electrical outages lose 7.5 percent of their annual sales due to these outages.

2.2 Theoretical Review

2.23 Solow Growth Theory

This theory was propounded by Robert Soiow and Trevor Swan in 1956. Theoretical economic growth thinking begins with the Solow model, which explains aggregate income based on aggregate capital and labour. Since capital exhibits diminishing marginal returns, long-run growth is explained by population growth and technological progress, both of which are exogenous. This general model, which has been revised to include several variables, notably government spending (infrastructure), human capital, protection of property rights and market distortions Barro (1990), has been criticized on several grounds including its failure to explain technological progress and cross-country income differences. These deficiencies have motivated the development and burgeoning empirical applications of endogenous growth models. This theory is in line with the findings of this study that technology development in form of infrastructural development in this study is the driving force of the kind of development that Africa need to enhance productivity that will encourage sustainable economic growth,

2.24 Endogenous growth Theory

This theory was propounded by Paul Romer in the 1980s. Barro (1990), one of the earliest contributors to theoretic endogenous growth modeling, argues that the government's contribution to current production is driven by its flow of productive (infrastructure) expenditure, which can prevent diminishing private-sector capital returns, raise the marginal product of private-sector capital, and these in turn raise the rate of output growth. There is a need for incremental infrastructure investment/development. This theory emerged in the

1980's with a view different from that of the neo-classical. The theory as put forward by David Romar argues that economic growth that comes within a system due to the nation's human capital will result to a greater growth through the channels of development of new kinds of innovations in technology and higher efficient means of production. This theory is relevant to this study in the sense that internal development of Africa human resources will stimulate productivity within, to achieve this there should be conscious effort on the part of the government and private sectors to invest massively on infrastructure in our educational institutions.

2.25 Modernization Theory

This theory is propounded by Walt Rostow (1971) and focuses on the relationship between education and its impact on people's beliefs, values and how they are exposed to modernization institutions like factories, schools, as well as mass media, through which individuals imbibe attitude. This attitude is in the form of access to new ideas and willingness to act independently from traditional laws. This will help the individual to develop a superior perception of personal and social worth. The proponent of this theory believed that this change of attitude will keep occurring through individual life cycle and will perpetually influence people's mode of relationship with the structure of social environment. Consequently, the more an individual becomes exposed to the institution of modernization, the more would be the level at which the society attains individual modernity. In addition, as more population of individuals attains modernity the society would achieve increase economic development. This occurs because more people have been exposed to education, and their values and attitudes change, leading to improvement in the productive capacity of individuals. This bring to mind the need for more investment on infrastructure that will accommodate these civilized population and better utilization of their potentials for economic growth which is part of the findings of this study.

2.1.8 Economic Growth Theories

In the analysis of the theory of economic growth, Pietak (2014) stated that joseph Schumpeter contrary to the classical did not consider capital accumulation as a major factor of economic growth but developed the concept of entrepreneur-innovator, assigning great importance to it.

Schumpeter, held the entrepreneur-innovation as a “hero of development”; opining that the innovation and creativity of entrepreneur determined economic development. The introduction of an innovation result in profits for the entrepreneur, but with time competition due to the presence of other substitute invention causes profit to reduce. The theory of economic growth as proposed by Schumpeter is based on the assumption of private property, a competitive market, and the efficiency of financial markets that is able to support production of new innovations. It is asserted that in countries lacking a democratic system, these assumption are not frequently met. Many SSA countries lack democratic system.

Another theory of economic growth was purposed Arthur Lewis. The theorists looked at the problem of poor countries with rich labour force; proposing the maintenance of a low level of life in short run. The saving obtained will contribute to increase in the stock of capital, and in the long run will lead to growth in income. The model Lewis proposed tended to enlarge differences between countries in the short run as a condition for equality of income level in the long run. Lewis bought into the overall vision of the classical economists, but disagreed with the diagnoses and method of the classical. Many SSA countries are facing the problems of low savings, decrease in capital stock; thereby becoming unable to attain equalization of income with developed countries of the world in the long run. Economic Growth and Economic Development

Economic growth is a prerequisite for economic development. Development as it relates to economic advancement has an entire multitude of yardstick and a multifaceted concept. There are factors regarded as fundamental elements of development in any given society. These factors are: improvement in health, growth of wealth, creation of new knowledge and technology. Development is a qualitatively higher step of macro-economic evolution. It is regarded as an increase in the national income per head of population. It is asserted that economic development pertains to the economy of each country, but its effect at a world level is particularly important Macaver (2018) and Reyes (2001) attested that development is a much broader concept and is described as sustained economic growth that is coupled with structural and institutional changes in the manner society plans production and distribution of goods and services, equity in the distribution of the output of the society, access of the people to food and non-food necessities of life and progressive reduction or non-increase in the incidence of poverty.

Economic development is integrated in appropriate social systems with high democracy and culture, good economic governance, efficient higher education, and high innovative output Economic development is not just about income since by definition, economic development is not identified by the level or growth of per capita income. Economists have generally accepted that economic development broadens to include removal of poverty and under-nutrition, increase in life expectancy, assess to sanitation, clean drinking water and health services, and reduction in infant mortality, increased access to knowledge and schooling and literacy in particular. Economic development has been described as the process that generates economic, social and technical progress of nations. (Coccia, 2019; Me Connell & Brue, 1999, Samuelson & Nordhaus, 1989).

These features of economic development follow in some natural way from the growth of per capita income with the passage of time. Economic growth concerns the quantitative side of economic activity, that is, the increase of results, of quantities of sizes while economic development is the qualitative change that takes place in economy and society (Haller and

Homania, 2012) Countries of the world have pursued and are attaining economic growth Globaliy inequality exists in the level of economic development and Sub-Saharan Africa in fering the challenges of poverty, famine, insurgency, and wars. Post-independent SSA is faced with widespread economic under development couple with varying proportions in economic growth (Hoedemakers, 2016). The minimal requirements to be considered in the measurement of development are a high uniform physical quality of life, physical fighting freedoms, intellectual and cultural development, stability of the family, a low crime social civility and so on, a high and widely accessible level of material well-being.

Economic development cannot be identified in a definitional sense with the level of growth of per capita income, since development goes beyond income, or the economic wealth

Development is broadly inclusive of poverty removal, under-nutrition eradication, increase in life expectancy, and access to sanitation, clean drinking water and medical services, production of infant mortality, increased access to knowledge, schooling and literacy. There are two sets of connection in economic development.

i. The connection between economic attainment and development, this connection studies the causes of growth in the average levels of income and other indicators.

ii. And the connection between distribution of economic attainment, across the citizens of a nation or a region and across the nations of the world and influence on development. Therefore, these two broad interrelationships known as levels of income and distribution of income are two routes to the study of the features of development according to Haller (2012) further accepted the no-unanimous definition of economic development and claimed that most theoreticians accepted that economic development is a process that generates economic and social quantitative and qualitative changes that causes the national economy to increase in its real national product cumulatively and durably, Economic development is the impact of economic growth on the society through the increase in the standard of life of the people. Economic development is a larger scope that is inclusive of the qualitative changes that take place in the economy and society. It entails a qualitatively higher step of macro-economic evolution. Haller (2012) opined further that a qualitatively higher step of macro-economic evolution is development. Haller further stated that the growth theories are discussed in reference to the developed countries while the theories of development are discussed in reference to the economic problems that are specific to the less developed countries.

Mouhammed (2011) opined that Schumpeter (1934) asserted that economic development generates changes in the socio-economic environment, inclusion of the existing equilibrium. Further, development can be regarded as changes in economic life that are not externally determined but internally initiated. If no changes arise the economy adapts itself continuously to them, then we can say that there is no economic development. To Schumpeter, according to Mouhammed, development primarily entails employing existing resources in a different way by doing new things with them, whether or not, these is crease in those resources.

Economic growth in SSA has improved in recent years, compared to what it used to be a few years back. The irony of it is that it is not impacting on the standard of living of the common man. The growth is numerical and is not making the kind of developmental impact that will justify the figures because access to basic needs is still very low when compared to other developing regions. Economic growth means a sustained economic improvement in productivity. This can only happen in an environment where technology, man power development (in terms of education, healthcare, accommodation, security, and life expectancy ratio are high. Odongo and Ojah (2016) calls the attention of countries to the maintenance of political and stable macroeconomic objectives that will create a favorable environment for business in order to attract investors; adequate human capital, functioning financial market and infrastructure. To achieve reasonable economic growth rate, power generation capacity must be equal to economic growth rate to meet demand.

Funlayo, Jeremiah & Thomas (2022) posit that economic growth and performance vary across the African region. East Africa posted the highest growth rate of 5.5 percent in 2019 and

South Africa stood at 0.3 percent, alluding to a decline in structural transformation and increasing unemployment while North, Central, and West Africa had GDP growth rates of 4.0, and 3.6 percent, respectively. In 2020, estimated GDP growth was negative except for the East African region, which stood at 0.7 percent. This is because countries in East Africa responded swiftly to the Covid-19 pandemic, including enforcing lockdown protocols and devising alternative survival measures while in lockdown. Nevertheless, South Africa had the highest negative growth rate of 7 percent as it was hit hard by the Covid-19 outbreak.

2.19. **The new economic growth theory**

This theory was propounded by Walt Rostow. In Rostow's theory of

stages of growth model, economic growth and development was dependent on capital accumulation, and there are five stages of development. Mbah and Ojo (2020) observed the Rostow (1960), hypothecate five stages of transition from underdevelopment to development. These are traditional society, preconditions for take-off, take-off, drive to maturity, and age of high mass consumption. The third stage which is the "take off" is the biggest challenge poor countries face, and many SSA countries are poor. They are faced with this problem. Hence, this study itemized those infrastructures that need to be invest in to enable developing countries in Africa overcome those challenges associated with this stage of development that they are now.

2.26 Empirical Literature Review

The bulk of the empirical literature on the effects of infrastructure focuses on its long-run contribution to the level or growth rate of aggregate income or productivity. Odongo and Ojah (2016) argued that many studies have found a positive long-run relationship between infrastructure and economic growth. Whyte et al. (2020) puts it that results of analysis of different approaches to infrastructure also reveal that infrastructure are facilities and systems that are the basis for society's prosperity, provided by governments for public use; that can be distinguished as soft and hard. They see infrastructure as essential for the economy and society and treat it as core infrastructure. Davidmac *et al.* (2022), this study examined the effects of both aggregate and disaggregated infrastructure development Indices (such as transport, electricity ICT, and water and sanitation infrastructure indices) on economic performance in Africa. The study established that both aggregate and disaggregated infrastructural development Indices impact positively on GDP per Capita growth in Africa. Davidmac et al.

(2022) posited that infrastructure development has a significant impact on GDP per capita growth in Africa. This was also in line with the findings of other recent studies in extant literature. Like (Fayissa & Nsiah, 2013; Calderon, Cantu, & Chuhan-Pole, 2018; Ehigiamusoe, 2021). These impacts were shown to be significant in all cases, except for the transportation infrastructure index. Alma et al. (2022) discussed different approaches to the relationship between infrastructure and economic growth. They developed a theoretical model for evaluating infrastructure impact on economic growth and convergence. Based on the neoclassical approach, the study specified an econometric model that includes indicators of different types of infrastructure and assessed growth and convergence outcomes of infrastructure development It also confirmed that infrastructure has positive effects on growth and convergence but the estimated impact is not statistically significant except for some types of ICT and transport infrastructure. Apurv and Uzma (2020) argued that there is a statiscally significant relationship between infrastructure development and economic growth, and advocated for more electricity generating capacity which is identified as the infrastructure stock index that has the greatest positive impact on Ghana's economic growth.

Moussa *et al.* (2019) pointed out that access to reliable electricity is the backbone of any modern economy. It is even more important with the digital revolution. If African nations intend to see their economies transformed, the issue of electricity must be tackled head-on.

Akinlo and Apanisile’s (2014) study reports take a broader look at the issue to show that the problem in Africa is not power but poverty. Reliability, affordability, and coordination are the links missing between making utilities viable and expanding their consumer base. Reliability and affordability go hand in glove: blackouts and brownouts are common in Africa. Reliable electricity would persuade consumers that electricity is a service worth paying for, and more consumers would bring down the cost of producing electricity.

Chengete and Alagidede (2018): this paper examines the effects of growth of infrastructure stock and quality in Sub Saharan Africa (SSA) based on infrastructure quality and a robust analysis on the causal links between infrastructure and economic growth. Using principal components analysis to cluster different infrastructure measures and examining the infrastructure growth nexus in a generalized method of moments results, reveal strong evidence of positive effect of infrastructure development on economic growth with most contribution coming from infrastructure stock. But the quality growth effect was weak. However, that longterm quality effect is higher than the short-term. Among the disaggregated infrastructure components, electricity supply exerted the greatest downward pressure on growth in SSA.

Sachs et al. (2021) opined that to achieve sustainable development objectives by 2050 in Africa, all Africans-whether living in Urbana or rural areas need access to affordable, clean, efficient, reliable, climate proof, and renewable energy for both residential and productive uses.

The Russian war on Ukraine in 2022 has reinforced the determination of Europeans and Americans to wean off Russian gas in the short term and all gas in the medium to long term, seeing in the energy transition an opportunity to meet parallel goals of decarbonization which is electricity.

Streatfield (2018) argued that electricity supply is lower and costs are higher in Sub-Saharan Africa (SSA) than in any other world region. That several SSA countries have sought to address this issue through cross-border trade and investment in domestic infrastructure, yet their efforts have been greatly impeded by the high degree of system losses-the difference between output and sales of electricity, as well as by electricity tariffs that are too low to recover utilities' cost. Rohit and Shigufta (2022) argue that the results of the study are mixed and that the association between infrastructure investment and development and economic growth for countries within BRICS is not robust. There was an insignificant relationship between infrastructure investment and development and economic growth in Brazil and South Africa. Energy and transportation infrastructure investment and development lead to economic growth in Russia.

Telecommunication infrastructure investment and development, as well as economic growth, have a negative relationship in India, whereas there is a negative association between transport infrastructure investment, development, and economic growth in China. The study used the ordinary least square regression method and applied it to panel data techniques to examine it.

The starting point was Aschauer's (1993) finding that the stock of public infrastructure capital is a significant determinant of aggregate TFP in the U.S. However, his estimate (based on time series data) of the marginal product of infrastructure capital -- as much as 100% per year -- was implausibly.The literature finds a positive long-run effect of infrastructure on output, productivity, or their growth rate. More specifically, this is the case with almost all of the studies using physical indicators of infrastructure stocks, but results are more mixed among the growth studies using measures of public capital stocks or infrastructure spending flows (Andres, Guasch, & Straub, 2007). Another strand of recent literature has examined the effects of infrastructure on income inequality. The rationale is that infrastructure provision may have a disproportionate effect on the income and welfare of the poor, by raising the value of the assets they hold (such as land or human capital), or by lowering the transaction costs (e.g., transport and logistic costs)

Another strand of recent papers has focused on the development impact of infrastructure in Africa. The estimated elasticity for core infrastructure as argued by Chengete and Alagidede (2017), with respect to productivity in the private business sectors, was 0.24% that is a 1% increase in the infrastructure component will cause an increase in productivity by 0.24%. Though they put it forward that it was not clear if it was investment in infrastructure that drive the growth.

Mathur et al. (2015) conduct a systematic review of the impact of electricity supply on health, education, and welfare, including 51 studies in 24 countries in 3 continents, among them 14

African countries. The review shows that electricity access has positive and significant impacts on educational outcomes (study time, years of schooling, and school enrollment), with higher impacts for rural areas compared with urban areas; positive impact on household income in the farm and non-farm sectors. Akinlo and Apanisile (2014) examined the impact of electricity on economic growth in selected Sub-Saharan African countries. A sample of 30 countries, for which data is available, was used to test various hypotheses about the effect of electricity on economic growth, using both Panel pooled OLS, fixed effect and Generalized method moment estimation techniques. The results indicate that electricity consumption is positive and highly significant in all three estimation techniques, meaning that electricity contributes significantly to the economic growth in sub-Saharan Africa. Another important finding is that enhanced transmission infrastructure has the potential to bring about sizeable gains from trade through increased economic efficiency. On the other hand, infrastructure development may influence output and productivity; economic growth can also influence the supply and demand for infrastructure (Esfahani & Ramirez, 2003). This, in essence, means that infrastructure drives growth, and in much the same way, growth also brings about improvement in infrastructure development as an economy grows.

According to the African Development Bank (2010), only 26% of the population in SSA had access to electricity in 2008. In terms of road network, only 25% of 204 km per 1000 km2 of land area was paved; 13 SSA countries had no functional rail networks. Access to fixed line telephones is still below 3%. For Africa at large, the estimated cost of redressing the infrastructure deficit has been estimated to be as high as US$38 billion of annual investment, and an additional US$37 billion in maintenance (World Bank 2013). An earlier study by Calderón and Servén (2008) included an index of infrastructure quality, in addition to the quantity index. They found positive and significant effects on economic growth for both variables. The implied elasticity of GDP with respect to electricity generation capacity is around 0.07. The implied elasticity of GDP with respect to the percentage of transmission and distribution losses in the production of electricity is –0.050. They also found negative effects of electricity infrastructure quantity and quality on income inequality. Andersen and Dalgaard

(2013) analyze the effect of electricity quality on economic growth in Sub-Saharan Africa. Using lightning strikes to instrument (measure) outages, they conclude that a 1% increase in outages per month leads to a 0.018 percentage point reduction in the rate of annual economic growth. Given that the standard deviation of log outages per month is 0.85, this implies very large changes in the economic growth rate due to outages: a one standard deviation increase in outages is associated with a reduction in the rate of annual economic growth of 1.5 percentage points. Odongo and Ojah (2016) observed that although many studies have found a positive long-run relationship between infrastructure and economic growth, interpretation of these results has always been complicated by infrastructure measurement issues.

According to Calderón and Servén (2010), measuring infrastructure as a single variable, either in physical or monetary unit has failed to capture the multi-dimensional nature and heterogeneity of infrastructure across time periods and countries, and has not properly distinguished between quality/productivity and bulk of infrastructure. Additionally, simultaneity can be a serious econometric problem in infrastructure growth studies, because countries with faster growing output may spend more on infrastructure, while infrastructure provision may also positively mediate the relationship between aggregate input and output, and hence faster output growth. Indeed, Kumo (2012), using South African data, confirms strong bi-directional causality between infrastructure investment and economic growth. These flagged issues inform our variable measurement and choice of econometric.

Two high-quality studies that analyze the effect of electricity infrastructure on economic performance, at a highly aggregated level within a country, are identified. Urrunaga and

Aparicio (2012) investigated the relationship between electricity consumption and economic growth by using ARDL bounds testing approach and VECMs in Cameroon, Cote d'Ivoire,

Congo, Ethiopia, Gabon, Ghana, Guatemala, Kenya, Senegal, Togo and Zambia, for the period 1970–2010. The ARDL results showed that there is a co-integration relation between electricity consumption and economic growth in ten of the eleven countries. The results reveal that income elasticity of electricity consumption is a luxury good for Gabon and Guatemala;

necessity good or Engel's good for Senegal, and an inferior good for Zambia the causality analysis reports that the growth hypothesis exists in Cameron, Congo Republic, Ethiopia, Kenya, and Mozambique, while the conservation hypothesis exists in Senegal and Zambia. For Gabon, Ghana, and Guatemala, there exists the bi-directional causality between economic growth and electricity consumption. Meanwhile, Studies also examined the relationship between electricity consumption and economic growth in Nigeria, using the Johansen and Juselius Co-integration technique, based on the Cobb-Douglas growth model, covering the period 1980–2008 (Ogundipe, 2014).

The study used VECM and the Pair Wise Granger Causality test in order to empirically ascertain the error correction adjustment and direction of causality between electricity consumption and economic growth. The study found the existence of a unique co-integrating relationship among the variables in the model with the indicator of electricity consumption impacting significantly on growth. Also, the study shows evidence of the bi-directional causal relationship between electricity consumption and economic growth. Prominent among the policy recommendations is the need to strengthen the effectiveness of energy generating agencies by ensuring periodic replacement of worn-out equipment in order to drastically curtail transmission power losses.

The results showed that there exists a long-run relationship between electricity consumption per capita and real GDP per capita among 9 of the countries studied, and Granger causality for 12 countries out of the 17 studied. Uni-directional causality, running from real GDP per capita growth to electricity consumption per capita, was found for 6 countries and the reverse for 3 of the countries. Thus, despite the evidence of long-run relationship between economic growth and electric energy consumption, direction of causality could vary significantly.The relationship between economic growth, electricity consumption and investment for Bangladesh, through co-integration and causality analysis over the period 1981 to 2011, was investigated.

The long run elasticity of economic growth with respect to electricity consumption and investment are higher than their short run elasticity. This implies that over time, higher electricity consumption and investment in Bangladesh give rise to more economic growth (Singh & Inglesi-Lotz, 2014). The empirical analysis is based on fixed effects panel data estimation as well as a Generalized Method of Moments (GMM) estimation, in fourteen subSaharan African countries (Benin, Botswana, Cameroon, Congo – Republic, Kenya, Mauritius,

Mozambique, Namibia, Nigeria, Senegal, South Africa, Swaziland (Eswatini), Tanzania and Togo) for the period from 1990 to 2016. The empirical investigation found that access to electricity is a positive contributor to this group of countries' economic growth, with relatively low impact on a direct basis.

2.4 Stylized Fact

The supply of infrastructure has remained poor in developing countries and particularly in Africa, despite the critical role it plays in industrial productivity. Prolonging Africa's unmet infrastructure demands means that businesses in the region will continue to be restrained, with productivity dampened. Sub-Sahara Africa Countries lack adequate interconnections that will facilitate network management. In more than 40 countries in Sub-Saharan Africa, more than half of the population has no access to electricity. Regular and frequent blackouts are due to insufficient generating capacity, especially at peak loads, weak infrastructure; minimal expansion of generation and transmission facilities; unreliable supplies; and increasing costs of fossil fuels. Arising from inadequate power infrastructure, the level of electricity is very poor, and investment is still very low in this regard. (Streatfeild, J. E. 2018).

Ogundipe, (2014) established that the demand considerations account for 56 percent of the overall constraint in lower-middle-income countries, compared with 30 percent in low-income countries, where infrastructure development lags further behind. To make electricity expansion financially viable and to encourage investment, uptake and utilization need to be higher. For example, if all households living within range of the electrical grid were connected to the grid, access rates would be well over 60 percent, on average, in Africa and nearly double the current rate in many countries. The question is “Why are these households not connected, and what kind of incentives would get them connected?” This situation underscores the need for a deeper understanding of demand-side constraints to uptake. Low uptake is affected by the maximum amount people are willing to pay. For example, when households in Rwanda were offered three price and payment options, 88 percent did not accept any of the options. When dis-aggregating the results by social and economic status, using a wide range of variables, uptake was low; nearly across board.

Similarly, willingness to pay in Liberia fell from 90 percent to 60 percent when the connection charges moved from zero to US$10; it fell to about 10 percent when the proposed connection charges exceeded US$50. Uptake is not always feasible for consumers because they face multiple constraints. Framing the demand for electricity in Africa, from the standpoint of basic consumer theory, helps organize potential constraints to uptake under three related categories:

(1) price, (2) household income, and (3) the expected benefit from electricity uptake.The expenditure on education, health, and information and communication technology (ICT) will be examined to ascertain their effects on the economic growth.

2.5 Gaps in Literature

Most existing research focuses on the economic implications of electricity use and household access to electricity. There is a need to identify the reasons for the short fall in the supply of electricity in Sub-Saharan Africa. This study seeks to examine roles of infrastructure on electricity supply, effect of infrastructure amenities on electricity supply and economic growth in sub-Saharan Africa, with respect to the determinant of electricity supply, which makes it different from other research. This study is innovative because it considered the magnitude of electricity supply that will enhance economic growth in Sub-Sahara Africa. Other works, along this path, were based on single country, selected country, and region, but this study considered selected countries that are grouped according to their geographical placement in Sub-Sahara Africa. The study will concentrated on these variables; electricity, education, health, and information and communication technology (ICT); as well as on effects on economic growth, which will be proxy by gross domestic product, GDP

CHAPTER THREE

METHODOLOGY

3.1 Theoretical Framework

This section examined the theoretical framework in relation to the model specification of the study. The study adopted the Solow growth model, which is a neo-classical model that explains long-run economic growth by considering the interactions between labour, capital, and technology. The model was extended by introducing infrastructural facilities. The study needs to add these variables to both the production function and the investment function. Adding these variables provide a better understanding of the factors that contribute to economic growth and the role that infrastructure plays in the production process. In this response, the study discussed how it extend the Solow growth model by incorporating infrastructural facilities which are the variables used.

Production function: In the Solow growth model, the production function is now given by:

$$Y = F(K,AL) \tag{3.1}$$

where Y is the output, K is the capital stock, L is the labour force, and A is the level of technology. To include infrastructural facilities, we can modify the production function as follows:

$$Y = F(K,IL,AL) \tag{3.2}$$

Where IL is the level of infrastructural facilities. The addition IL indicates that infrastructure facilities are also crucial inputs in the production process.

Investment function: In the Solow growth model, the investment function is given by:

$$I = sY \tag{3.3}$$

Where I is investment, Y is output, and s is the savings rate. To include infrastructural facilities we can modify the investment function as follows:

$$I = s(Y - IL) \tag{3.4}$$

Where I is investment, Y is output, IL is the level of infrastructural facilitie . The addition of (IL) in the investment function implies that part of the investment goes towards maintaining and expanding the infrastructural facilities.

Change in capital stock: The change in the capital stock is given by:

$$\Delta K = I - \delta K \qquad (3.5)$$

where ΔK is the change in the capital stock, I is investment, δ is the depreciation rate, and K is the existing capital stock. To include infrastructure, we can modify this equation as follows:

$$\Delta K = I - \delta K - \delta IL \qquad (3.6)$$

where ΔK is the change in the capital stock, I is investment, δ is the depreciation rate, IL is the level of infrastructure. The addition of (δIL) indicates that the depreciation rate of the capital stock is affected by the quality of infrastructural facilities.

By incorporating infrastructural facilities into the Solow growth model, we can analyze the effects of these variables on economic growth. For instance, an increase in infrastructural facilities can increase the productivity of both capital and labour, leading to higher economic growth rates (Dwivedi, 2019).

3.2 Model Specification

Following the theoretical framework of Solow growth model upon which the study anchors, two multiple regression models are specified to capture the interaction between economic growth and infrastructure development in SSA between 1990 and 2021. To incorporate the extended Solow growth model into an econometric model to capture the growth model and electricity supply models, we modify equation 3.2 thus;

$$\ln(Y_{it}) = \alpha + \beta_1\ln(K_{it}) + \beta_2\ln(ELS_{it}) + \beta_3\ln(GSH_{it}) + \beta_4\ln(GED_{it}) + \beta_5\ln(IFR_{it}) + \beta_6\ln(EXR_{it}) +$$

$\beta_7 \ln(E_{it}) + \quad \varepsilon_{it}$ (3.7)

Adapting equation 3.7 into the current study requires the introduction of the current variables with the control variables. The new model will be

$$PGDP_{it} = \alpha_0 + \beta_1 InELS_{it} + \beta_2 InGED_{it} + \beta_3 InGSH_{it} + \beta_4 InGSE_{it} + \beta_5 InICT_{it} + \varepsilon_{it} \quad (3.8)$$

Where ln(Y) is the natural logarithm of output, ln(K) is the natural logarithm of the capital stock, ln(E) is the natural logarithm of electricity supply, ln(I) is the natural logarithm of infrastructure, ln(AL) is the natural logarithm of labour, α is the intercept, β_1, β_2, β_3, β_4,β_5, β_6 and β_7 are the coefficients of the respective variables, and ε is the error term. Reason for the natural logarithm is due to transformation of the production function (Cobb-Douglas production function) into linearity assumption of OLS estimation technique.

Adapting equation 3.8 into the current study requires the introduction of the current variables as expressed in the objectives and the specification of the model

Model 1

$$\Delta lnPGDP_t = \alpha_0 + \sum_{i=1}^{k} \alpha_{1i} \Delta lnPGDP_{t-i} + \sum_{i=0}^{k} \alpha_{2i} \Delta lnELS_{t-i} + \sum_{i=0}^{k} \alpha_{3i} \Delta lnEI_{t-i} + \sum_{i=0}^{k} \alpha_{4i} \Delta lnGFCF_{t-i}$$
$$+ \sum_{i=0}^{k} \alpha_{5i} \Delta lnFDI_{t-i} + \sum_{i=0}^{k} \alpha_{6i} \Delta lnED_{t-i} + \sum_{i=0}^{k} \alpha_{7i} \Delta lnEG_{t-i} + \beta_1 lnPGDP_{t-1} + \beta_2 lnELS_{t-1}$$
$$+ \beta_3 lnEI_{t-1} + \beta_4 lnGFCF_{t-1} + \beta_5 lnFDI_{t-1} + \beta_6 lnED_{t-1} + \beta_7 lnEG_{t-1} + \beta_8 lnPGDP_{t-1} + {}_t$$

(3.12)

Model 2

$$\Delta lnPGDP_t = \alpha_0 + \sum_{i=1}^{k} \alpha_{1i}\, \Delta lnPGDP_{t-i} + \sum_{i=0}^{k} \alpha_{2i}\, \Delta lnGSH_{t-i} + \sum_{i=0}^{k} \alpha_{3i}\, \Delta lnEI_{t-i} + \sum_{i=0}^{k} \alpha_{4i}\, \Delta lnGFCF_{t-i}$$
$$+ \sum_{i=0}^{k} \alpha_{5i}\, \Delta lnFDI_{t-i} + \sum_{i=0}^{k} \alpha_{6i}\, \Delta lnED_{t-i} + \sum_{i=0}^{k} \alpha_{7i}\, \Delta lnEG_{t-i} + \beta_1 lnPGDP_{t-1} + \beta_2 lnGSH_{t-1}$$
$$+ \beta_3 lnEI_{t-1} + \beta_4 lnGFCF_{t-1} + \beta_5 lnFDI_{t-1} + \beta_6 lnED_{t-1} + \beta_7 lnEG_{t-1} + \beta_8 lnPGDP_{t-1} + \quad _t$$

(3.13)

Model 3

$$\Delta lnPGDP_t = \alpha_0 + \sum_{i=1}^{k} \alpha_{1i}\, \Delta lnPGDP_{t-i} + \sum_{i=0}^{k} \alpha_{2i}\, \Delta lnGSE_{t-i} + \sum_{i=0}^{k} \alpha_{3i}\, \Delta lnEI_{t-i} + \sum_{i=0}^{k} \alpha_{4i}\, \Delta lnGFCF_{t-i}$$
$$+ \sum_{i=0}^{k} \alpha_{5i}\, \Delta lnFDI_{t-i} + \sum_{i=0}^{k} \alpha_{6i}\, \Delta lnED_{t-i} + \sum_{i=0}^{k} \alpha_{7i}\, \Delta lnEG_{t-i} + \beta_1 lnPGDP_{t-1} + \beta_2 lnGSE_{t-1}$$
$$+ \beta_3 lnEI_{t-1} + \beta_4 lnGFCF_{t-1} + \beta_5 lnFDI_{t-1} + \beta_6 lnED_{t-1} + \beta_7 lnEG_{t-1} + \beta_8 lnPGDP_{t-1} + \quad _t$$

(3.14) Model 4

$$\Delta lnPGDP_t = \alpha_0 + \sum_{i=1}^{k} \alpha_{1i}\, \Delta lnPGDP_{t-i} + \sum_{i=0}^{k} \alpha_{2i}\, \Delta lnICT_{t-i} + \sum_{i=0}^{k} \alpha_{3i}\, \Delta lnEI_{t-i} + \sum_{i=0}^{k} \alpha_{4i}\, \Delta lnGFCF_{t-i}$$
$$+ \sum_{i=0}^{k} \alpha_{5i}\, \Delta lnFDI_{t-i} + \sum_{i=0}^{k} \alpha_{6i}\, \Delta lnED_{t-i} + \sum_{i=0}^{k} \alpha_{7i}\, \Delta lnEG_{t-i} + \beta_1 lnPGDP_{t-1} + \beta_2 lnICT_{t-1}$$
$$+ \beta_3 lnEI_{t-1} + \beta_4 lnGFCF_{t-1} + \beta_5 lnFDI_{t-1} + \beta_6 lnED_{t-1} + \beta_7 lnEG_{t-1} + \beta_8 lnPGDP_{t-1} + \quad _t$$

(3.15)

Where:

PGDP = Per capita gross domestic product which measures Economic growth at time t

ELS = Electricity supply at time t

Where:

PGDP = Per capita gross domestic product which measures Economic growth at time t

ELS = Electricity supply at time t. (kwi)

EG = Stands for electricity generation at time t. (kwi)

ED = Connote the electricity distribution at time t. (kwi)

GHS = Government spending on health at time t. ($)

GED = Government spending on Education ($)

ICT = Information and communication technology (no of servers)

β_0 = the constant term also known as the Intercept term

e_t = the Error term and β_1 to β_5 are the estimated parameters of the regression model.

Δ = the change operator while γ $(1-\sum_{i-1}^{p} \delta i)$ represent the speed of adjustment parameters with a negative sign.

ECT $(ln Y_{t-1} - \theta X_t)$, represent the error correction term and lastly, β, α and $\lambda$are the estimation parameters that represent the short run dynamic coefficient of the model's adjustment long run equilibrium.

3.3 A *priori* expectations

A priori expectations was made about the relationship between economic growth and other variables, such as electricity supply, electricity distribution, government spending on education and health, and government spending on ICT. These expectations are often based on theoretical models and empirical evidence from previous studies. For example, it is generally expected that a higher level of electricity supply and distribution will lead to higher economic growth. This is because electricity is a key input in the production process and is required for many industrial and commercial activities. According to a study by Akinlo (2008), there is a positive and significant relationship between electricity supply and economic growth in Nigeria.

Similarly, it is expected that government spending on education and health will have a positive effect on economic growth. This is because investment in human capital can increase the productivity and efficiency of the workforce, leading to higher levels of output. Studies by

Bokhari, Gaiyan and Shahbaz (2007), and Lee and Wong (2009) found a positive relationship between government spending on education and health and economic growth in Pakistan and Hong Kong. Regarding government spending on ICT, the expectation is that it will have a positive effect on economic growth as well. This is because ICT can improve productivity and efficiency in many sectors of the economy, leading to higher levels of output. However, the relationship may not be straightforward, and the impact of government spending on ICT may depend on the level of development of the economy and the effectiveness of the government's policies. According to a study by Kshetri (2014), the relationship between governments spending on ICT and economic growth is positive and significant in developing countries but not in developed countries.

The a priori expectations are also shown in the following expresion.

$B_1 > 0$, $\beta_2 > 0$, $\beta_3 > 0$, $\beta_4 > 0$, $\beta_5 > 0$, $\beta_6 > 0$ and $\beta_7 > 0$

Where < represents a negative relationship while > positive relationship

3.4 Estimation Techniques,

Several estimations techniques exist to evaluate panel data as would be used in this study. Some of them include the ARDL Co-integration technique, which does not require pre-tests for unit roots, unlike other techniques. Consequently, the ARDL co-integration technique is preferable when dealing with variables that are integration of a different order,I(0), I(1) or a combination of them both and, robust when there is a single long-run relationship between the underlying variables in a small sample size. The long-run relationship of the underlying variables is detected through the F-statistic (Wald test). In this approach, the long run relationship of the series is said to be established when the F-statistic exceeds the critical value band. The major advantage of this approach lies in its identification of the co-integrating vectors, where there b are multiple co-integrating vectors. However, this technique will crash in the presence of an integrated stochastic trend of I (2).

Another estimation technique is the Generalized Methods of Moments (GMM) estimation technique. GMM. As prescribed in the GMM short dynamic panel data analysis (Bond, 2001), it would be estimated using E-views 11. GMM helps to resolve the endogeneity problem posed by unobserved variables and deals with reverse causality bias that usually plagues other models. From the literature, finding the right instrumental variables for GMM estimation is very difficult and often results in weak instruments leading to spurious results. Hence, researchers and scholars adopted the use of the lag repressors, which serve the purpose of instrumentation for the model (Qamruzzaman & Jianguo, 2018). Since the lag value of the regressor (xit-1) precedes the current value of the Regressor (xit), in time, the causality runs entirely from xit-1 to xit. This helps to solve the problem of weak instrumentation in a GMM model estimation process. Therefore, Pooled OLS, Fixed Effects Estimation and the System GMM analytical techniques (Bond, 2001) would be examined. According to Bond, Hoeffler and Temple (2001), close or lower difference estimates from the fixed-effects estimates suggest weak instrumentation. Hence, system GMM becomes most applicable. Others include the pooled OLS estimation technique.

3.5 Techniques of Analysis

The study applied econometrics technique to analyze the models. To avoid a spurious regression result, the data was subjected to descriptive analysis to understand the characteristics of the data and a correlation matric was produced to understand their level of relationship and the possible existence of multi-collinearity, Panel unit root test, using the famous Im Pesaran test, Levin and Lin Chu t test etc, to determine the order of integration and a possible level relationship in the model. The study also employed the Pedroni co-integration test to examine the existence of a long run (level) relationship. To be sure of stationary test, an examination of the long run (co-integration) relationship among the variables. From this perspective, a longrun analysis was performed with the inclusion of error correction terms in the model to correct the previous dis-equilibrium.

Post estimation analysis was done to determine the stability and robustness of the model. Hence, cross-sectional dependence tests, Arellano-Bond Serial Correlation Test, and valid test was conducted.

3.5.1 ARDL Pooled Mean Group (PMG) Estimator

One of the estimators commonly used to estimate panel data models is the mean group estimator, which consists of averaging individual estimates for each group in the panel. This estimator, according to Pesaran, Shin & Smith (1999) produces consistent estimates of the parameters' averages while allowing the parameters to be freely independent between groups, and does not take potential homogeneity across groups into account. The random or fixed effects and GMM approaches are the second method. These models need equal parameters across nations, which may result in inconsistent and misleading long-term co-efficients, an issue that is compounded when the time frame is long. To address this issue, Pesaran *et al.* (1999) suggested an intermediate estimator that permits short-term parameters to fluctuate between groups while requiring long-term co-efficient to be identical across nations. The PMG has the benefit of allowing the short-run dynamic specification to change from Country to country, while constraining the long-run co-efficient to be the same. In addition, unlike the Dynamic OLS (DOLS) and Fully Modified OLS (FMOLS), the PMG estimator emphasizes the adjustment dynamics between the short and long runs. The absence of short-run slope co-efficient equality permits the dynamic specification to differ between nations. Therefore, the long-run relationship between public capital formation, infrastructural facilities and endogenous growth in SSA countries is expected to be identical from country to country, but the short-run co-efficient was country-specific.

3.5.2 Granger Causality Tests

Granger causality (also known as "G-causality") was invented in the 1960s and has been frequently employed in economics since then. However, only in the last several years, have applications in neuron-science gained popularity. Granger causality is a statistical causality notion based on prediction. If a signal X_1 "Granger-causes" (or "G-causes") a signal X_2, then previous values of X_1 should include information that helps forecast X_2 above and above the information contained in past values of X_2 alone, according to Granger causality. Its mathematical formulation is based on stochastic process linear regression modelling (Granger, 1969).

The null hypothesis for the test is that lagged x-values do not explain the variation in y. In other words, it assumes that x(t) doesn't Granger-cause y(t). A typical bivariate causality equation is represented below:

$$x_t = c_1 + \sum_{i=1}^{3} \alpha_{1,i} y_{t-i} + \sum_{i=1}^{3} \beta_{1,i} x_{t-i} + \epsilon_{x,t}$$
$$y_t = c_2 + \sum_{i=1}^{3} \alpha_{2,i} y_{t-i} + \sum_{i=1}^{3} \beta_{2,i} x_{t-i} + \epsilon_{y,t}$$

The analysed data shows that infrastructural facilities granger-cause economic growth and economic growth also granger-cause infrastructural development. That is if the economic grows it will give room for infrastructural development. Likewise infrastructural development will pave way for rapid economic growth. The Pairwise Dumitrescu Hurlin Panel Causality Tests provided valuable insights into the directional relationships between key economic indicators in Sub-Saharan African countries. The results indicate a significant homogeneous causality running from per capita GDP (PGDP) to information and communication technology (ICT), suggesting that economic growth stimulates the development and adoption of technological infrastructure. This is intuitive, as higher economic output can afford investments in advanced technologies, fostering innovation and efficiency gains. Conversely, the test reveals that ICT does not homogeneously cause PGDP, implying that while technological advancements are influenced by economic growth, they do not uniformly drive overall economic output. Notably, the causality tests highlight a bidirectional relationship between PGDP and electricity supply (ELS), emphasizing the symbiotic nature of economic growth and energy infrastructure. The results also suggest that economic growth homogeneously causes government spending on health (GSH) and education (GSE), underscoring the role of a thriving economy in facilitating increased investments in these essential sectors. In essence, the causality tests reflect the interconnectedness of economic growth and infrastructure development in Sub-Saharan Africa, emphasizing the need for a holistic approach where improvements in economic conditions drive advancements in crucial infrastructural domains, and reciprocally, strategic investments in infrastructure contribute to sustained economic growth.

3.6 Stationary Test

To prevent a spurious regression, the study conducted a unit root test first to confirm the stationarity of each variable. In recent years, several investigators, including Levin, Lin and

Chu (2002), Maddala and Wu (1999), Choi (2001), Hadri (1999), and Im, Pesaran and Shin (2003), have developed panel-based unit root tests that are similar to tests carried out on a single series. These researchers have shown that panel unit root tests are more powerful than unit root tests applied to individual series because the information in the time series is enhanced by that contained in the cross-section data. Interestingly, these researchers have shown that panel unit root tests are more powerful (less likely to commit a Type II error) than unit root tests applied to individual series, because the information in the time series is enhanced by that contained in the cross-section data.

To define these tests' approaches, the study considered the following AR (1) process for panel data:

$$yit = \rho yit-1+xit\delta_i +\varepsilon_i t \qquad (3.16)$$

where i = 1, 2,.... N cross-section units or series that are observed over periods t = 1, 2,....... Ti. Xit represents the exogenous variables in the model, including any fixed effects or individual trends, ρi are the auto-regressive co-efficients, and the errors εit are assumed to be mutually independent idiosyncratic disturbance. If ρi <1, yi is said to be weakly (trend) stationary. On

the other hand, if sρi = 1 then yi contains a unit root. (3.17)

For testing purposes, two natural assumptions can be made about the ρi. The first assumption is that the persistence parameters are common across cross-sections, so that ρi = ρ for all i. The

Levin et al. (2002), Breitung (2000), and Hadri (2000) tests all employ this assumption. Alternatively, one can allow ρi to vary freely across cross-sections. The Im et al. (2003), and Fisher-ADF and Fisher-PP tests, defined by Maddala and Wu (1999) and Choi (2001), are of this form. All the tests assume that there is a common unit root process so that ρi is identical across cross-sections. The first two tests employ a null hypothesis of a unit root, while the Hadri (2000) test assumes that there is a common unit root process so that ρi is identical across cross-sections. The first two tests employ a null hypothesis of a unit root, while the Hadri (2000) test uses a null of no unit root. Levin at al. (2002) and Breitung (2000) both consider the following basic ADF specifications:

Δyit = αyit−1+ where we assume a common α = ρ −1 but allow the lag order for the difference terms, ρi to vary across cross-sections. The null and alternative hypotheses for the tests may be written as H0: α = 0 H1: α < 0. so under the null hypothesis, there is a unit root, while under the alternative, there is no unit root. The Im et al. (2003), the Fisher-ADF and PP tests all allow for individual unit root processes so that ρi may vary across cross-sections. The tests are all characterized by the combining of individual unit root tests to derive a panel-specific result. Im et al. (2003) begin by specifying a separate ADF regression for each cross section:

$$\Delta y_{it} = \alpha y_{it-1} + \sum_{j=1}^{pi} \beta_i j \Delta y_{it-j} + x'_{it}\delta + \quad_{it}$$

H0: α = 0 for all *i* while the alternative hypothesis is given by

$$H_1 \begin{bmatrix} \alpha_i = 0\ for \ldots i = 1,2,3, \ldots \quad N_1 \\ \alpha_i < 0\ for \ldots i = N^1 + 1, \ldots \quad N_1 \end{bmatrix}$$

(where they may be reordered as necessary), *i which* may be interpreted as a non-zero fraction of the individual processes is stationary. Maddalaand Wu (1999) and Choi (2001) proposed an alternative approach to panel unit root tests, and used Fisher's (1932) results to derive tests that combine the p-values from individual unit root tests

3.7 Co-integration Tests

Co-integration is a statistical concept that refers to the long-run equilibrium relationship between two or more time series variables. Panel ARDL (Auto-Regressive Distributed Lag) co-integration process is a technique used to investigate the long-run relationship among variables in panel data. There are different methods of panel ARDL co-integration, including Pedroni and Kao. The Pedroni panel ARDL co-integration approach tests the null hypothesis of no co-integration using the following equation:

(1) $\Delta yt = \alpha i + \beta iL(\Delta yt) + \sum j=1p\gamma ij\Delta xtj + \sum j=1p\delta ijL(\Delta xtj) + \mu it$

where Δ is the first difference operator, yt is the dependent variable, αi is the individual-specific intercept, L is the lag operator, βi is the coefficient on the lagged dependent variable, Δxtj is the jth independent variable, γij and δij are the co-efficients on the current and lagged values of the jth independent variable, respectively, p is the maximum lag order, and μit is the error term.

The null hypothesis for the Pedroni panel ARDL cointegration approach is:

H_0: No co-integration exists among the variables.

The alternative hypothesis is:

H_1: Co-integration exists a10mong the variables.

If the calculated t-statistic value is less than the critical values, the null hypothesis is accepted, indicating that there is no co-integration among the variables. If the t-statistic value is greater than the critical values, the null hypothesis is rejected, indicating that there is co-integration among the variables. On the other hand, the Kao panel ARDL co-integration approach tests the null hypothesis of no co-integration, using the following equation:

(2) Δyt = αi + βiL(Δyt) + ∑j=1pγijΔxtj + μit

where the variables are defined as before, and μit is the error term.

The null hypothesis for the Kao panel ARDL co-integration approach is:

H_0: No co-integration exists among the variables.

The alternative hypothesis is:

H_1: Co-integration exists among the variables.

If the calculated t-statistic value is less than the critical values, the null hypothesis is accepted, indicating that there is no co-integration among the variables. If the t-statistic value is greater than the critical values, the null hypothesis is rejected, indicating that there is co-integration among the variables. In both cases, the panel ARDL co-integration approach can be used to investigate the long-run relationship among variables in panel data. Hence, based on the majority of alternative tested statistics, in comparison to the conventional significance level of 0.05, the null hypothesis suggesting no co-integration is to be rejected, while the alternative hypothesis indicating the presence of co-integration is to be accepted. This suggests that there is indeed co-integration, implying that there is a long-term relationship among the variables.

3.8 Sources of Data

The data used for this analysis are secondary data. Data on electricity generation and economic growth were sourced from World Bank Development indicator (WBDI), reputable Journals, World development indicators (WDI) and Worldwide Governance indicators (WGI), with emphases on the selected Countries. This study span from the year 1991 to 2021.

Table 3.1: **Presentation of Variables, Measurement and Sources**

Variables	Symbol	Measurement	Sources
Electricity supply (ELS)	Kwi	Kilowatt	World development index 2021
Government spending on education (GSE)	US$	United States of America currency	World development index (WDI) 2021
Government spending on health	US$	United States of America currency	World development index (WDI) 2021
Government spending on information Technology (ICT)	US$	United States of America currency	World development index (WDI) 2021

Foreign Direct Investment FDI	US$	United States of America currency	World development index (WDI) 2021
Per capital gross domestic product (PGDP)		United States of America currency	World development index (WDI) 2021
Electrical generation (EG)	Kwi	Kilowatt	World development index (WDI) 2021
Electrical distribution ED	Kwi	Kilowatt	World development index (WDI) 2021
Gross fixed capital formation (GFCF)	US$	United States of America currency	World development index (WDI) 2021

Author's computation, 2023

CHAPTER FOUR

DATA PRESENTATION AND ANALYSIS

4.1 Introduction

This chapter presents the empirical analyses of the study, the data was analysed based on the methodology and data description in chapter three. The chapter is organized based on the objective of the study. Therefore, section 4.2 in page presents the time series properties and descriptive statistics of the study. In Section 4.3 of this chapter, we explore the core of the study, focusing on data analysis and the presentation of results. Here, we present, examine, and analyze the data collected. Using the specified tools and methods, we aim to uncover interesting patterns and connections within the data.

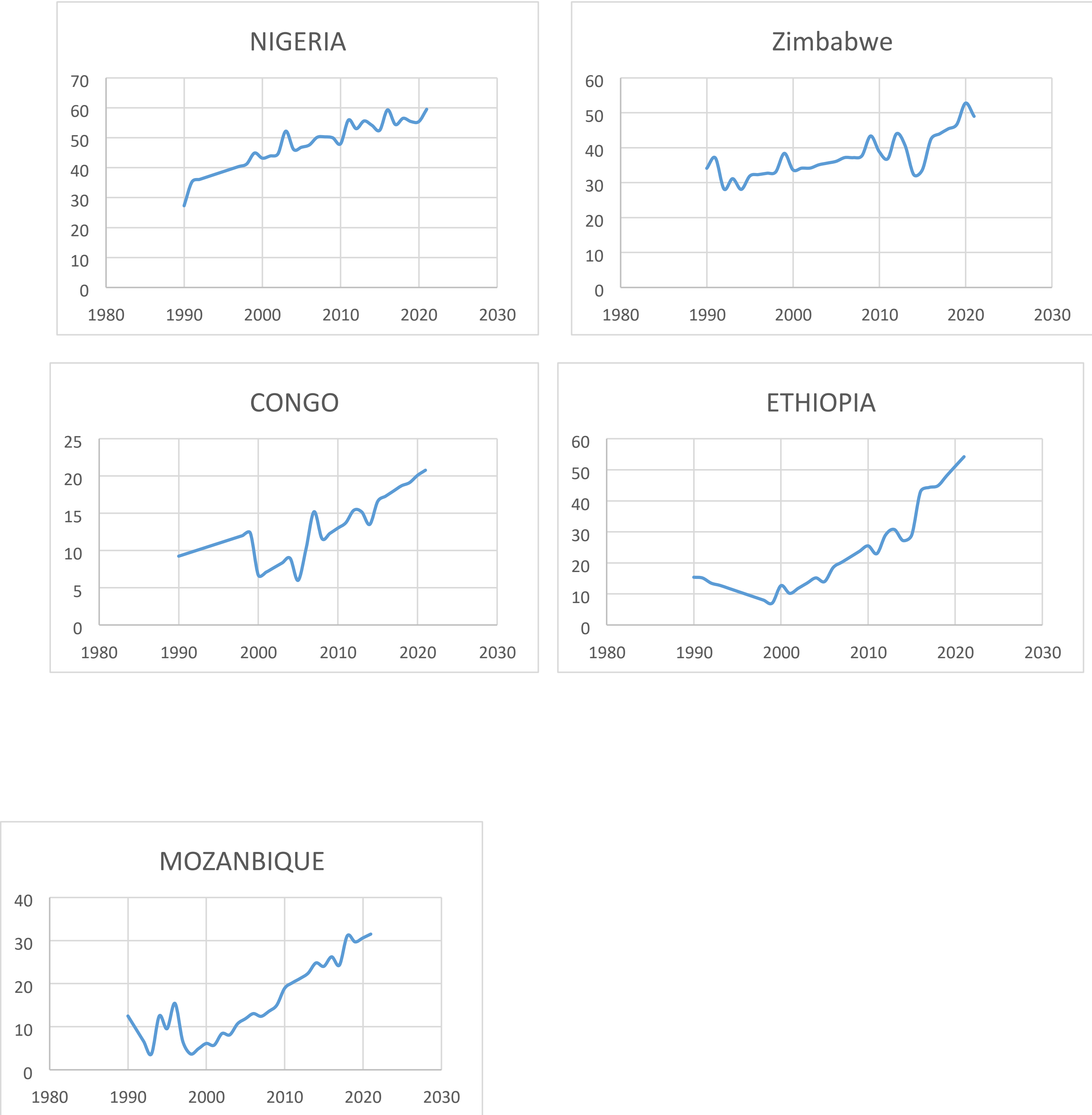
4.2 Preliminary Analysis

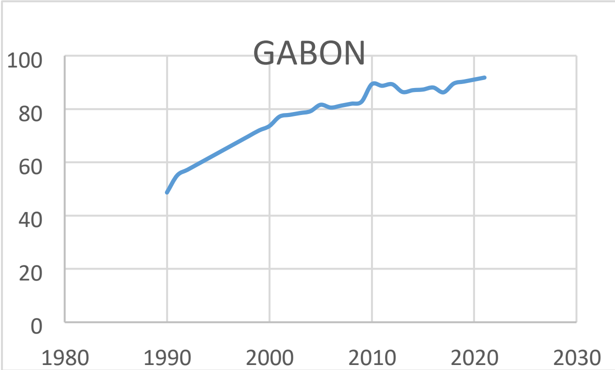
The section begins by presenting a descriptive analysis of the study's variables, accompanied by the correlation matrix. Subsequently, the unit root results are discussed, offering insights into the stationarity of the utilized variables.

4.2.1 Descriptive Analysis

The descriptive statistics in fiqure 4.1 in page 80 for a set of economic indicators across SubSaharan African countries reveal several noteworthy patterns. Mauritius stood out with the highest per capita GDP in 2018, indicating robust economic growth, potentially driven by factors such as effective governance or diversified economic activities. The maximum electricity supply in Mauritius in 2019 reflected a well-developed energy infrastructure contributing to economic activities, while the minimum in the Central African Republic in 1990 suggested historical infrastructural challenges. Senegal led in electricity distribution in 1999, showcasing investments in the power sector, while Ethiopia's lower distribution in 2014 might reflect challenges in expanding the electricity network. Interestingly, Congo's peak government spending on health in 1990 indicated a commitment to public health, contrasting with a decline in 2001, possibly due to shifting priorities. Zimbabwe's high government spending on education in 2000 suggested a focus on human capital, while Mozambique's minimum in 1992 might reflect budget constraints. Nigeria consistently emerged with high values, showcasing maximums in information and communication technology in 2017 and Gross Fixed Capital Formation in 2021. These statistics provided a nuanced picture of economic dynamics in SubSaharan Africa, offering insights into variations in development trajectories, policy priorities, and potential areas for intervention.

Fig 4.1 Graphical Representation of Electricity Supply and Distribution 1990-2021

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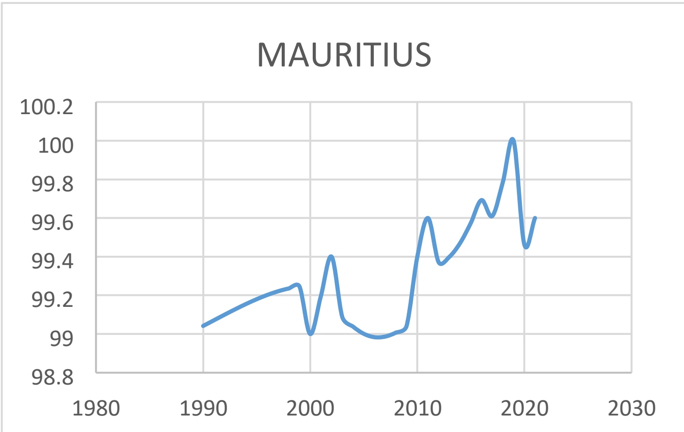
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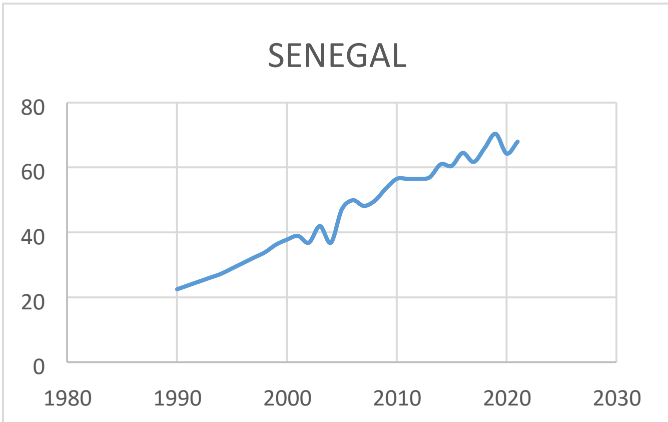
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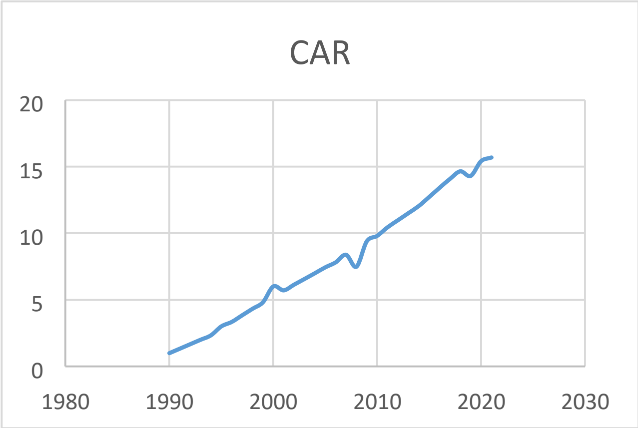
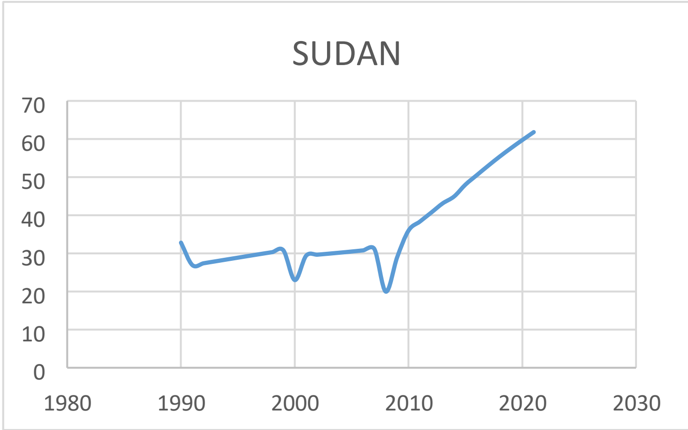
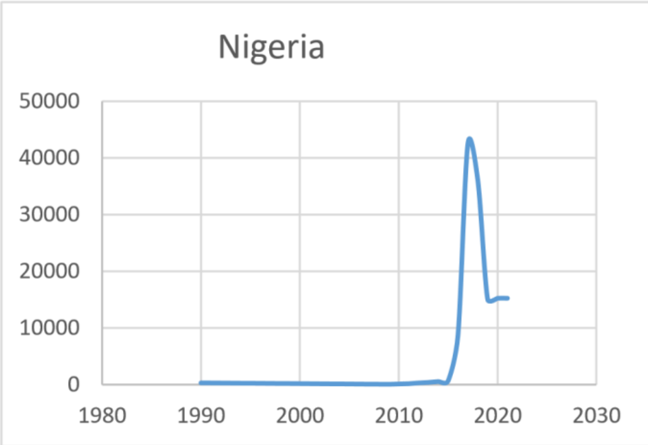
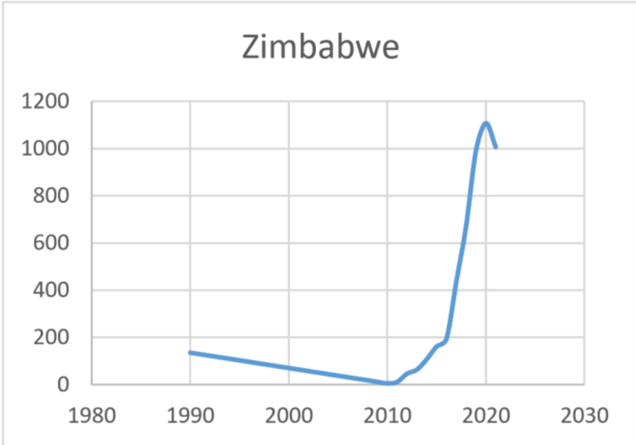


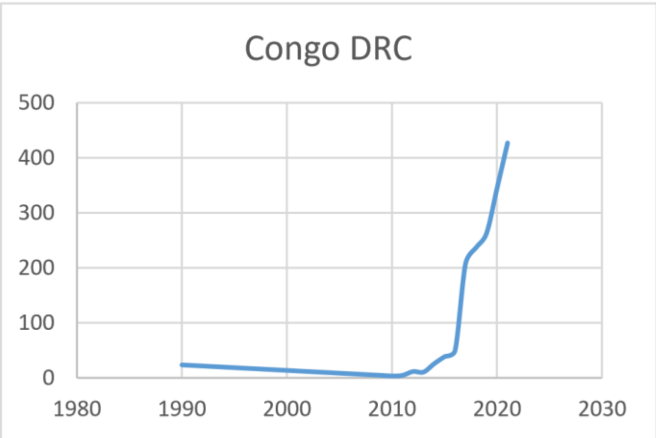


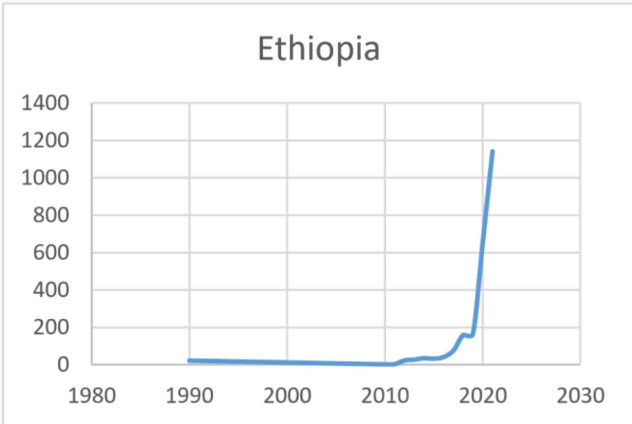
Sources: Author's computation Data from *World development indicators (2022)* **Fig 4.12 Graphical**

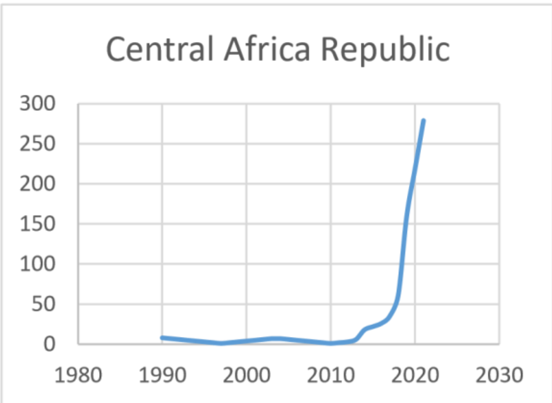
Representation of Electricity Generation (Megawatt), 1990-2021

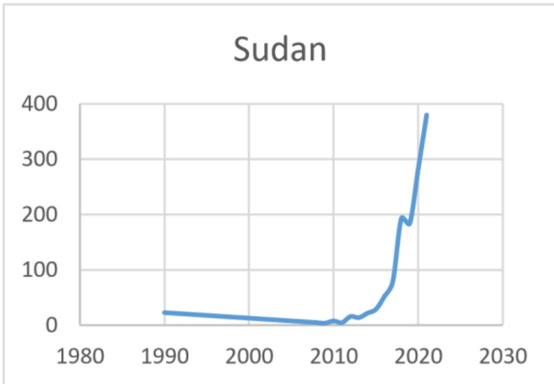


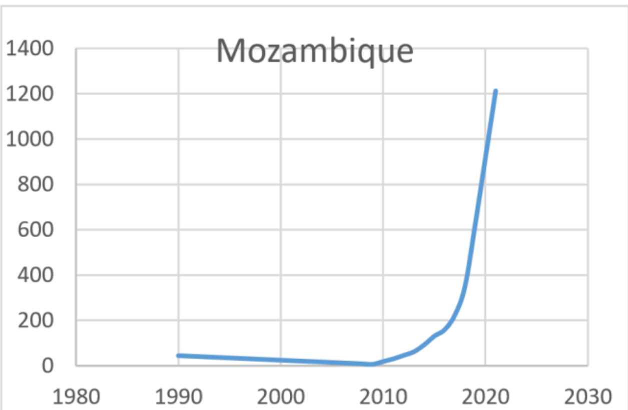


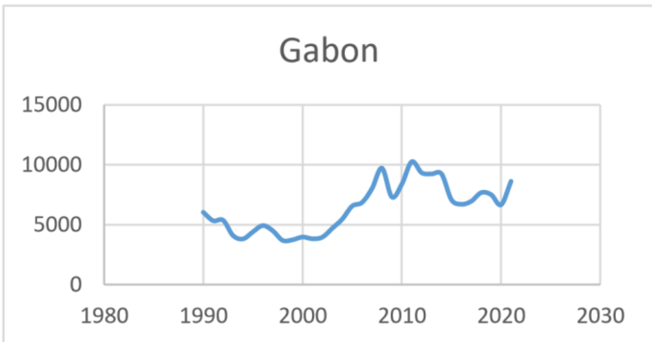


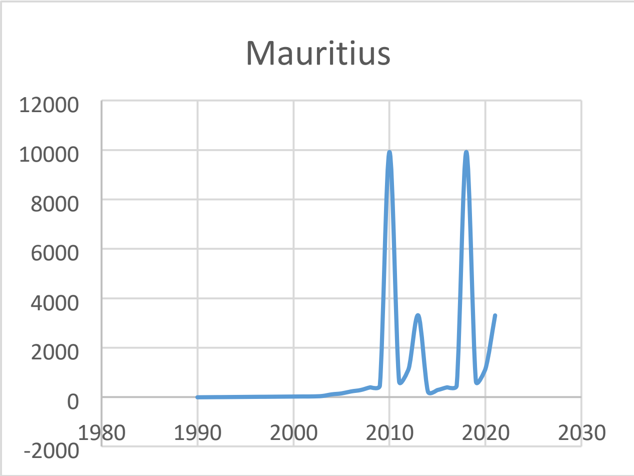


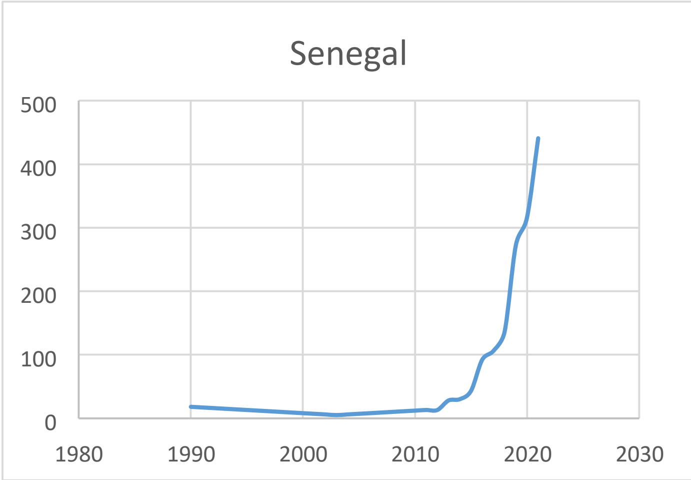






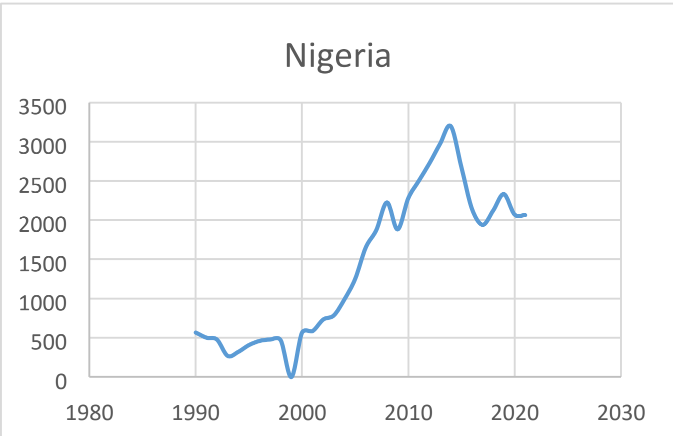


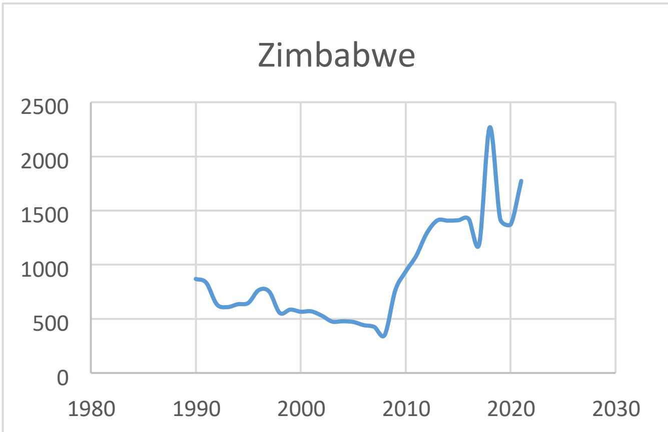


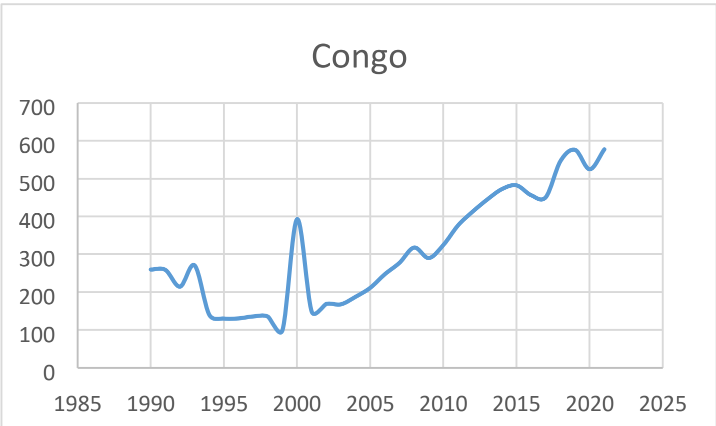


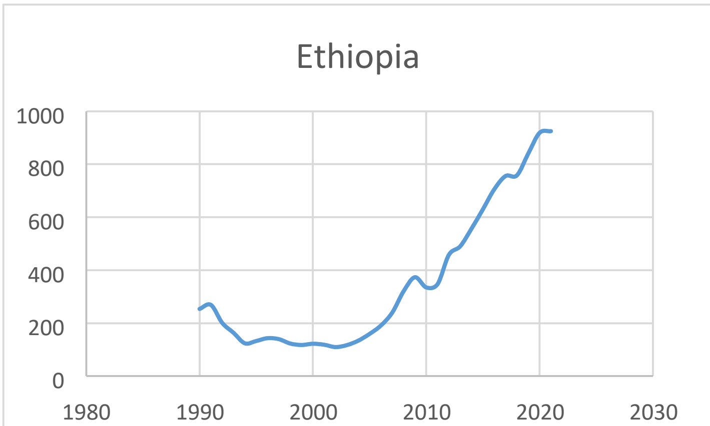
Sources: Author's computation Data from *World development indicators (2022)*

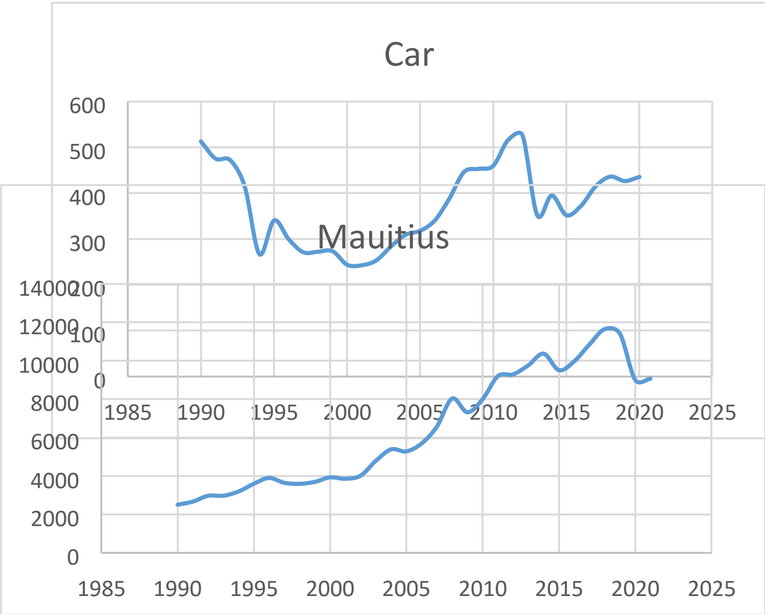
Fig 4.13 Graphical representation of electricity distribution (Kwl) 1990-2021

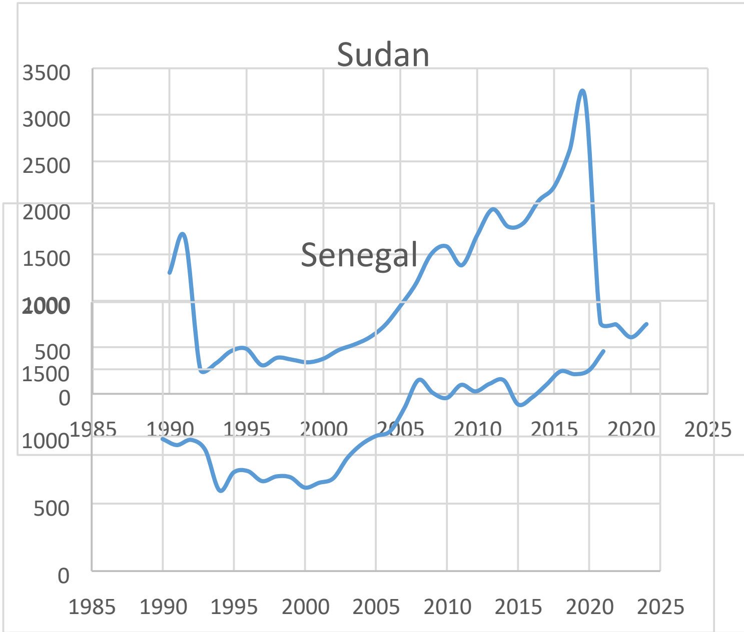


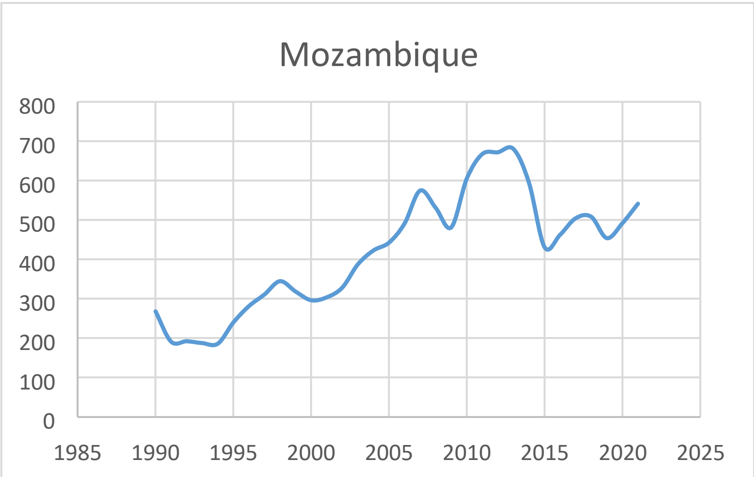


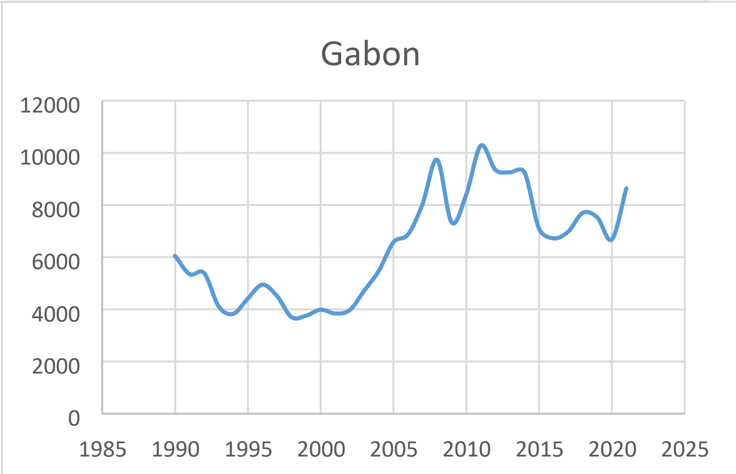




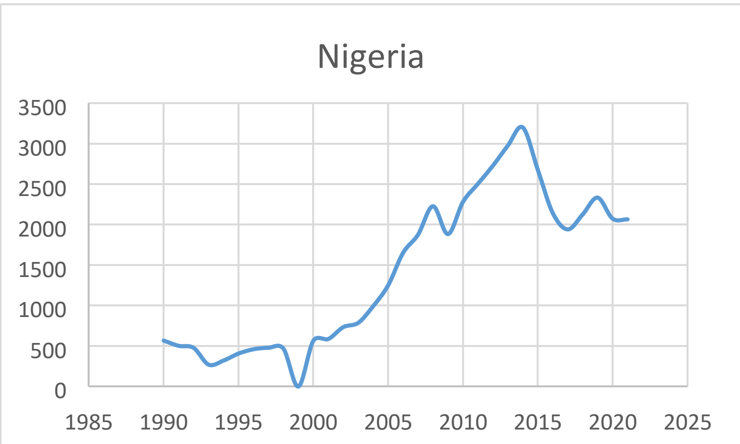


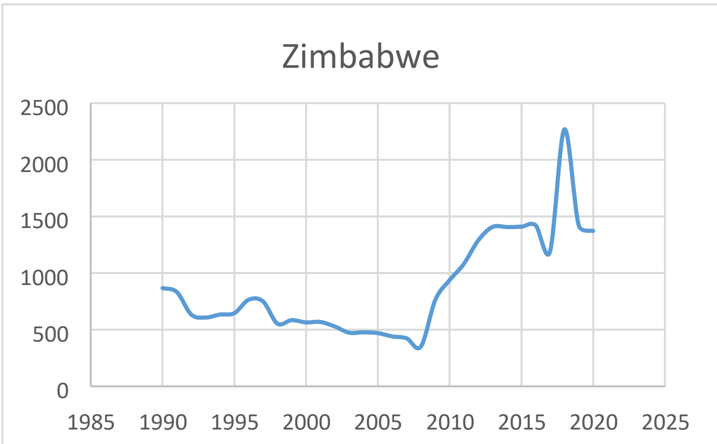


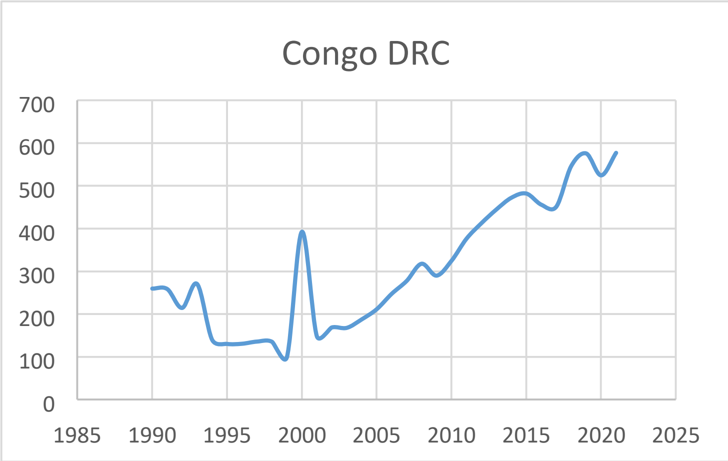


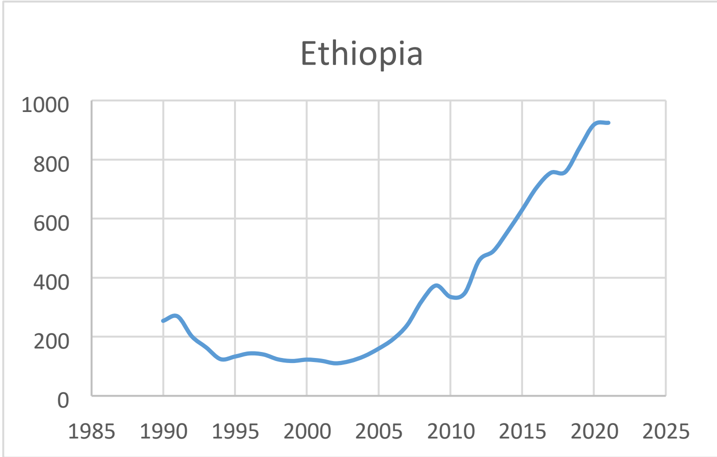


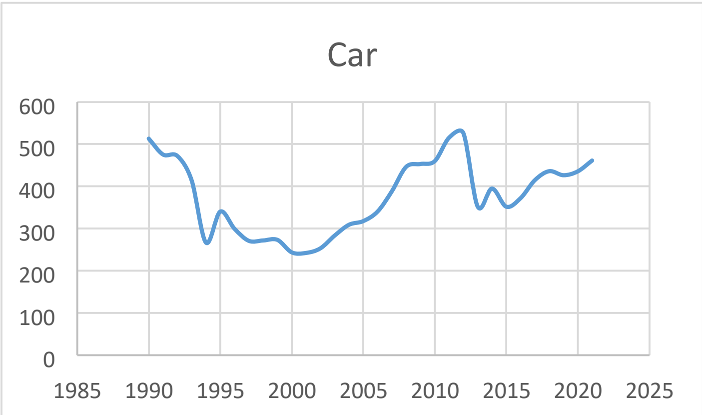
Sources: Author's computation. Data from *World development indicators (2022***Fig 4.14) Graphical Representation of Government Spending on Education (%GDP), 1990-2021**

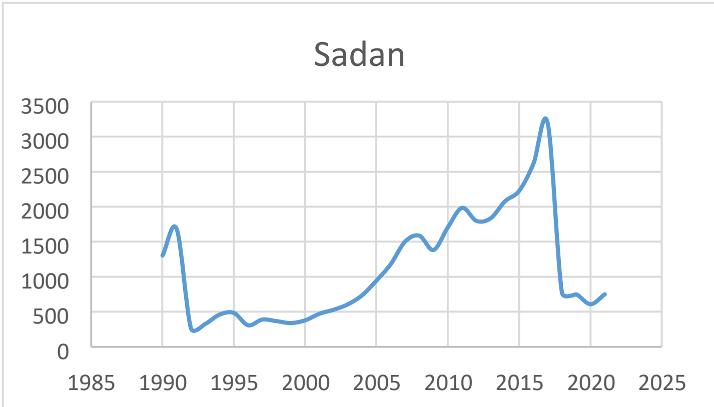






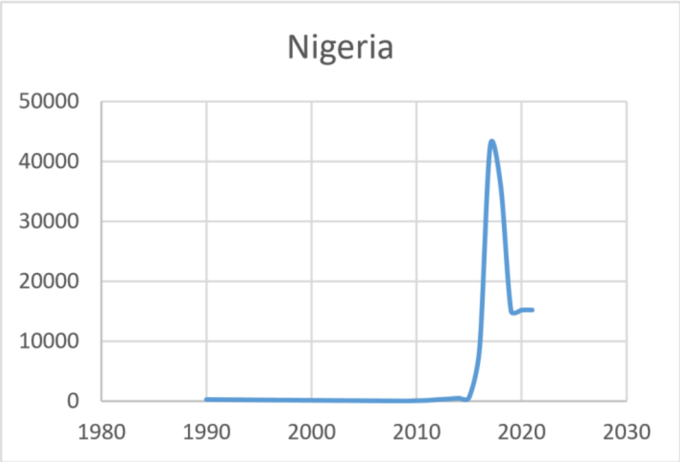


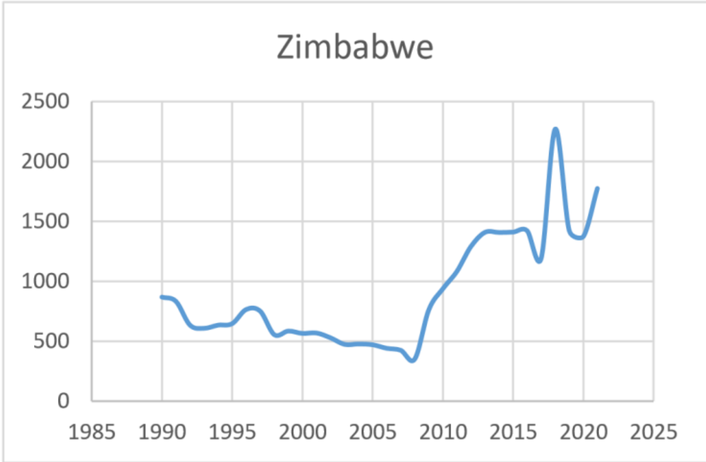


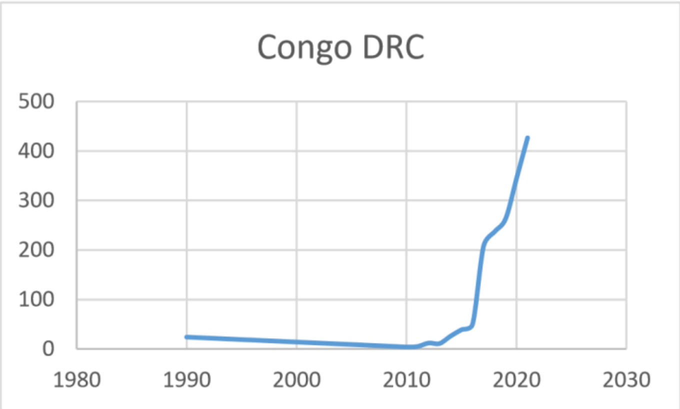


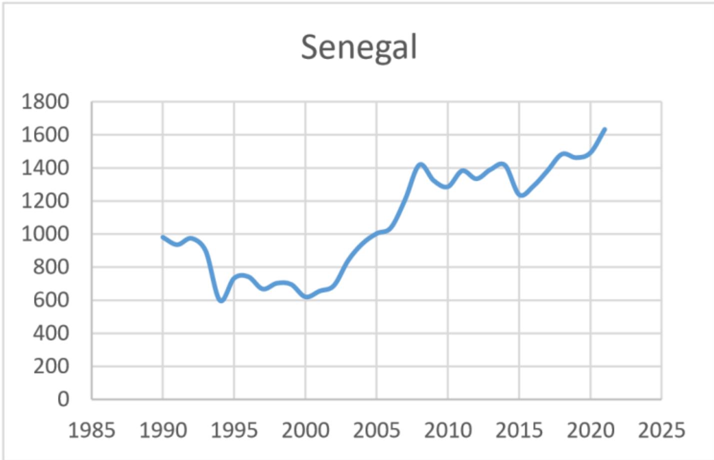
Sources: Author's computation Data from *World development indicators (2022)*

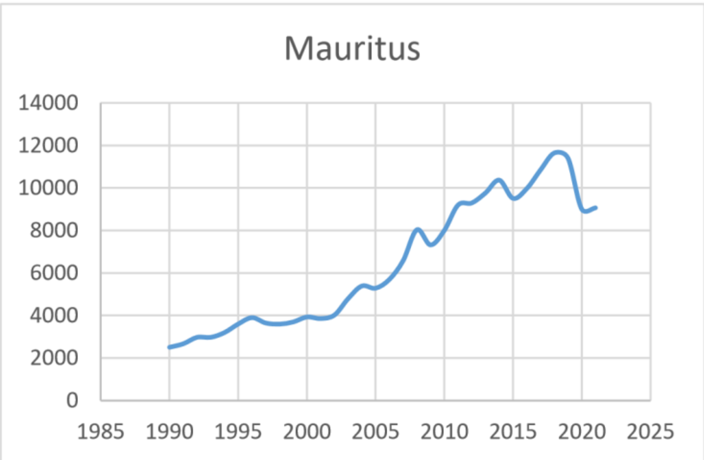
Fig 4.1 5 Graphical representation of GDPpc($) 1990-2021

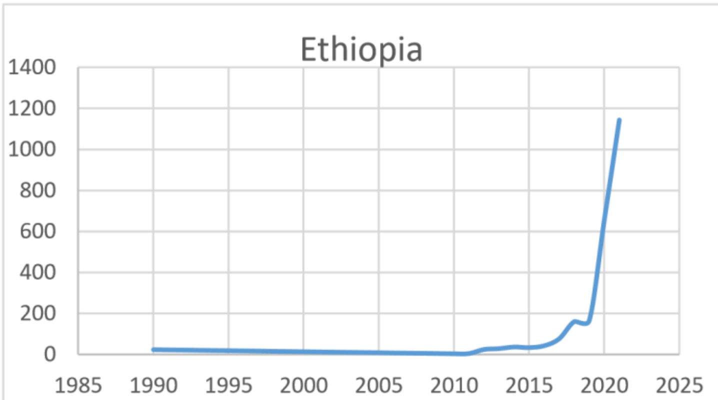


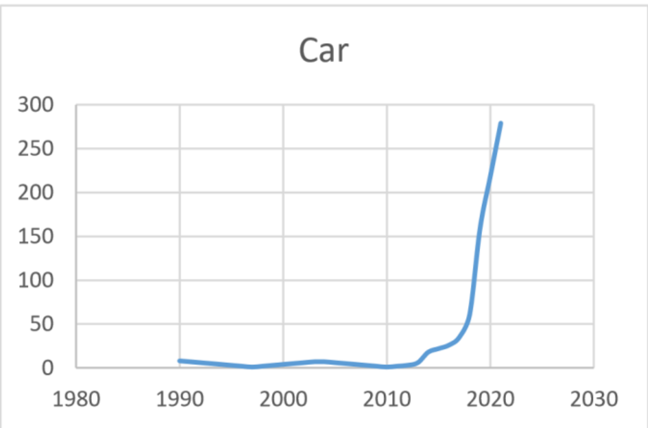


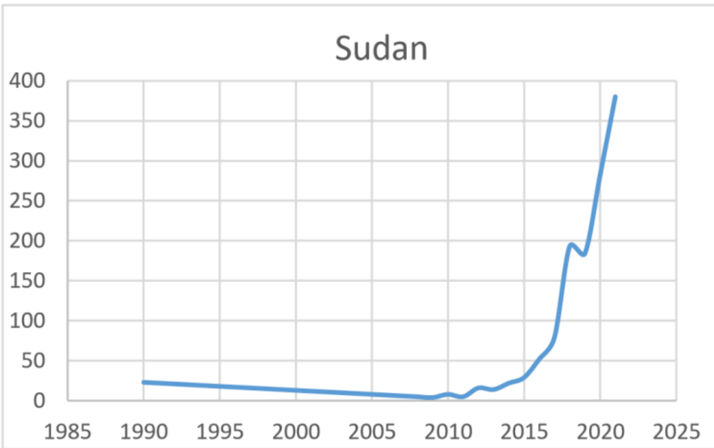


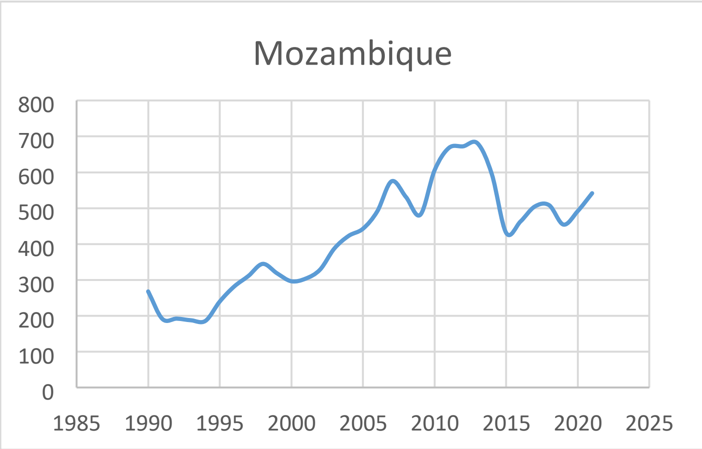


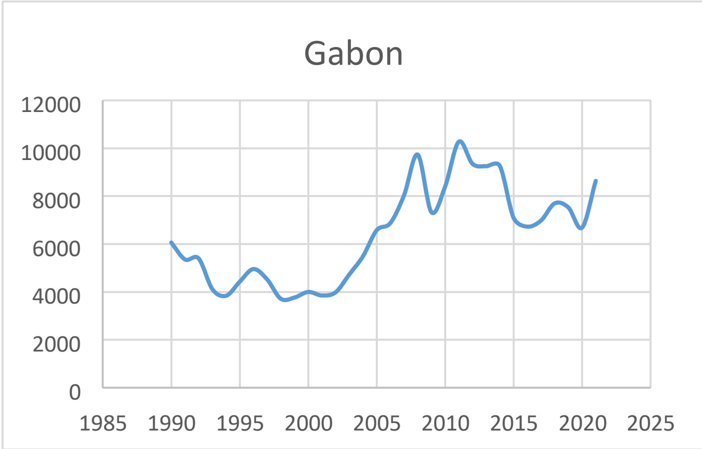


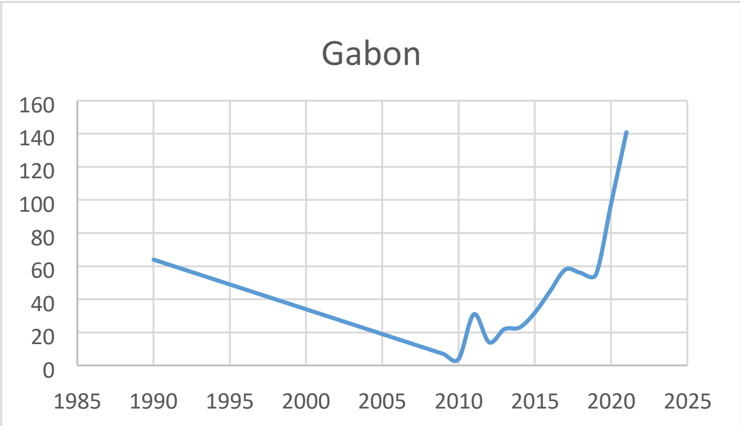


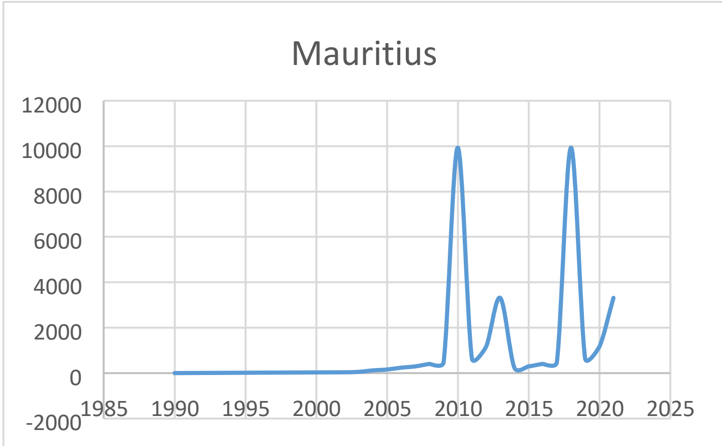






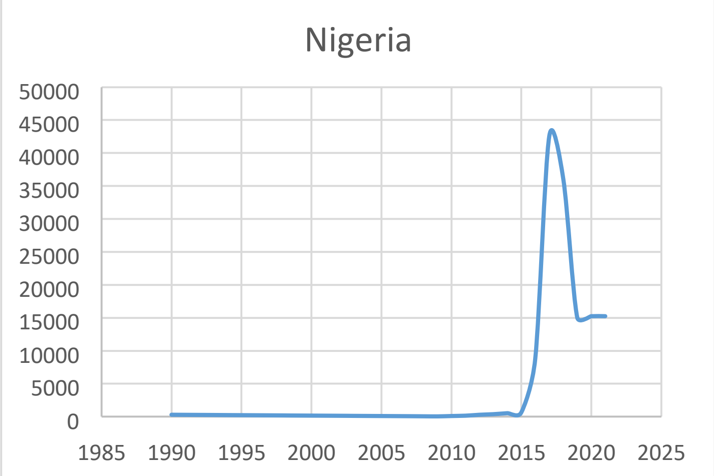


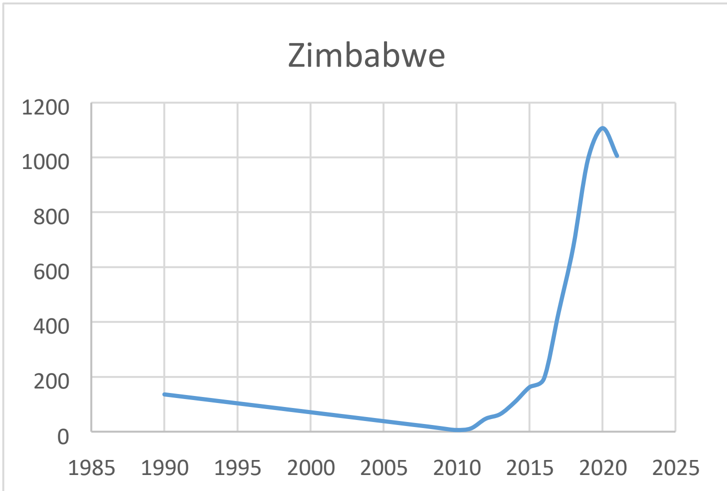


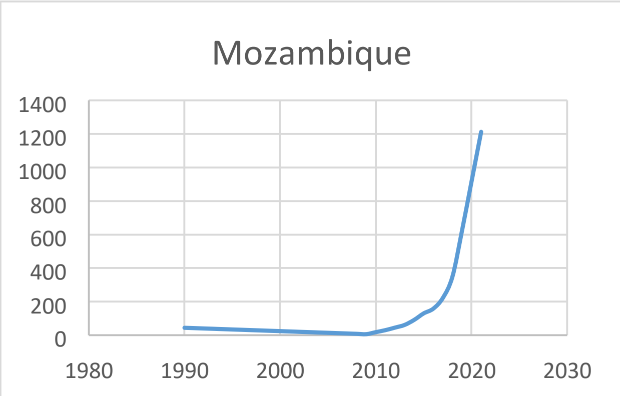


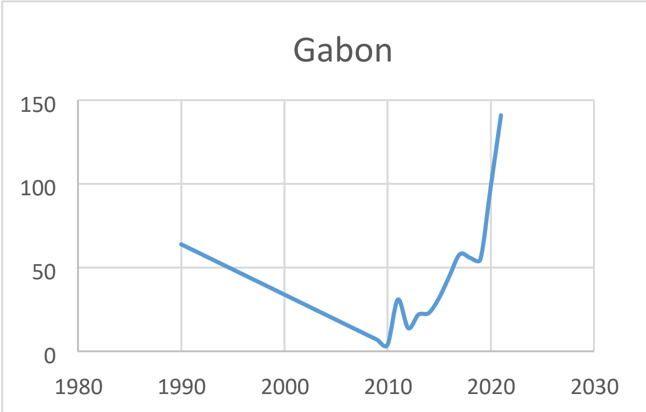
Sources: Author's computation Data from *World development indicators (2022)*

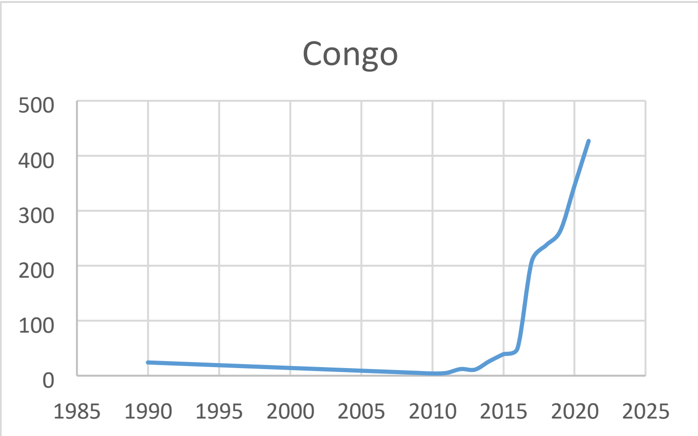
Fig 4.1 5 Graphical Representation of Government Spending on Health (% GdP), 1990 2021

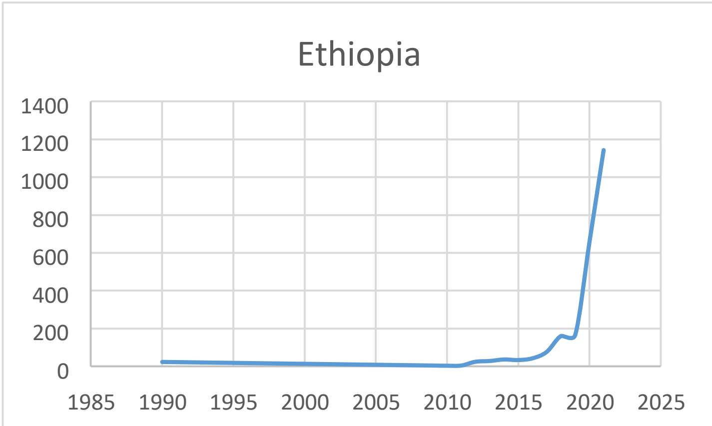


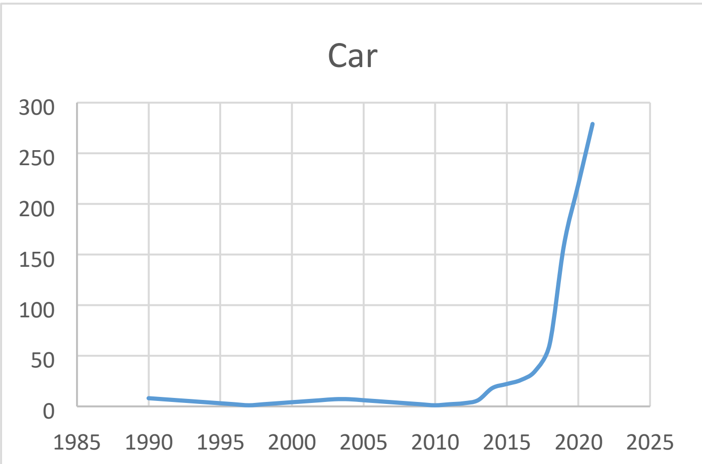


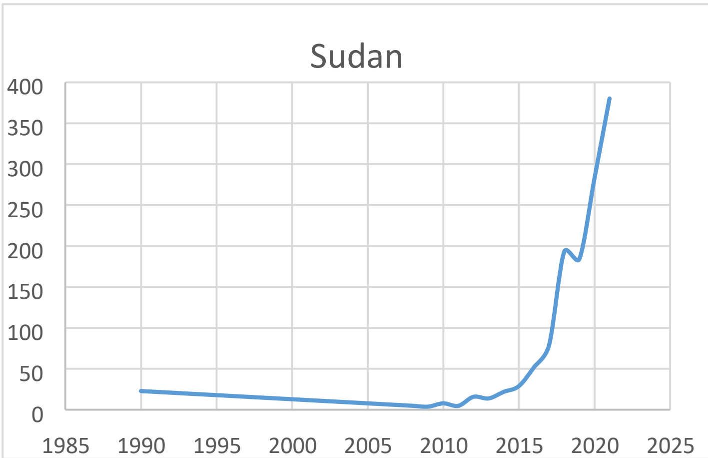






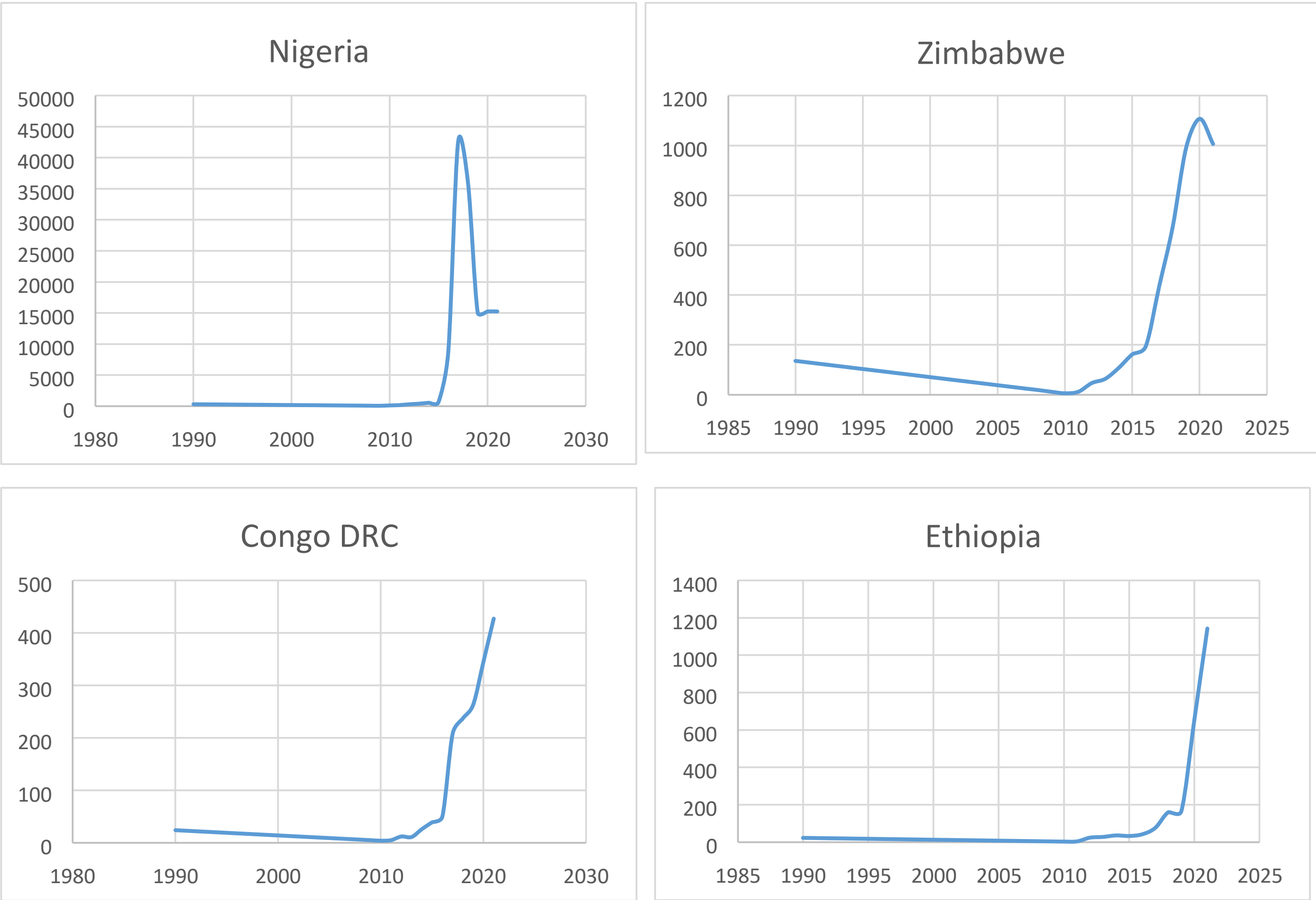






Sources: Author's computation Data from *World development indicators (2022)*

Fig 4.1 6 Graphical Representation of ICT (Number of Servers), 1990-2021



The mean and standard deviations the selected economic indicators for Sub-Saharan African (SSA) countries provides further insights into the region's economic landscape. The mean per capita GDP of $1880.39 indicates a moderate average economic output, yet the standard deviation of $2597.00 underscores considerable variability among countries, suggesting a diverse range of economic development levels. The mean electricity supply of 0.4025kwi and its standard deviation of 0.2935 highlight variations in energy accessibility across SSA, with some countries demonstrating robust infrastructure, while others face challenges. The mean electricity distribution at 439.41kwi, coupled with a high standard deviation of 547.24, indicates disparities in the reach of electricity infrastructure, with some nations excelling in distribution while others lag behind. The mean government spending on health at 0.0459, with a low standard deviation of 0.0176, implies a relatively consistent but modest commitment to healthcare, potentially sign alling a shared regional focus. The mean government spending on education at 0.0575, accompanied by a standard deviation of 0.0716, reflects varying levels of investment in education, indicating diverse policy priorities.

4.2.2 Correlation matrix

Table 4.2 Correlation Matrix showing relationship among the variables.

	PGDP	ELS	EG	ED	GSH	GSE	ICT	GFCF	EI
ELS	0.82365								
EG	0.4117	0.650519							
ED	0.827529	0.756361	0.378704						
GSH	-0.16821	-0.23795	-0.11737	0.059212					
GSE	-0.13579	-0.07382	0.110462	0.191605	0.286452				
ICT	0.091239	0.124961	0.189346	0.035382	-0.05934	-0.04052			
GFCF	-0.01788	0.092717	0.225344	-0.21033	-0.21289	-0.11948	0.49851		
EI	0.743491	0.741465	0.314366	0.797194	-0.00314	0.16391	0.15814	0.064016	
FDI	-0.01136	0.058722	0.079475	-0.13199	-0.04224	-0.09445	0.102964	0.608849	0.08453

Source: Author's Computation (2023)

From Table 4.2, the strong positive correlations between per capita GDP and both electricity supply and electricity distribution at 0.82365 and 0.827529, respectively, underscore the essential role of energy infrastructure in driving economic growth.

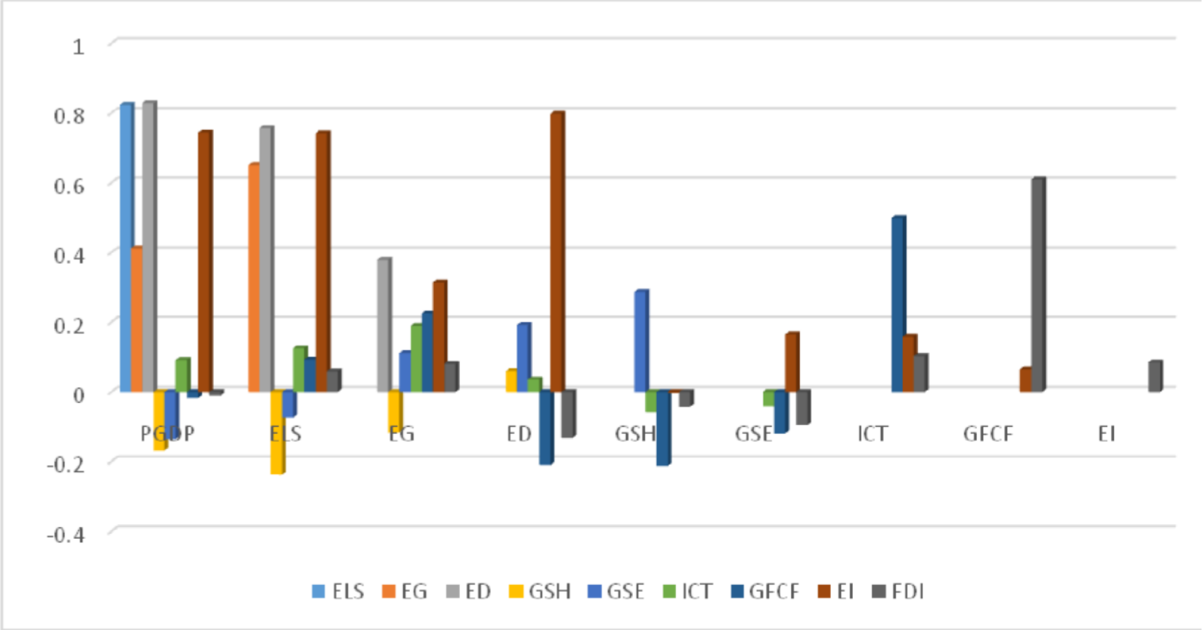


Figure 1: Correlation among various economic Indicators in SSA

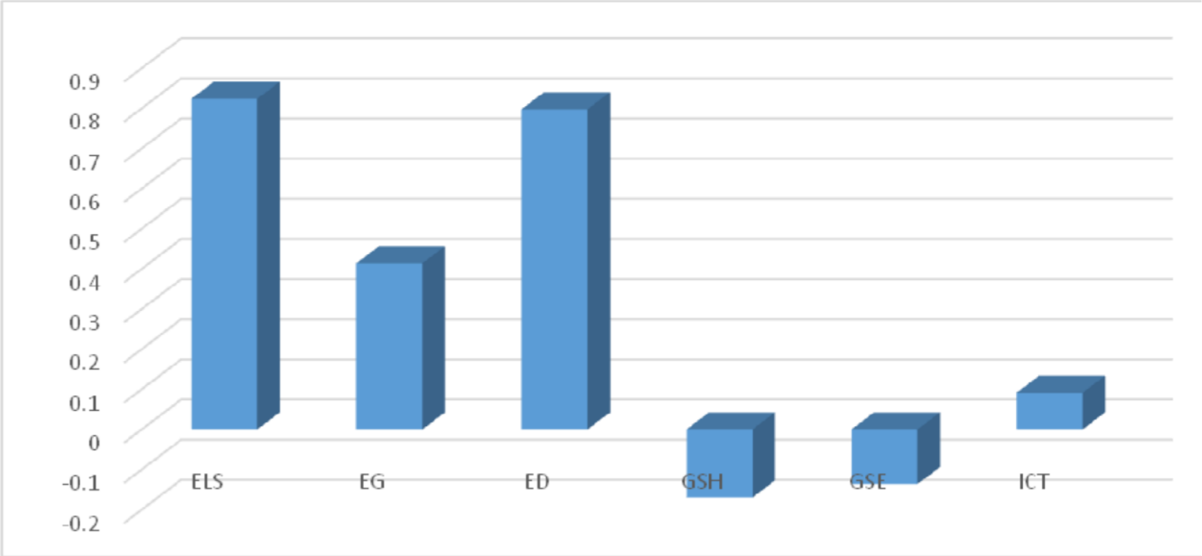


Figure 2: Correlation of Real economic Growth and Infrastructural development Indicators in SSA

Notably, the negative correlations between government spending on health and per capita GDP (-0.168206) and government spending on education and per capita GDP (-0.135793) suggest that higher investments in these sectors do not necessarily immediately translate to economic prosperity, pointing to potential lags in impact. The robust positive correlation of 0.743491 between PGDP and the education index emphasizes the critical link between education and economic development. Additionally, the relatively low correlation (0.011359) between foreign direct investment and PGDP suggests that while FDI plays a role, other factors contribute more significantly to a country's overall economic prosperity. Overall, this comprehensive analysis underscores the complex inter-dependencies among key economic indicators in SSA, providing valuable insights for policy makers aiming at fostering sustainable development in the region.

4.2.3 Panel Unit Root Test

Table 4.3 Panel unit root test showing the level of significant at 1%

Variable	Levin-Lin-Chu (LLC)			Im-Pesaran-Shin (IPS)		
	Level	**1st Difference**	**Remark**	**Level**	**1st Difference**	**Remark**
LNPGDP	-0.20268	-7.04012*	I(1)	1.65432	-9.37123*	I(1)
LNELS	-6.01229*		I(0)	-0.69733	-11.6847*	I(1)
LNEG	-0.93919	-6.70178*	I(1)	-0.66008	-8.37420*	I(1)
LNED	-0.80554	-10.6282*	I(1)	1.18533	-10.3835*	I(1)
LNGSH	-0.28806	-5.28691*	I(1)	-0.82065	-7.76926*	I(1)
LNGSE	-0.87494	-9.38028*	I(1)	-0.71596	-9.52961	I(1)
LNICT	2.05889	-5.05972*	I(1)	0.43086	-5.62968*	I(1)
LNGFCF	1.65316	-6.08618*	I(1)	3.04563	-8.10548*	I(1)
LNEI	-3.87068*		I(0)	0.68367	-5.90559*	I(1)
LNFDI	-1.41382	-5.85245*	I(1)	-1.13111	-11.8462*	I(1)

Source: Author's computation (2023) Note:

** indicate significance at 1% level.*

The Panel Unit Root Test, as depicted in Table 4.3, assesses the stationarity properties of the logarithmic transformations of various variables, using the Levin-Lin-Chu (LLC) and ImPesaran-Shin (IPS) tests. The LNPGDP and LNEG exhibit unit root behaviour in their levels but become stationary in their first differences, denoted as I(1). This suggests that these variables are integrated parts of order one and that their growth rates, rather than absolute levels, are more suitable for analysis. Natural Log of Electricity Supply and Education Index remain stationary at level (I(0)), indicating no need for differencing. However, Natural Log of the per capita GDP, Electricity Generated, Electricity Distribution, Government Spending on

Health, Government Spending on Education, Information and Communication Technology, Gross Fixed Capital Formation and Foreign Direct Investment, all show unit root behavior in their levels, but become stationary in first differences (I(1)), highlighting the importance of considering growth rates when examining these variables.

4.2.4 Panel Co-integration Test

Based on the findings from the panel unit root analysis, the Pedroni Co-integration Test emerges as a more appropriate selection than the Westerlund test in examining potential cointegration among the variables. This preference is rooted in the fact that the Pedroni test accommodates the possibility of distinct levels of integration among the variables, permitting the inclusion of both I(0) and I(1) variables within a single analysis, which aligns with the observations from the panel unit root analysis. In contrast, the Westerlund test assumes that each individual time series variable is integrated at order one, or I(1).

Table 4.4 Pedroni Co-integration Test Result

Test statistics	Panel	Group
V-statistic	-0.239190 (0.5945)	
Rho-statistic	1.233587 (0.8913)	2.202236 (0.9862)
t-statistic	-2.050862 (0.0201)	-2.135016 (0.0164)
ADF-statistic	-2.376269 (0.0208)	-2.144145 (0.0160)

Source: Author's Computation from Eviews 13
Note: The probability values are in parenthesis

Based on the majority of alternative test statistics, in comparison to the conventional significance level of 0.05, the null hypothesis suggesting no co-integration is to be rejected, while the alternative hypothesis indicating the presence of co-integration is to be accepted. This suggests that there is indeed co-integration, implying a long-term relationship among the variables.

4.3 Panel ARDL Long and Short Run Estimates

Table 4.5: ARDL Estimates

Dependent Variable: LNPGDP			Dependent Variable: LNPGDP		
Variables	**Coefficient Short Run**	**Status**	**Variables**	**Coefficient Short Run**	**Status**

D(LNPGDP(-1))	-0.039045	NS (0.5869)	D(LNGSH)	-0.074305	0.4815
D(LNELS)	1.451403	NS (0.3032)	D(LNGSH(-1))	-0.067239	0.5692
D(LNELS(-1))	-0.357723	NS (0.4817)	D(LNEI)	0.152234	0.9166
D(LNEI)	3.056530	S (0.0020)	D(LNEI(-1))	-4.075703	0.0132
D(LNEI(-1))	-3.510415	NS (0.1245)	D(FDI)	0.179401	0.5832
D(FDI)	0.247587	NS (0.4040)	D(FDI(-1))	-0.005481	0.9659
D(FDI(-1))	0.039572	NS (0.6617)	D(LNED)	0.223516	0.4060
D(LNED)	0.343956	NS (0.0417)	D(LNED(-1))	0.036247	0.8251
D(LNED(-1))	0.282849	NS (0.1953)	D(LNEG)	0.130209	0.4876
D(LNEG)	0.029966	NS (0.9287)	D(LNEG(-1))	0.150092	0.4192
D(LNEG(-1))	0.006430	NS (0.9739)	C	2.786522	0.0073
C	4.442407	S (0.0018)		**Long Run**	
	Long Run		LNGSH	-0.232583	0.0104
LNELS	-0.539738	NS (0.0655)	LNEI	1.431461	0.0000
LNEI	4.856423	S (0.0000)	FDI	1.032126	0.0000
FDI	0.190787	S (0.0000)	LNED	-0.617963	0.0000
LNED	-0.844722	S (0.0003)	LNEG	0.030471	0.3280
LNEG	-0.054118	NS (0.5357)			

Source: Author's Computation from Eviews 13

4.3.1 Long and Short Run P-ARDL Discussion of Results

i. Effect of Electricity Supply on Economic Growth

In the short run, the panel ARDL estimates for the natural logarithm of per capita GDP (LNPGDP) revealed intriguing dynamics. The negative and non-significant co-efficient for the lagged values of LNPGDP (-0.039045) implies that short-term deviations from the equilibrium are self-correcting, although this effect does not reach conventional levels of statistical significance. The positive impact of electricity supply (LNELS) on LNPGDP (1.451403), while not statistically significant, aligns with economic intuition, as a temporary boost in energy availability could stimulate economic activity. Remarkably, the highly significant positive co-efficient for the education index (LNEI) in the short run (3.056530) suggests that improvements in education have an immediate and substantial impact on economic output. While foreign direct investment (FDI) and electricity distribution (LNED) also contribute positively to LNPGDP in the short run, the lack of statistical significance indicates caution in drawing strong conclusions about their immediate effects. These short-run dynamics underscore the relationship between education and economic growth, emphasizing the need for targeted policy interventions to enhance human capital and infrastructure for rapid economic gains.

In the long run, the panel ARDL estimates shed light on sustained relationships among variables. The negative co-efficient for electricity supply (LNELS) in the long run (-0.539738) suggests that an increase in long-term electricity supply may have a dampening effect on per capita GDP. This unexpected result prompts potential structural challenges or inefficiencies associated with increased electricity supply. On the other hand, the highly significant positive co-efficient for the education index (LNEI), in the long run (4.856423), reaffirms the crucial role of education in fostering persistent economic growth. Foreign direct investment (FDI) maintains a positive and statistically significant impact on LNPGDP in the long run (0.190787), emphasizing its role as a driver of sustained economic development. The negative and significant coefficient for electricity distribution (LNED) in the long run (-0.844722) suggests that challenges or inefficiencies in the distribution of electricity could have enduring adverse effects on economic output. The non-significant co-efficient for electricity generated (LNEG) in the long run prompts further exploration of its nuanced role in the region's economic landscape. These long-run estimates provide nuanced insights into the lasting effects of key variables on economic growth, offering valuable guidance for policy makers seeking to cultivate sustained and inclusive development in Sub-Saharan African countries.

ii. Effect of Health Expenditure on Economic Growth

The co-efficient of government spending on health (GSH) and its lagged values (D(LNGSH) and D(LNGSH(-1))) are non-significant, indicating that short-term fluctuations in health expenditure do not significantly impact LNPGDP in the immediate period. Foreign direct investment (FDI) exhibits a positive but non-significant impact on LNPGDP in both the short run and its lagged values. Electricity distribution (LNED) and electricity generated (LNEG) also do not exert statistically significant short-term effects on LNPGDP. However, the constant term (C) is statistically significant, suggesting the presence of a short-term deterministic trend. These findings highlight the nuanced and potentially lagged impact of health spending, education, and foreign investment on short-term economic growth in the region.

In the long run, the Government spending on health (LNGSH) exhibits a negative and statistically significant impact on LNPGDP in the long run (-0.232583), suggesting that sustained increases in health spending may have a dampening effect on economic output. This counter-intuitive result prompts potential inefficiencies or challenges associated with health expenditure. The education index (LNEI) maintains a highly significant positive impact on LNPGDP (1.431461), reinforcing the critical role of education in fostering long-term economic growth. Foreign direct investment (FDI) also plays a substantial and significant role in shaping the long-term trajectory of LNPGDP (1.032126), and underscoring its importance as a driver of sustained economic development. Electricity distribution (LNED) exhibits a negative and significant coefficient in the long run (-0.617963), implying that challenges in the distribution of electricity may have lasting adverse effects on economic output. The co-efficient for electricity generated (LNEG) is not statistically significant in the long run, suggesting a nuanced role that requires further investigation. These long-run estimates provide valuable insights into the persistent effects of government spending, education, foreign investment, and energy infrastructure on economic growth in the region.

Table 4.6: ARDL Estimates

Dependent Variable: LNPGDP			Dependent Variable: LNPGDP		
Variables	**Coefficient**	**Status**	**Variables**	**Coefficient**	**Status**
	Short Run			**Short Run**	
D(LNPGDP(-1))	0.038745	NS (0.7242)	D(LNPGDP(-1))	-0.106484	NS (0.0702)
D(LNGSE)	-0.030015	NS (0.7840)	D(LNICT)	0.025032	NS (0.5067)
D(LNGSE(-1))	0.066485	NS (0.6507)	D(LNICT(-1))	0.010541	NS (0.8260)
D(LNEI)	0.626334	NS (0.7109)	D(LNEI)	0.774020	NS (0.6016)

D(LNEI(-1))	-3.807353	S (0.0375)	D(LNEI(-1))	-3.708842	NS (0.0641)
D(FDI)	0.367323	NS (0.2148)	D(FDI)	0.269034	NS (0.4016)
D(FDI(-1))	0.126281	NS (0.1189)	D(FDI(-1))	0.102214	NS (0.5301)
D(LNED)	0.276041	NS (0.3440)	D(LNED)	0.261361	NS (0.3433)
D(LNED(-1))	0.193866	NS (0.2853)	D(LNED(-1))	0.010764	NS (0.9458)
D(LNEG)	0.051948	NS (0.7554)	D(LNEG)	0.031488	NS (0.8882)
D(LNEG(-1))	0.132332	NS (0.4745)	D(LNEG(-1))	0.133229	NS (0.4607)
C	3.409279	S (0.0107)		**Long Run**	
	Long Run		LNICT	-0.232583	S (0.0104)
LNGSE	-0.083352	S (0.0072)	LNEI	1.431461	S (0.0000)
LNEI	1.597263	S (0.0000)	FDI	1.032126	S (0.0000)
FDI	0.042100	S (0.0001)	LNED	-0.617963	S (0.0003)
LNED	-0.179880	S (0.0000)	LNEG	0.030471	NS (0.1587)
LNEG	-0.037663	S (0.0000)			

Source: Author's Computation from Eviews 13

iii. Effect of Educational Expenditure on Economic Growth

In the short run, the non-significant positive co-efficient for lagged LNPGDP suggests that short-term economic deviations tend to self-correct, although this effect lacks statistical significance. Interestingly, government spending on education (GSE) and its lagged values do not exhibit significant short-term impacts on LNPGDP, implying that changes in education spending may take time to manifest in economic output. The education index (LNEI) also shows non-significant short-term effects, reflecting the relationship between educational improvements and immediate economic growth. Foreign direct investment (FDI) and electricity distribution (LNED) similarly lack immediate impact, underlining the complex dynamics governing these factors in the short term. The significant constant term (C) indicates the presence of a short-term deterministic trend, emphasizing the importance of considering underlying economic patterns. These findings underscore potentially delayed effects of education, foreign investment, and energy infrastructure on short-term economic growth in the region.

In the long run, the negative and significant co-efficient for government spending on education (LNGSE) in the long run suggests a counter-intuitive impact, wherein sustained increases in education spending may pose challenges to long-term economic output. This result may be attributed to potential inefficiencies or miss-allocation of educational resources. The highly significant positive impact of the education index (LNEI) re-affirms the well-established intuition, that improvements in education foster sustained economic growth, by enhancing human capital. Foreign direct investment (FDI) and electricity distribution (LNED) play pivotal roles in shaping the long-term trajectory of LNPGDP, and reflecting their importance in sustaining economic development. The negative co-efficient for electricity generated (LNEG) indicates a long-term adverse impact on LNPGDP, thus suggesting a need for careful management of energy generation for sustained economic growth. These long-run estimates provide nuanced insights into the persistent effects of government spending, education, foreign investment, and energy infrastructure on economic growth in the region, guiding policy makers towards effective and sustainable development strategies.

iv. Impact of Information and Communication Technology on Economic Growth

In the short run, Information and Communication Technology (ICT) its lagged values (D(LNICT) and D(LNICT(-1))) do not exert statistically significant effects on LNPGDP in the short run, thereby indicating that changes in ICT infrastructure may not have an immediate impact on economic output. The education index (LNEI) and its lagged values similarly show non-significant short-term impacts on LNPGDP, suggesting that improvements in education may take time to manifest in immediate economic growth. Foreign direct investment (FDI) and electricity distribution (LNED) also exhibit non-significant coefficients in the short run, indicating that changes in these variables do not immediately impact LNPGDP. The positive and non-significant co-efficient for electricity generated (LNEG) suggest a potential positive impact on LNPGDP in the short term. These findings highlight potentially-delayed effects of education, foreign investment, and energy infrastructure on short-term economic growth in the region.

In the long run, the negative and significant co-efficient for Information and Communication Technology (ICT), in the long run (-0.232583), suggests that, in the absence of other factors, increases in ICT infrastructure may have a dampening effect on long-term economic output. This result might be attributed to challenges associated with rapid technological advancements, such as potential disruptions in traditional economic sectors. The highly significant positive impact of the education index (LNEI) reaffirms the well-established intuition that improvements in education foster sustained economic growth by enhancing human capital. Foreign direct investment (FDI) and electricity distribution (LNED) play pivotal roles in shaping the long-term trajectory of LNPGDP, reflecting their importance in sustaining economic development. These long-run estimates provide insights into the persistent effects of education, foreign investment, and technology on economic growth in the region, guiding policy makers towards effective and sustainable development strategies.

4.4 Causality test

Table 4.6: Pairwise Dumitrescu Hurlin Panel Causality Tests

Sample: 1990 2021
Lags: 2

Null Hypothesis:	W-Stat.	Zbar-Stat.	Prob.
PGDP does not homogeneously cause ICT	9.46822	9.72482	0.0000
ICT does not homogeneously cause PGDP	2.73185	0.74385	0.457
PGDP does not homogeneously cause ELS	3.63363	1.94610	0.0516
ELS does not homogeneously cause PGDP	4.39512	2.96132	0.0031
PGDP does not homogeneously cause GSH	4.55313	3.17198	0.0015
GSH does not homogeneously cause PGDP	3.86144	2.24982	0.0245
PGDP does not homogeneously cause GSE	4.87061	3.59526	0.0003
GSE does not homogeneously cause PGDP	5.54942	4.50025	7.E-06

Source: Author's Computation from Eviews 13

The Pairwise Dumitrescu Hurlin Panel Causality Tests provide valuable insights into the directional relationships between key economic indicators in Sub-Saharan African countries. The results indicate a significant homogeneous causality running from per capita GDP (PGDP) to information and communication technology (ICT), suggesting that economic growth stimulates the development and adoption of technological infrastructure. This is intuitive, as higher economic output can afford investments in advanced technologies, fostering innovation and efficiency gains. Conversely, the test reveals that ICT does not homogeneously cause PGDP. This implies that while technological advancements are influenced by economic growth, they do not uniformly drive overall economic output. Notably, the causality tests highlight a bidirectional relationship between PGDP and electricity supply (ELS), emphasizing the symbiotic nature of economic growth and energy infrastructure. The results also suggest that economic growth homogeneously causes government spending on health (GSH) and education (GSE), thus underscoring the role of a thriving economy in facilitating increased investments in these essential sectors. In essence, the causality tests reflect the interconnectedness of economic growth and infrastructure development in Sub-Saharan Africa, emphasizing the need for a holistic approach whereby improvements in economic conditions drive advancements in crucial infrastructural domains, and reciprocally, strategic investments in infrastructure contribute to sustained economic growth.

CHAPTER FIVE

SUMMARY, CONCLUSION AND POLICY RECOMMENDATIONS

5.1 Summary

This study explores the impact of infrastructural development on economic growth in SubSaharan African (SSA) nations. The Solow growth model was applied as the theoretical framework of the study. The study extends the model to include critical variables like electricity supply, infrastructure, and education, yielding a nuanced understanding of the factors shaping long-term economic growth. Spanning the years 1990 to 2021, the data is extracted from the World Development Indicators (WDI), World Bank database, encompassing 10 strategically chosen SSA countries: Nigeria, Zimbabwe, Congo, Ethiopia, Central African Republic (CAR), Sudan, Mozambique, Gabon, Mauritius, and Senegal.

The descriptive analysis paints a vivid picture of economic variations across SSA, revealing disparities in per capita GDP, electricity infrastructure, and government spending. Notable patterns emerge, such as Mauritius' robust economic growth driven by effective governance and Central African Republic, faced with historical infrastructural challenges. These insights serve as a crucial backdrop for the subsequent in-depth exploration of regional economic intricacies.

The correlation matrix uncovers the interconnectedness of variables, revealing strong positive correlations between per capita GDP and electricity supply/distribution. Unexpected negative correlations with health and education spending hint at temporal lags in their impact on economic prosperity, adding layers of complexity to the regional economic narrative. The unit root and co-integration analyses build a robust empirical foundation, affirming different integration order of variables and the long-term relationships among them, respectively.

The ARDL estimates yield insights into both short - and long-term relationships. The unexpected dampening effect of increased long-term electricity supply on per capita GDP prompts a closer examination of potential inefficiencies within the energy infrastructure. Furthermore, the causality tests exhibit bi-directional relationships, emphasizing the interdependent nature of economic growth and infrastructure development. Economic prosperity stimulates technological advancements (ICT), while electricity supply reciprocally impacts economic growth, illustrating the interactions within the economic system.

In essence, this study significantly contributes to the understanding of Sub-Saharan African economies, unravelling the relationships among key indicators. The findings, derived from a comprehensive dataset spanning over three decades, offer valuable insights for policy makers. The analysis sheds light on the impact of infrastructure, education, and healthcare on economic growth, guiding strategic interventions for sustainable development in the region.

Policy makers are encouraged to consider these relationships when formulating strategies for economic growth and infrastructure development in Sub-Saharan Africa.

5.2 Conclusion

This study offers an examination of the relationship between infrastructural development and economic growth in Sub-Saharan Africa (SSA). The empirical analysis, spanning 1990 to 2021 and encompassing ten strategically selected countries, reveals complex relationships that extend beyond traditional GDP-centric frameworks. While short-term dynamics underscore the positive impact of electricity supply, education, and foreign direct investment on economic growth, the long-term analysis shows unexpected complexities, particularly regarding the sustained effects of electricity supply this in line with the study of . Mathur, Oliver, and Tripney (2015) that conduct a systematic review of the impact of electricity supply on health, education, and welfare, including 51 studies in 24 countries in 3 continents, among them 14 African countries. The review showed that electricity access had positive and significant impacts on educational outcomes (study time, years of schooling, and school enrolment), with higher impacts for rural areas compared with urban areas. Also on income generation, the pooled estimate effect suggests that electricity access has an overall positive impact on household income in the farm and nonfarm sectors.

Counter-intuitive findings regarding heightened government spending on health add an additional layer of complexity, indicating potential inefficiencies. Causality tests illuminate bidirectional relationships, emphasizing the inter-dependency nature between economic growth and infrastructure development. Bagnoli, Bertomeu-Sanchez, Estache, and Vagliasindi (2021) argued that insufficient power generation capacity limits economic growth in Ghana, and inadequate infrastructure facilities has contributed to high transaction cost of doing business in most sub-Saharan African countries. These resulted in the lowest level of productivity of all low-income countries, which made them the least competitive economies in the world. , Kodongo and Ojah (2016), in their work, aligned with these views that the nature of relation between infrastructure and economic growth is important and the development of one will also have a positive impact on the other . This view is particularly germane for less developed regions, such as SSA, where traditional antecedents of economic growth are dominant. According to Trisnowati, Hadiwidjaja, and Nurvita (2021), hard infrastructure is essential to running an industrialized, modern economy. Hence, this study contributes significantly to the academic discourse on SSA's development, guiding policymakers with evidence for formulating sustainable strategies that encompass diverse infrastructural components.

5.3 Policy Recommendations

Investment in Robust Electricity Infrastructure

Given the positive short-term impact of electricity supply on economic growth, policy makers should prioritize substantial investments in electricity infrastructure. This involves not only increasing generation capacity but also addressing distribution challenges. A reliable and widespread electricity network can serve as a catalyst for economic activities, encouraging industrialization and innovation.

Strategic Focus on Education

The research highlights the immediate and sustained positive impact of education on economic growth. Policymakers should allocate resources to enhance educational systems, focusing on both access and quality. Initiatives that promote skill development, vocational training, and technological education can contribute to a skilled workforce, fostering long-term economic development.

Efficient Allocation of Health Expenditure:

Acknowledging the counter-intuitive long-term impact of increased health spending, policy makers should conduct thorough assessments to ensure the efficient allocation of healthcare resources. Strategies should aim at enhancing healthcare outcomes, while avoiding potential inefficiencies that may hinder long-term economic growth.

Facilitation of Foreign Direct Investment (FDI)

The research emphasizes the positive role of FDI in both short and long-term economic growth. Policymakers should create an environment conducive to foreign investment by implementing transparent regulations, minimizing bureaucratic hurdles, and offering incentives. Attracting FDI can provide not only financial resources but also technological know-how and employment opportunities.

Adoption of Sustainable Information and Communication Technology (ICT) Policies:

Acknowledging the potential dampening effect of ICT in the long run, policy makers should adopt a strategic approach to technology integration. Sustainable ICT policies should be developed to harness the benefits of technological advancements without disrupting traditional economic sectors. This involves creating an environment that encourages innovation and addresses the digital divide.

Critical Evaluation of Infrastructure Spending

The study underscores the need for a critical evaluation of infrastructure spending. Policy makers should assess the efficiency and effectiveness of infrastructure projects, considering both short-term and long-term implications. This involves regular monitoring, evaluation, and adaptation of infrastructure plans to ensure they align with broader economic development goals.

Integrated Development Planning

Causality tests reveal inter-connected relationships between economic growth and various infrastructure components. Policy makers should adopt an integrated approach to development planning, recognizing the interdependencies between sectors. Comprehensive strategies that synchronize investments in electricity, education, health, and technology can create a synergistic effect, fostering sustainable and inclusive economic growth.

5.4 Contribution to knowledge

This study significantly contributes to the understanding of Sub-Saharan African economies, unravelling the relationships among key indicators. The findings, derived from a comprehensive dataset spanning over three decades, offer valuable insights for policy makers. The analysis sheds light on the impact of infrastructure; electricity supply, education, TCT and healthcare, on economic growth, guiding strategic interventions for sustainable development in the region. Policy makers are encouraged to consider these relationships when formulating strategies for economic growth and infrastructural development in Sub-Saharan Africa.

This study also offered additional knowledge to existing one in the area of infrastructural development in SSA in the study of strategically selection of ten Countries according to their geographical location. The study also contributed to existing literature with an indepth analysis of the Countries. In addition to reviewed literature the study contributed empirically by analyzing he various data collected in these Countries to determine the trend of infrastructural facilities available in SSA and recommendations were made on how to improve these facilities to enhance sustainable development in the region in the nearest feature. The causal relationship between infrastructural development and economic growth.

i. Investment in electricity infrastructure will make a positive impact on electricity supply that will improve economic growth on the sort-run. Policy makers should prioritise substantial investments in electricity infrastructure, increase generation capacity and also address distribution challenges. Because Building a reliable and widespread electricity network can serve as a catalyst for economic activities, encouraging industrialization and innovation.

ii. Policymakers should strategically focus on providing educational facilities that will immediate improve and sustain a positive impact on economic growth. Allocate resources to enhance educational systems, focusing on both access and quality. Couple with initiatives that will promote skill development, vocational training, and technological education that can contribute to a skilled workforce which will foster long-term economic development.

iii. Efficient allocation of health expenditure: Acknowledging the counter-intuitive long-term impact of increased health spending, policy makers should conduct thorough assessments to ensure the efficient allocation of healthcare resources while avoiding potential inefficiencies that may hinder long-term economic growth.

iv. Facilitation of Foreign Direct Investment (FDI), the positive role of FDI in both short and long-term economic growth cannot be undermined. Policymakers should create an environment conducive for foreign investment by implementing transparent regulations, minimizing bureaucratic hurdles, and offering incentives and also technological know-how that will provide employment opportunities.

Adoption of sustainable information and communication technology policies that encourage the potential dampening effect of ICT in the long run, this involves creating an environment that encourages innovation and addresses the digital divide.

The study also underscores the need for a critical evaluation of infrastructure spending. Policy makers should assess the efficiency and effectiveness of infrastructure projects, considering both short-term and long-term implications. This involves regular monitoring, evaluation, and adaptation of infrastructure plans to ensure they align with broader economic development goals.Causality tests reveal inter-connected relationships between economic growth and various infrastructure components. Policy makers should adopt an integrated approach to development planning, recognizing the interdependencies between sectors. Comprehensive strategies that synchronize investments in electricity, education, health, and technology can create a synergistic effect, fostering sustainable and inclusive economic growth.

5.5 Limitations of the Study

While this study provides valuable insights into the relationship between infrastructural development and economic growth in Sub-Saharan Africa, it is essential to acknowledge certain limitations that point to avenues for refinement. Firstly, the analysis is based on historical data, which may not fully capture rapid shifts in economic conditions or policy dynamics. The use of quantitative data also limits the exploration of qualitative factors that can reflects the dynamics of infrastructure and its relationship with economic growth. Furthermore, the study assumes stationary and causal relationships among the variables, which might oversimplify the complexities of real-world interactions. Lastly, external global factors and geopolitical events that could influence the study's findings are not extensively accounted for. Recognizing these limitations, future research could incorporate a more extensive range of variables and qualitative insights to provide a more comprehensive understanding of the multifaceted dynamics shaping infrastructural improvement and hence economic growth in SSA.

5.6 Suggestions for Future Research

Building upon the identified limitations, future research in this domain could embark on a more intense exploration by incorporating qualitative data and insights. Qualitative methodologies, such as case studies or interviews, could offer a deeper understanding of the contextual factors influencing the relationship between infrastructure and economic growth. Additionally, employing more recent and dynamic data sets, potentially with a focus on real-time or nearreal-time indicators, would allow for a more accurate depiction of the rapidly changing economic and policy landscape. Exploring the impacts of external global factors and geopolitical events on Sub-Saharan African countries' infrastructural development and economic growth could also enrich the analysis. Furthermore, researchers might consider expanding the scope to include additional countries, considering the heterogeneity within the region, to provide a more comprehensive and representative picture. This approach would contribute to overcoming the limitations of the current study and foster a more robust understanding of the relationship between infrastructure and economic growth in Sub-Saharan Africa.

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Year	**CID**	**PGDP**	**ELS**	**EG**	**ED**	**GSH**	**GSE**	**ICT**	**GFCF**	**EI**
1990	**1**	567.5179	0.273	0.674144	87.0773	0.03205298	0.03205298	296	28.705	0.341
1991	**1**	502.8229	0.352346	0.581351	89.58354	0.03213213	0.03213213	283	23.77341	0.341
1992	**1**	477.081	0.360995	0.591546	90.03609	0.03221128	0.03221128	270	20.92195	0.341
1993	**1**	270.0275	0.369636	0.615857	100.812	0.03229043	0.03229043	257	12.34317	0.341
1994	**1**	320.8258	0.378265	0.641878	95.41409	0.03236957	0.03236957	244	14.23283	0.341
1995	**1**	407.2783	0.386873	0.65315	91.28587	0.03244872	0.03244872	231	16.39385	0.341
1996	**1**	460.3242	0.395453	0.661393	85.68247	0.03252787	0.03252787	218	18.68439	0.341
1997	**1**	478.5769	0.404	0.652975	81.76381	0.03260702	0.03260702	205	20.92393	0.341
1998	**1**	467.939	0.412506	0.617828	76.72431	0.03268616	0.03268616	192	22.1438	0.341
1999	**1**	496.0307	0.449	0.617876	75.49152	0.03276531	0.03276531	179	22.72667	0.341
2000	**1**	565.306	0.4318	0.617845	74.14614	0.03284446	0.03197383	166	23.64688	0.341
2001	**1**	586.8331	0.439117	0.617837	75.11533	0.03197383	0.03189469	153	22.23726	0.359
2002	**1**	733.5382	0.446349	0.617823	103.8639	0.03189469	0.0249064	140	25.4447	0.377
2003	**1**	786.8024	0.522	0.630995	100.9917	0.0249064	0.0505361	127	29.71539	0.395
2004	**1**	992.7453	0.460836	0.665994	122.3339	0.0505361	0.04633684	114	35.3847	0.413
2005	**1**	1250.407	0.468232	0.669994	127.8305	0.04633684	0.04465919	101	43.85813	0.422
2006	**1**	1652.154	0.475821	0.728992	110.3653	0.04465919	0.04257751	88	62.39531	0.425

2007 **1** 1876.413 0.501309 0.729002 137.079 0.04257751 0.03909972 75 56.15313 0.429

2008 **1** 2227.79 0.503 0.728991 125.4803 0.03909972 0.03695815 62 64.02442 0.432

2009 **1** 1883.887 0.499689 0.770997 118.8857 0.03695815 0.03580197 49 62.29244 0.419

2010 **1** 2280.112 0.48 0.755982 134.3499 0.03580197 0.03296533 102 61.70951 0.407

2011 **1** 2504.878 0.559 0.782385 147.7846 0.03296533 0.03320779 155 64.97306 0.424

2012 **1** 2728.023 0.530174 0.802864 154.1723 0.03320779 0.03359843 290 65.93548 0.437

2013 **1** 2976.757 0.556 0.815601 140.311 0.03359843 0.03420693 382 73.69398 0.449

2014 **1** 3200.953 0.541537 0.824087 142.1292 0.03420693 0.03348404 528 86.60721 0.458

2015 **1** 2679.555 0.525 0.818049 144.7146 0.03348404 0.0358195 643 73.10195 0.467

2016 **1** 2144.78 0.593 0.807106 147.5736 0.0358195 0.03647737 8814 59.58439 0.481

2017 **1** 1941.879 0.544 0.815936 150.4325 0.03647737 0.03747625 42529 55.2933 0.494

2018 **1** 2125.834 0.565 0.824766 153.2914 0.03747625 0.03090693 36082 80.20798 0.508

2019 **1** 2334.024 0.554 0.833596 156.1504 0.03090693 0.02985471 15036 116.851 0.521

2020 **1** 2074.614 0.554 0.842426 159.0093 0.02985471 0.03380634 15242 115.5881 0.521

2021	**1**	2065.749	0.595	0.851256	161.8683	0.03380634	0.03306652	15242	145.9484	0.521
1990	**2**	868.4902	0.341273	0.533326	892.6335	0.03775798	0.36798342	136	1.59951	0.439
1991	**2**	832.688	0.37091	0.646795	881.1103	0.04170962	0.39191297	129	1.77888	0.459
1992	**2**	634.4474	0.282	0.616244	806.3712	0.04566126	0.36798342	123	1.509816	0.455
1993	**2**	608.0466	0.311637	0.723889	757.5787	0.04961289	0.34405387	116	1.548517	0.461
1994	**2**	634.5826	0.281	0.721964	806.458	0.05356453	0.32012432	110	1.472638	0.467
1995	**2**	646.8296	0.319486	0.707464	854.19	0.05751617	0.29619477	103	1.747756	0.473
1996	**2**	765.1651	0.323373	0.704629	895.4953	0.06146781	0.27226522	97	1.54303	0.48
1997	**2**	750.6839	0.327226	0.709098	924.4525	0.06541945	0.41584251	90	1.539558	0.486
1998	**2**	554.3615	0.331038	0.707428	891.3817	0.06937108	0.43977206	84	1.3189	0.492
1999	**2**	585.3318	0.384	0.589903	935.2659	0.07332272	0.46370161	77	0.175133	0.498
2000	**2**	565.2844	0.336789	0.543388	901.4188	0.07727436	0.48763116	71	0.78928	0.505
2001	**2**	569.0032	0.341705	0.624968	872.9762	0.081226	0.34405387	64	0.82127	0.521
2002	**2**	529.1869	0.342	0.556422	876.1211	0.08517763	0.15261748	58	0.645151	0.512
2003	**2**	474.3022	0.35135	0.392658	872.818	0.10475839	0.17654703	51	0.791196	0.507
2004	**2**	477.3995	0.35622	0.433995	845.8269	0.08082884	0.20047658	45	0.296539	0.515
2005	**2**	470.7838	0.361214	0.475677	881.0812	0.05689929	0.22440613	38	0.11513	0.523
2006	**2**	441.4988	0.372	0.321169	859.5765	0.03296974	0.24833568	32	0.121109	0.532
2007	**2**	425.0368	0.371796	0.284269	748.3193	0.08082884	0.27226522	25	0.268746	0.54

2008	**2**	351.8391	0.377364	0.241049	619.3454	0.05689929	0.29619477	19	0.145096	0.548
2009	**2**	762.298	0.433691	0.243588	578.3998	0.03296974	0.10475839	12	0.959737	0.556
2010	**2**	937.8403	0.388862	0.319908	599.9328	0.10475839	0.08082884	6	2.048494	0.564
2011	**2**	1082.616	0.369	0.421441	629.8277	0.08082884	0.06917949	12	2.063775	0.572
2012	**2**	1290.194	0.44	0.396067	601.8696	0.06917949	0.07109403	47	2.07917	0.58
2013	**2**	1408.368	0.406442	0.460606	619.2356	0.07109403	0.08132273	64	1.752817	0.582
2014	**2**	1407.034	0.323	0.443946	597.297	0.08132273	0.07449827	108	1.873382	0.589
2015	**2**	1410.329	0.337	0.472757	628.5508	0.07449827	0.07466447	162	1.995427	0.597
2016	**2**	1421.788	0.424656	0.305844	616.1348	0.07466447	0.06363585	194	2.015381	0.604
2017	**2**	1192.107	0.439791	0.290628	603.7188	0.06363585	0.04670418	435	1.699378	0.611
2018	**2**	2269.177	0.454003	0.275413	591.3027	0.04670418	0.03659765	673	3.773667	0.619
2019	**2**	1421.869	0.466821	0.260197	578.8867	0.03659765	0.03425581	991	2.335908	0.627
2020	**2**	1372.697	0.527477	0.244981	566.4706	0.03425581	0.03331608	1107	2.160882	0.627
2021	**2**	1773.92	0.489799	0.229765	554.0546	0.03331608	0.02707755	1006	3.517888	0.627
1990	**3**	259.8056	0.092431	0.004425	125.8769	0.11965054	0.01550592	24	0.439127	0.305
1991	**3**	258.7844	0.09587	0.004166	121.1459	0.10807892	0.0139343	23	0.439127	0.31
1992	**3**	214.6321	0.099308	0.003129	112.2291	0.09650729	0.00654774	22	0.439127	0.315
1993	**3**	270.4909	0.102746	0.003066	100.6042	0.08493567	0.00916119	21	0.439127	0.321
1994	**3**	140.2097	0.106185	0.003389	98.23669	0.07336405	0.0046821	20	0.439127	0.326
1995	**3**	130.3763	0.109623	0.002914	104.584	0.06179242	0.00204002	19	0.544795	0.331

1996	**3**	130.8165	0.113062	0.002946	101.6122	0.0502208	0.01550592	18	1.563816	0.337
1997	**3**	135.8889	0.1165	0.003768	93.27967	0.03864917	0.02897183	17	0.152271	0.342
1998	**3**	135.4774	0.119939	0.004019	91.27252	0.02707755	0.04243773	16	0.130574	0.348
1999	**3**	99.75725	0.123377	0.004523	92.53135	0.01550592	0.05590363	15	0.144589	0.354
2000	**3**	392.6263	0.067	0.000502	93.56941	0.02707755	0.06936953	14	2.752174	0.359
2001	**3**	148.4471	0.071113	0.000839	92.34302	0.02654774	0.01550592	13	0.495591	0.365
2002	**3**	168.9448	0.077261	0.001311	86.62061	0.03818178	0.02707755	12	0.6484	0.371
2003	**3**	167.9816	0.083393	0.001139	87.19001	0.04420287	0.02654774	11	0.842346	0.377
2004	**3**	187.8568	0.08958	0.001132	85.37714	0.04252658	0.03818178	10	1.250332	0.383
2005	**3**	211.5726	0.06	0.000949	86.66629	0.04393809	0.04420287	9	1.396986	0.389
2006	**3**	247.5419	0.102395	0.006098	98.62691	0.04335553	0.04252658	8	2.107791	0.394
2007	**3**	277.6121	0.152	0.011038	102.0411	0.0498872	0.04393809	7	2.278323	0.4
2008	**3**	317.8892	0.115992	0.012849	98.2173	0.04546159	0.04335553	6	2.126515	0.424
2009	**3**	290.1557	0.12301	0.01095	103.765	0.03860356	0.0498872	5	2.702721	0.43
2010	**3**	324.8277	0.130124	0.010879	101.7754	0.03262673	0.04546159	4	6.194087	0.442
2011	**3**	376.375	0.137295	0.011141	105.0335	0.03300995	0.03860356	5	6.412225	0.456
2012	**3**	412.7763	0.154	0.001182	109.0596	0.03566633	0.03262673	12	4.175543	0.454
2013	**3**	444.8644	0.151655	0.00109	113.6809	0.03978741	0.03300995	11	7.104316	0.466
2014	**3**	472.2662	0.135	0.001244	105.2796	0.03969214	0.03566633	26	8.298948	0.475
2015	**3**	482.0646	0.165845	0.001789	97.5766	0.04366031	0.03978741	39	6.954571	0.485

2016 **3** 456.028 0.172873 0.005729 97.35751 0.04156466 0.03969214 50 6.374157 0.495

2017 **3** 451.0891 0.179868 0.005839 97.13843 0.03302493 0.04366031 208 9.418793 0.5

2018 **3** 546.2126 0.186839 0.005948 96.91934 0.035423 0.04156466 237 9.700335 0.506

2019 **3** 575.8828 0.191 0.006058 96.70025 0.04050926 0.03302493 263 10.53107 0.507

2020 **3** 524.6667 0.200738 0.006168 96.48116 0.04187328 0.035423 345 11.82685 0.507

2021 **3** 577.2092 0.207682 0.006277 96.26207 0.00067607 0.04050926 427 15.03392 0.507

1990 **4** 254.2953 0.154 0.116473 22.59907 0.00425727 0.01141967 23 10.25929 0.115

1991 **4** 269.6148 0.151655 0.105045 21.78726 0.00783847 0.01500087 22 10.25929 0.115

1992 **4** 201.7435 0.135 0.072522 21.476 0.01141967 0.01858207 21 10.25929 0.115

1993 **4** 164.1651 0.127885 0.086768 23.14485 0.01500087 0.02216327 20 10.25929 0.115

1994 **4** 124.5581 0.118385 0.06685 23.48067 0.01858207 0.02574447 19 10.25929 0.115

1995 **4** 133.3411 0.108885 0.064833 23.90541 0.02216327 0.02932567 18 10.25929 0.115

1996 **4** 144.0316 0.099385 0.058016 24.31436 0.02574447 0.03290687 17 10.25929 0.115

1997 **4** 140.2702 0.089885 0.02974 23.72885 0.02932567 0.03648807 16 10.25929 0.115

1998 **4** 123.8302 0.080385 0.029038 23.56799 0.03290687 0.04006927 15 10.25929 0.133

1999 **4** 118.3331 0.070885 0.011557 22.74209 0.03648807 0.04365047 14 10.25929 0.151

2000 **4** 122.9617 0.127 0.01374 22.48184 0.04006927 0.04723167 13 10.25929 0.169

2001 **4** 119.2619 0.102196 0.009443 26.23918 0.04365047 0.04723167 12 10.25929 0.187

2002 **4** 110.4609 0.118762 0.010274 25.8888 0.04723167 0.0471263 11 10.25929 0.199

2003 **4** 117.8602 0.135312 0.006969 28.23606 0.0471263 0.04899709 10 10.25929 0.207

2004	**4**	134.5425	0.151916	0.007089	30.34487	0.04899709	0.04312819	9	10.25929	0.219
2005	**4**	160.0768	0.14	0.004218	33.04508	0.04312819	0.04100981	8	10.25929	0.244
2006	**4**	191.7513	0.185568	0.003059	36.91757	0.04100981	0.04457573	7	10.25929	0.262
2007	**4**	240.348	0.202698	0.045672	38.92864	0.04457573	0.05001283	6	10.25929	0.279
2008	**4**	320.8611	0.22	0.123643	40.29299	0.05001283	0.04280639	5	10.25929	0.295
2009	**4**	373.894	0.237437	0.111222	41.4152	0.04280639	0.04649834	4	10.25929	0.296
2010	**4**	335.4385	0.254969	0.006225	47.43506	0.04649834	0.05466372	3	10.25929	0.299
2011	**4**	348.0013	0.23	0.00584	51.59123	0.05466372	0.04468977	4	10.25929	0.304
2012	**4**	458.5509	0.290166	0.001581	56.16652	0.04468977	0.04539596	24	16.06739	0.309
2013	**4**	490.7925	0.307754	0.000919	62.93495	0.04539596	0.04075065	28	16.23907	0.317
2014	**4**	557.5341	0.272	0.000315	68.05233	0.04075065	0.04033655	36	21.12916	0.325
2015	**4**	630.3126	0.29	0.000383	55.51959	0.04033655	0.03823168	33	26.2693	0.334
2016	**4**	705.6175	0.429	0.001526	57.2035	0.03823168	0.03600338	42	27.74892	0.342
2017	**4**	755.7526	0.443	0.004464	58.88742	0.03600338	0.03453369	76	31.43599	0.353
2018	**4**	758.2977	0.448443	0.007402	60.57133	0.03453369	0.03303718	160	29.2657	0.364
2019	**4**	840.4496	0.480476	0.000339	62.25525	0.03303718	0.03233824	165	33.82261	0.375
2020	**4**	918.6526	0.511446	0.003277	63.93917	0.03233824	0.03480963	654	32.92062	0.375
2021	**4**	925.0007	0.541884	0.006215	65.62308	0.03480963	0.03473818	1143	31.18147	0.375
1990	**5**	512.8509	0.009905	0.015202	88.4945	0.0682553	0.03955942	8	0.170187	0.218
1991	**5**	475.2761	0.013254	0.014391	82.20108	0.06506687	0.04274785	7	0.16772	0.212
1992	**5**	471.9406	0.016603	0.012788	90.59429	0.06187844	0.04593628	6	0.17135	0.193

1993	**5**	413.9595	0.019953	0.010593	69.1449	0.05869001	0.04912471	5	0.126083	0.199
1994	**5**	267.0063	0.023302	0.011765	78.67836	0.05550158	0.05231314	4	0.101588	0.204
1995	**5**	340.3997	0.03	0.01149	99.5428	0.05231314	0.05550158	3	0.145602	0.21
1996	**5**	299.6195	0.033349	0.011375	101.892	0.04912471	0.05869001	2	0.067482	0.217
1997	**5**	271.1433	0.038302	0.011509	103.2106	0.04593628	0.06187844	1	0.073506	0.223
1998	**5**	272.1015	0.043214	0.016414	104.2659	0.04274785	0.06506687	2	0.079805	0.229
1999	**5**	273.4279	0.048078	0.012441	111.1353	0.03955942	0.0682553	3	0.129552	0.236
2000	**5**	243.8776	0.06	0.01092	93.64951	0.04227613	0.07144373	4	0.101508	0.242
2001	**5**	242.5757	0.057064	0.018921	97.36803	0.04397203	0.04274785	5	0.095511	0.248
2002	**5**	253.4107	0.06133	0.035758	94.66939	0.04304423	0.03955942	6	0.095871	0.254
2003	**5**	283.6753	0.065579	0.042345	101.2728	0.04367321	0.04227613	7	0.073163	0.26
2004	**5**	309.1902	0.069883	0.046229	105.4766	0.04441054	0.04397203	7	0.086675	0.266
2005	**5**	317.8777	0.074313	0.057942	107.5006	0.04718515	0.04304423	6	0.131981	0.273
2006	**5**	340.4145	0.078052	0.111829	106.3967	0.04086991	0.04367321	5	0.14961	0.278
2007	**5**	388.4778	0.083764	0.251764	100.2061	0.04819011	0.04441054	4	0.181663	0.284
2008	**5**	446.2288	0.0748	0.241507	102.5314	0.03566999	0.04718515	3	0.253729	0.289
2009	**5**	452.9222	0.093903	0.293273	121.2761	0.03675619	0.04086991	2	0.267142	0.295
2010	**5**	459.777	0.098	0.267842	121.2747	0.03918144	0.04819011	1	0.345738	0.303
2011	**5**	515.2095	0.104423	0.247087	131.7296	0.04766602	0.03566999	2	0.327016	0.314
2012	**5**	525.8675	0.10973	0.246349	141.1941	0.04565574	0.03675619	3	0.270331	0.318

2013	**5**	352.2269	0.115018	0.246642	141.2845	0.05034342	0.03918144	6	0.10741	0.327
2014	**5**	394.8569	0.120367	0.246749	151.4739	0.05444023	0.04766602	18	0.400865	0.336
2015	**5**	351.8798	0.12713	0.238828	135.6768	0.06665416	0.04565574	22	0.348878	0.345
2016	**5**	372.1355	0.134048	0.240296	137.9705	0.10996952	0.05034342	26	0.381021	0.35
2017	**5**	414.7403	0.140705	0.238684	140.2643	0.07828387	0.05444023	35	0.502297	0.356
2018	**5**	435.9323	0.14644	0.237072	142.558	0.09402068	0.06665416	61	0.364196	0.362
2019	**5**	426.4088	0.143	0.235461	144.8517	0.07576394	0.10996952	159	0.319604	0.368
2020	**5**	435.4692	0.154057	0.233849	147.1454	0.07791318	0.07828387	219	0.425761	0.368
2021	**5**	461.1375	0.156803	0.232237	149.4391	0.08006241	0.09402068	279	0.411672	0.368
1990	**6**	1301.819	0.328	0.367657	60.78455	0.05543254	0.03364569	23	3.511111	0.167
1991	**6**	1678.18	0.269193	0.375075	58.91755	0.05301178	0.03606645	22	4.643712	0.173
1992	**6**	263.0036	0.274086	0.333537	59.45806	0.05059102	0.03848721	21	0.86984	0.18
1993	**6**	326.7309	0.278973	0.352906	57.30206	0.04817026	0.04090797	20	1.349851	0.186
1994	**6**	459.4402	0.283845	0.396663	59.19758	0.0457495	0.04332873	19	1.363218	0.193
1995	**6**	483.7038	0.288698	0.478541	58.43559	0.04332873	0.0457495	18	0.766087	0.2
1996	**6**	307.8218	0.293523	0.479399	59.17294	0.04090797	0.04817026	17	1.082802	0.207
1997	**6**	388.8052	0.298315	0.509767	55.57288	0.03848721	0.05059102	16	1.048338	0.214
1998	**6**	366.1159	0.303065	0.469481	54.09694	0.03606645	0.05301178	15	1.150492	0.221
1999	**6**	339.281	0.307768	0.500619	80.08844	0.03364569	0.05543254	14	1.104924	0.229

2000	**6**	378.1575	0.23	0.53951	82.51336	0.03300109	0.0578533	13	3.0506	0.236
2001	**6**	471.3728	0.293859	0.553521	69.32061	0.03891879	0.03606645	12	3.226727	0.244
2002	**6**	529.4519	0.296539	0.583899	81.35561	0.04155935	0.03364569	11	3.911516	0.249
2003	**6**	607.0062	0.299204	0.65325	86.27486	0.04094182	0.03300109	10	4.714142	0.255
2004	**6**	737.1228	0.301923	0.680704	87.19614	0.04885443	0.03891879	9	6.291584	0.267
2005	**6**	945.6896	0.304768	0.670413	102.977	0.05662692	0.04155935	8	7.461118	0.274
2006	**6**	1179.898	0.307804	0.69697	114.5948	0.05423136	0.04094182	7	10.36052	0.282
2007	**6**	1500.673	0.311049	0.711014	123.24	0.06394963	0.04885443	6	12.66439	0.282
2008	**6**	1585.583	0.1997	0.73429	134.0704	0.05058102	0.05662692	5	13.40029	0.297
2009	**6**	1382.621	0.29	0.502696	153.8174	0.05615796	0.05423136	4	13.01943	0.304
2010	**6**	1706.415	0.359887	0.172956	179.3424	0.0568827	0.06394963	8	15.12575	0.305
2011	**6**	1982.817	0.383378	0.235127	195.1794	0.06964875	0.05058102	5	18.23841	0.3
2012	**6**	1797.401	0.407031	0.298538	217.3505	0.05676197	0.05615796	16	12.46491	0.312
2013	**6**	1834.561	0.431009	0.191462	220.2791	0.07267686	0.0568827	14	11.3534	0.322
2014	**6**	2076.001	0.449	0.216508	263.5174	0.05483687	0.06964875	22	11.55472	0.326
2015	**6**	2226.409	0.480157	0.226182	279.8826	0.05923124	0.05676197	29	10.88495	0.332
2016	**6**	2614.294	0.50505	0.407623	302.966	0.04463583	0.07267686	52	9.579836	0.336
2017	**6**	3188.769	0.529681	0.403827	326.0495	0.04633694	0.05483687	79	13.96892	0.34
2018	**6**	769.8691	0.55339	0.40003	349.1329	0.03017477	0.05923124	193	3.229935	0.344
2019	**6**	748.0109	0.575705	0.396234	372.2163	0.05832645	0.04463583	184	4.625965	0.348

2020	**6**	608.3325	0.596957	0.392438	395.2998	0.05910192	0.04633694	282	1.564366	0.348
2021	**6**	749.7068	0.617677	0.388642	418.3832	0.0598774	0.03017477	380	1.18633	0.348
1990	**7**	267.9332	0.124736	0.374449	41.19229	0.09098922	0.01531429	44	0.377276	0.156
1991	**7**	191.0707	0.095368	0.314225	54.78876	0.08410968	0.00843475	42	0.377276	0.156
1992	**7**	192.1354	0.066	0.21875	54.0643	0.07723014	0.00155521	40	0.336583	0.155
1993	**7**	187.5263	0.036632	0.122449	51.24504	0.0703506	0.02907337	38	0.358351	0.155
1994	**7**	185.9534	0.124736	0.073418	44.39118	0.06347106	0.02219383	36	0.417955	0.158
1995	**7**	239.8574	0.095368	0.071078	45.84853	0.05659153	0.03251314	34	0.52427	0.165
1996	**7**	281.3773	0.154105	0.056723	45.52365	0.04971199	0.03939268	32	0.55606	0.176
1997	**7**	311.0456	0.066	0.027861	54.05005	0.04283245	0.04627222	30	0.665201	0.187
1998	**7**	344.7018	0.036632	0.003934	48.74966	0.03595291	0.05315176	28	0.672555	0.199
1999	**7**	318.3427	0.048791	0.003113	68.8665	0.02907337	0.06003129	26	0.769149	0.21
2000	**7**	296.2868	0.061015	0.004538	125.2216	0.02219383	0.02219383	24	1.13143	0.224
2001	**7**	303.6657	0.057	0.003702	277.3766	0.02907337	0.02907337	22	0.690272	0.24
2002	**7**	328.5287	0.083978	0.002989	266.7566	0.03311286	0.03311286	20	1.067518	0.254
2003	**7**	387.4757	0.081	0.003392	377.2915	0.03395339	0.03395339	18	0.881615	0.267
2004	**7**	422.6429	0.10688	0.003927	453.8343	0.03672265	0.03672265	16	0.901302	0.28
2005	**7**	442.5591	0.118483	0.001581	457.3226	0.04375388	0.04375388	14	1.043062	0.299
2006	**7**	491.0984	0.130279	0.001357	466.6285	0.04088738	0.04088738	12	1.062441	0.309

2007	**7**	574.7697	0.124	0.000809	468.3158	0.03930671	0.03930671	10	1.099699	0.328
2008	**7**	531.027	0.135712	0.000859	452.174	0.0423884	0.0423884	8	1.81717	0.342
2009	**7**	481.2682	0.15	0.000766	452.8303	0.0520393	0.0520393	6	1.602961	0.347
2010	**7**	605.2735	0.188978	0.00114	462.3008	0.05438929	0.05438929	18	1.889732	0.356
2011	**7**	667.7178	0.202	0.001188	462.5339	0.05003119	0.05003119	30	2.947305	0.353
2012	**7**	672.204	0.212137	0.001385	467.0117	0.05246406	0.05246406	45	5.307865	0.353
2013	**7**	680.3753	0.224122	0.023431	456.5628	0.0612556	0.0612556	61	6.387185	0.373
2014	**7**	594.2269	0.248	0.088424	483.4726	0.06332318	0.06332318	91	7.193967	0.376
2015	**7**	430.9929	0.24	0.135891	584.0877	0.06716633	0.06716633	130	4.997728	0.381
2016	**7**	462.7	0.262186	0.183358	608.5918	0.07281345	0.07281345	158	3.094364	0.38
2017	**7**	504.5358	0.243	0.230825	633.0959	0.07836802	0.07836802	222	3.019235	0.379
2018	**7**	508.1634	0.311	0.278292	657.6001	0.08088962	0.08088962	349	4.000232	0.385
2019	**7**	454.0624	0.296864	0.325759	682.1042	0.07952718	0.07952718	623	3.69575	0.39
2020	**7**	491.8391	0.306124	0.373225	706.6083	0.07619396	0.07619396	918	3.242242	0.39
2021	**7**	541.4544	0.31494	0.420692	731.1124	0.08420078	0.08420078	1213	3.242242	0.39
1990	**8**	6055.06	0.48635	0.276074	888.0724	0.05373752	0.02160298	64	1.276698	0.473
1991	**8**	5349.452	0.550473	0.274112	876.242	0.05126564	0.01913109	61	1.411167	0.48
1992	**8**	5390.537	0.571625	0.274924	855.9482	0.04879375	0.0166592	58	1.233888	0.487

1993	**8**	4109.899	0.592776	0.281281	838.1907	0.04632186	0.01418731	55	1.002245	0.494
1994	**8**	3832.093	0.613928	0.291745	740.6656	0.04384997	0.01171543	52	0.883098	0.501
1995	**8**	4419.79	0.635079	0.297629	746.0132	0.04137808	0.00924354	49	1.124515	0.509
1996	**8**	4948.753	0.656231	0.359967	821.3099	0.0389062	0.03149053	46	1.335933	0.516
1997	**8**	4514.994	0.677383	0.350318	828.9498	0.03643431	0.02901864	43	1.606046	0.523
1998	**8**	3705.818	0.698534	0.390171	888.5531	0.03396242	0.02654675	40	1.722175	0.531
1999	**8**	3758.162	0.719686	0.368976	872.8493	0.03149053	0.02901864	37	1.220239	0.536
2000	**8**	3991.157	0.736	0.38403	849.2185	0.02901864	0.03149053	34	1.11273	0.543
2001	**8**	3844.561	0.771664	0.371002	866.3774	0.03149053	0.03324849	31	1.142551	0.549
2002	**8**	3976.647	0.778303	0.37247	889.1731	0.03324849	0.03532529	28	1.339542	0.557
2003	**8**	4724.255	0.784927	0.408735	896.6931	0.03532529	0.03330484	25	1.474218	0.563
2004	**8**	5483.145	0.791605	0.414935	875.0203	0.03330484	0.02932388	22	1.670287	0.569
2005	**8**	6570.963	0.816	0.479034	873.5882	0.02932388	0.03143385	19	2.010612	0.575
2006	**8**	6873.454	0.805404	0.427628	899.8132	0.03143385	0.03162926	16	2.392865	0.58
2007	**8**	8036.92	0.812607	0.533449	921.4247	0.03162926	0.02789792	13	2.945072	0.584
2008	**8**	9732.227	0.819984	0.50494	931.8878	0.02789792	0.03835747	10	3.896867	0.589
2009	**8**	7325.91	0.827494	0.479803	894.4436	0.03835747	0.02475569	7	3.576997	0.594
2010	**8**	8399.597	0.8933	0.526615	908.7695	0.02475569	0.02557716	4	4.514027	0.599
2011	**8**	10273.8	0.887271	0.584027	919.0409	0.02557716	0.02420976	31	5.222756	0.609
2012	**8**	9348.515	0.893	0.574861	941.9041	0.02420976	0.02840872	14	4.76262	0.62

2013	**8**	9250.081	0.864	0.550095	1031.423	0.02840872	0.02532823	22	5.269113	0.63
2014	**8**	9255.368	0.870752	0.596597	1118.537	0.02532823	0.02657439	23	6.497931	0.641
2015	**8**	7090.455	0.873277	0.562559	983.9508	0.02657439	0.03107698	32	4.20432	0.652
2016	**8**	6722.198	0.880797	0.573426	991.4113	0.03107698	0.02780689	45	3.783963	0.657
2017	**8**	6975.695	0.8627	0.574386	998.8718	0.02780689	0.02745004	58	3.179453	0.663
2018	**8**	7694.906	0.895746	0.575345	1006.332	0.02745004	0.02768363	56	3.248349	0.669
2019	**8**	7523.862	0.903191	0.576304	1013.793	0.02768363	0.03427246	55	3.695292	0.675
2020	**8**	6680.083	0.910628	0.577264	1021.253	0.03427246	0.02740693	98	3.047513	0.675
2021	**8**	8635.797	0.918064	0.578223	1028.714	0.02740693	0.02719641	141	3.394428	0.675
1990	**9**	2506.185	0.990416	0.688462	670.5863	0.03546087	0.0289582	2	0.81152	0.487
1991	**9**	2669.326	0.990707	0.69895	728.7908	0.03481061	0.02960846	5	0.812778	0.492
1992	**9**	2973.205	0.990997	0.673118	780.1254	0.03416034	0.03231903	8	0.889817	0.498
1993	**9**	2973.794	0.99128	0.722952	820.1397	0.03351007	0.03224867	11	0.912332	0.503
1994	**9**	3197.337	0.99155	0.771947	857.2615	0.0328598	0.03392909	14	1.080181	0.509
1995	**9**	3599.552	0.991799	0.731561	945.2478	0.03220953	0.03518729	17	0.948972	0.514
1996	**9**	3899.442	0.992021	0.74077	1021.168	0.03155927	0.03644548	20	1.09811	0.52
1997	**9**	3646.638	0.992209	0.754825	1108.611	0.030909	0.03770368	23	1.079613	0.526
1998	**9**	3593.242	0.992356	0.723667	1205.597	0.03025873	0.03896188	26	0.953189	0.535
1999	**9**	3695.934	0.992455	0.792429	1226.955	0.02960846	0.04022008	29	1.169597	0.545
2000	**9**	3929.082	0.99	0.7036	1363.246	0.0289582	0.04147828	32	1.051264	0.55

2001 **9** 3856.631 0.99196 0.712716 1453.665 0.02960846 0.0289582 35 1.029245 0.565

2002 **9** 4018.949 0.994 0.724103 1473.492 0.03231903 0.02960846 38 1.037155 0.572

2003 **9** 4793.722 0.990877 0.727666 1561.766 0.03224867 0.03231903 55 1.308471 0.587

2004 **9** 5388.063 0.990383 0.726559 1614.247 0.03361191 0.03224867 121 1.428101 0.598

2005 **9** 5282.9 0.990013 0.75 1683.691 0.03565293 0.03361191 159 1.393772 0.616

2006 **9** 5695.975 0.989835 0.777447 1743.117 0.03654289 0.03565293 239 1.630342 0.626

2007 **9** 6574.664 0.989866 0.776065 1816.671 0.03570651 0.03654289 296 1.955664 0.636

2008 **9** 8030.052 0.99007 0.767697 1881.65 0.03991997 0.03570651 406 2.373366 0.645

2009 **9** 7318.126 0.990407 0.763679 1907.123 0.04226503 0.03991997 480 2.328863 0.659

2010 **9** 8000.376 0.993973 0.756787 1995.361 0.04579822 0.04226503 9926 2.416646 0.669

2011 **9** 9197.043 0.996 0.797876 2025.704 0.04307829 0.04579822 652 2.702123 0.681

2012 **9** 9291.236 0.993714 0.792992 2075.036 0.04276751 0.04307829 1158 2.635111 0.702 **2013 9** 9764.644 0.993991 0.793975 2147.861 0.04683036 0.04276751 3314 2.528162 0.71

2014 **9** 10366.36 0.9947 0.797072 2182.035 0.05493996 0.04683036 239 2.416267 0.732

2015 **9** 9507.871 0.995737 0.772773 2313.744 0.05699958 0.05493996 296 2.029084 0.732

2016 **9** 9965.725 0.996928 0.774812 2380.066 0.05706786 0.05699958 406 2.109624 0.742

2017 **9** 10841.68 0.9961 0.769056 2446.387 0.05809852 0.05706786 480 2.3053 0.749

2018 **9** 11643.46 0.997866 0.7633 2512.709 0.05867059 0.05809852 9926 2.659307 0.759

2019 **9** 11403.25 1 0.757544 2579.03 0.06200562 0.05867059 652 2.755436 0.769

2020 **9** 9005.462 0.99464 0.751787 2645.351 0.06659961 0.06200562 1158 1.954816 0.769

2021 **9** 9062.722 0.996 0.746031 2711.673 0.06504266 0.06659961 3314 2.250305 0.769

1990 **10** 980.7546 0.224285 0.953439 103.5032 0.0486349 0.03325405 18 1.078879 0.189

1991 **10** 935.6384 0.23619 0.954592 102.6529 0.04732156 0.0312401 17 1.065989 0.191

1992 **10** 974.3312 0.248095 0.957224 109.4738 0.04600823 0.02922615 16 1.191845 0.192

1993 **10** 898.913 0.26 0.956606 104.8002 0.04469489 0.0272122 15 1.08012 0.194

1994	**10**	598.1454	0.271905	0.957944	110.6095	0.04338156	0.02519825	14	0.862928	0.195
1995	**10**	732.8364	0.288572	0.959364	110.0469	0.04206822	0.0231843	13	0.967901	0.196
1996	**10**	741.7617	0.305212	0.960931	110.9299	0.04075488	0.02117035	12	1.075168	0.198
1997	**10**	667.4532	0.322	0.96282	118.5434	0.03944155	0.0191564	11	0.957457	0.199
1998	**10**	702.4337	0.338383	0.963811	123.3058	0.03812821	0.03550154	10	1.219475	0.201
1999	**10**	695.5521	0.362	0.964235	119.4274	0.03681488	0.03681488	9	1.205699	0.203
2000	**10**	619.6421	0.3774	0.900249	103.5625	0.03550154	0.03952944	8	1.156054	0.209
2001	**10**	654.8407	0.38889	0.914905	125.7795	0.03681488	0.04297036	7	1.233508	0.214
2002	**10**	688.1875	0.368	0.797456	148.8073	0.03952944	0.04568562	6	1.431555	0.219
2003	**10**	840.3583	0.419373	0.749534	128.8034	0.04297036	0.03674665	5	1.526654	0.224
2004	**10**	941.8738	0.368	0.780035	141.793	0.04568562	0.03763376	6	1.76321	0.229
2005	**10**	1003.187	0.471	0.818003	161.9274	0.03674665	0.03414966	7	2.013995	0.233
2006	**10**	1038.579	0.499	0.870029	161.2304	0.03763376	0.03506876	8	2.481604	0.242
2007	**10**	1210.167	0.481494	0.900602	186.0104	0.03414966	0.03841573	9	2.946968	0.259
2008	**10**	1419.531	0.497481	0.886053	162.7231	0.03506876	0.04027644	10	3.806088	0.275
2009	**10**	1323.971	0.535	0.881386	194.5875	0.03841573	0.04214167	11	3.211765	0.286
2010	**10**	1286.605	0.565	0.863784	205.2654	0.04027644	0.0426688	12	2.985119	0.298
2011	**10**	1383.539	0.565	0.860362	206.2772	0.04214167	0.04385736	13	3.743856	0.322
2012	**10**	1334.726	0.565	0.867246	218.2615	0.0426688	0.04389623	13	3.65623	0.335
2013	**10**	1391.532	0.57	0.877843	218.3065	0.04385736	0.04377896	28	4.194064	0.344
2014	**10**	1417.095	0.61	0.877793	232.7078	0.04389623	0.04256069	30	4.648326	0.351
2015	**10**	1238.126	0.605	0.877876	220.1697	0.04377896	0.04163594	43	4.088307	0.351
2016	**10**	1290.75	0.645	0.883149	225.6925	0.04256069	0.04431821	92	4.570874	0.349
2017	**10**	1385.199	0.617	0.886333	231.2153	0.04163594	0.0449531	106	5.440191	0.346
2018	**10**	1484.227	0.66	0.889517	236.738	0.04431821	0.05151192	136	6.551475	0.345
2019	**10**	1462.678	0.704	0.892701	242.2608	0.0449531	0.04617448	272	6.922963	0.344
2020	**10**	1492.476	0.643	0.895885	247.7836	0.05151192	0.0466314	316	7.459721	0.347

2021	**10**	1633.56	0.6797	0.899069	253.3064	0.04617448	0.04708832	441	9.381925	0.347

APPENDIX A

DATA SET

APPENDIX B

Descriptive Statistics and Correlation Matrix Table: 4.1

	PGDP	ELS	EG	ED	GSH	GSE	ICT	GFCF	EI	FDI
Mean	1880.387	0.402507	0.399368	439.4080	0.045874	0.057521	602.1547	8.760393	0.389006	0.856135
Median	640.7061	0.336895	0.386336	144.7832	0.042332	0.040145	27.00000	2.118069	0.353000	0.266723
Maximum	11643.46	1.000000	0.964235	2711.673	0.119651	0.487631	42529.00	145.9484	0.769000	8.841062
Minimum	99.75725	0.009905	0.000315	21.47600	0.000676	0.001555	1.000000	0.067482	0.115000	-1.983179
Std. Dev.	2597.003	0.293453	0.322613	547.2373	0.017642	0.071591	3540.456	18.28826	0.155707	1.522363
Skewness	2.003929	0.737653	0.121651	1.985178	1.190787	4.028629	9.183991	4.035525	0.368646	2.632547
Kurtosis	6.103061	2.463416	1.571794	7.027821	5.048531	19.43156	96.66256	22.33411	2.358943	10.81066
Jarque-Bera	342.5589	32.85931	27.98627	426.4942	131.5783	4465.539	121467.4	5852.661	12.72738	1183.036
Probability	0.000000	0.000000	0.000001	0.000000	0.000000	0.000000	0.000000	0.000000	0.001723	0.000000
Sum	601723.8	128.8022	127.7976	140610.6	14.67977	18.40663	192689.5	2803.326	124.4820	273.9631
Sum Sq. Dev.	2.15E+09	27.47051	33.20133	95530500	0.099282	1.634960	4.00E+09	106692.9	7.734076	739.3109
Observations	320	320	320	320	320	320	320	320	320	320

Table 4.2 Correlation Matrix

	PGDP	ELS	EG	ED	GSH	GSE	ICT	GFCF	EI
ELS	0.82365								
EG	0.4117	0.650519							
ED	0.827529	0.756361	0.378704						
GSH	-0.16821	-0.23795	-0.11737	0.059212					
GSE	-0.13579	-0.07382	0.110462	0.191605	0.286452				
ICT	0.091239	0.124961	0.189346	0.035382	-0.05934	-0.04052			
GFCF	-0.01788	0.092717	0.225344	-0.21033	-0.21289	-0.11948	0.49851		
EI	0.743491	0.741465	0.314366	0.797194	-0.00314	0.16391	0.15814	0.064016	
FDI	-0.01136	0.058722	0.079475	-0.13199	-0.04224	-0.09445	0.102964	0.608849	0.08453

Source: Author's Computation (2023)

UNIT ROOT TEST LNPGDP

Null Hypothesis: Unit root (common unit root process)
Series: LNPGDP
Date: 10/11/23 Time: 09:12
Sample: 1990 2021
Exogenous variables: Individual effects
User-specified lags: 1
Newey-West automatic bandwidth selection and Bartlett kernel
Total (balanced) observations: 300 Cross-
sections included: 10

Method	Statistic	Prob.**
Levin, Lin & Chu t*	-0.20268	0.4197

** Probabilities are computed assuming asympotic normality

Null Hypothesis: Unit root (common unit root pro cess)
Series: D(LNPGDP)
Date: 10/11/23 Time: 09:13
Sample: 1990 2021
Exogenous variables: Individual effects
User-specified lags: 1
NeweyWest automatic bandwidth selection and Bartlett kernel
Total (balanced) observations: 290
Cross-sections included: 10

Method	Statistic	Prob.**
Levin, Lin & Chu t*	-7.04012	0.0000

** Probabilities are computed assuming asympotic normality

Null Hypothesis: Unit root (individual unit root process)

Series: LNPGDP
Date: 10/11/23 Time: 09:16
Sample: 1990 2021
Exogenous variables: Individual effects
User-specified lags: 1
Total (balanced) observations: 300
Cross-sections included: 10

Method	Statistic	Prob.**
Im, Pesaran and Shin W-stat	1.65432	0.9510

** Probabilities are computed assuming asympotic normality

Null Hypothesis: Unit root (individual unit root process)
Series: D(LNPGDP)
Date: 10/11/23 Time: 09:14
Sample: 1990 2021
Exogenous variables: Individual effects
User-specified lags: 1
Total (balanced) observations: 290
Cross-sections included: 10

Method	Statistic	Prob.**
Im, Pesaran and Shin W-stat	-9.37123	0.0000

** Probabilities are computed assuming asympotic normality

LNELS

Null Hypothesis: Unit root (common unit root process)
Series: LNELS
Date: 10/11/23 Time: 09:19

Sample: 1990 2021
Exogenous variables: Individual effects
User-specified lags: 1
Newey-West automatic bandwidth selection and Bartlett kernel
Total (balanced) observations: 300
Cross-sections included: 10

Method	Statistic	Prob.**
Levin, Lin & Chu t*	-6.01229	0.0000

** Probabilities are computed assuming asympotic normality

Null Hypothesis: Unit root (individual unit root process)
Series: LNELS
Date: 10/11/23 Time: 09:20
Sample: 1990 2021
Exogenous variables: Individual effects
User-specified lags: 1
Total (balanced) observations: 300
Cross-sections included: 10

Method	Statistic	Prob.**
Im, Pesaran and Shin W-stat	3	-0.6973 0.2428

** Probabilities are computed assuming asympotic normality

LNEG

Null Hypothesis: Unit root (individual unit root process)

Series: D(LNELS)
Date: 10/11/23 Time: 09:20
Sample: 1990 2021
Exogenous variables: Individual effects
User-specified lags: 1
Total (balanced) observations: 290
Cross-sections included: 10

Method	Statistic	Prob.**
Im, Pesaran and Shin W-stat	-11.6847	0.0000

** Probabilities are computed assuming asympotic normality

Null Hypothesis: Unit root (common unit root process) Series: LNEG
Date: 10/11/23 Time: 09:22
Sample: 1990 2021
Exogenous variables: Individual effects
User-specified lags: 1
Newey-West automatic bandwidth selection and Bartlett kernel
Total (balanced) observations: 300 Cross-sections included: 10

Method	Statistic	Prob.**
Levin, Lin & Chu t*	-0.93919	0.1738

** Probabilities are computed assuming asympo tic normality

Null Hypothesis: Unit root (commo n unit root pro cess)
Series: D(LNEG)
Date: 10/11/23 Time: 09:22
Sample: 1990 2021
Exogenous variables: Individual effects
User-specified lags: 1
NeweyWest automatic bandwidth selection and Bartlett kernel
Total (balanced) observations: 290
Cross-sections included: 10

Method	Statistic	Prob.**
Levin, Lin & Chu t*	-6.70178	0.0000

** Probabilities are computed assuming asympotic normality

Null Hypothesis: Unit root (individual unit root process)
Series: LNEG
Date: 10/11/23 Time: 09:22
Sample: 1990 2021
Exogenous variables: Individual effects
User-specified lags: 1
Total (balanced) observations: 300
Cross-sections included: 10

Method	Statistic	Prob.**
Im, Pesaran and Shin W-stat	-0.66008	0.2546

** Probabilities are computed assuming asympotic normality

Null Hypothesis: Unit root (individual unit root process)
Series: D(LNEG)
Date: 10/11/23 Time: 09:23
Sample: 1990 2021
Exogenous variables: Individual effects
User-specified lags: 1
Total (balanced) observations: 290
Cross-sections included: 10

Method	Statistic	Prob.**
Im, Pesaran and Shin W-stat	-8.37420	0.0000

** Probabilities are computed assuming asympotic normality

LNED

Null Hypothesis: Unit root (common unit root process)
Series: LNED
Date: 10/11/23 Time: 09:23
Sample: 1990 2021
Exogenous variables: Individual effects
User-specified lags: 1
Newey-West automatic bandwidth selection and Bartlett kernel
Total number of observations: 299 Cross-sections included: 10

Method	Statistic	Prob.**
Levin, Lin & Chu t*	-0.80554	0.2103

** Probabilities are computed assuming asympotic normality

Null Hypothesis: Unit root (common unit root process)
Series: D(LNED)
Date: 10/11/23 Time: 09:24
Sample: 1990 2021
Exogenous variables: None
User-specified lags: 1
NeweyWest automatic bandwidth selection and Bartlett kernel
Total number of observations: 289
Cross-sections included: 10

Method	Statistic	Prob.**
Levin, Lin & Chu t*	-10.6282	0.0000

** Probabilities are computed assuming asympotic normality

Null Hypothesis: Unit root (individual unit root process)
Series: LNED
Date: 10/11/23 Time: 09:25
Sample: 1990 2021
Exogenous variables: Individual effects
User-specified lags: 1
Total number of observations: 299
Cross-sections included: 10

Method	Statistic	Prob.**
Im, Pesaran and Shin W-stat	1.18533	0.8821

** Probabilities are computed assuming asympotic normality

Null Hypothesis: Unit root (individual unit root process)
Series: D(LNED)
Date: 10/11/23 Time: 09:25
Sample: 1990 2021
Exogenous variables: Individual effects
User-specified lags: 1
Total number of observations: 289
Cross-sections included: 10

Method	Statistic	Prob.**
Im, Pesaran and Shin W-stat	-10.3835	0.0000

** Probabilities are computed assuming asympotic normality

LNGSH

Null Hypothesis: Unit root (common unit root process)
Series: LNGSH
Date: 10/11/23 Time: 09:29
Sample: 1990 2021
Exogenous variables: Individual effects
User-specified lags: 1
Newey-West automatic bandwidth selection and Bartlett kernel
Total (balanced) observations: 300 Cross-sections included: 10

Method	Statistic	Prob.**
Levin, Lin & Chu t*	-0.28806	0.3866

** Probabilities are computed assuming asympo tic normality

Null Hypothesis: Unit root (common unit roo t pro cess)
Series: D(LNGSH)
Date: 10/11/23 Time: 09:30
Sample: 1990 2021
Exogenous variables: Individual effects
User-specified lags: 1
NeweyWest automatic bandwidth selection and Bartlett kernel
Total (balanced) observations: 290
Cross-sections included: 10

Method	Statisti c	Prob.**
Levin, Lin & Chu t*	-5.28691	0.0000

** Probabilities are computed assuming asympotic normality

Null Hypothesis: Unit root (individual unit root process)
Series: LNGSH
Date: 10/11/23 Time: 09:31
Sample: 1990 2021
Exogenous variables: Individual effects
User-specified lags: 1
Total (balanced) observations: 300
Cross-sections included: 10

Method	Statisti c	Prob.**

Im, Pesaran and Shin W-stat	-0.82065	0.2059

** Probabilities are computed assuming asympotic normality

Null Hypothesis: Unit root (individual unit root process)
Series: D(LNGSH)
Date: 10/11/23 Time: 09:31
Sample: 1990 2021
Exogenous variables: Individual effects
User-specified lags: 1
Total (balanced) observations: 290
Cross-sections included: 10

Method	Statistic	Prob.**
Im, Pesaran and Shin W-stat	-7.76926	0.0000

** Probabilities are computed assuming asympotic normality

LNGSE

Null Hypothesis: Unit root (common unit root process)
Series: LNGSE
Date: 10/11/23 Time: 09:32
Sample: 1990 2021
Exogenous variables: Individual effects
User-specified lags: 1
Newey-West automatic bandwidth selection and Bartlett kernel
Total (balanced) observations: 300
Cross-sections included: 10

Method	Statistic	Prob.**
Levin, Lin & Chu t*	-0.87494	0.1908

** Probabilities are computed assuming asympotic normality

Null Hypothesis: Unit root (common unit root process)
Series: D(LNGSE)
Date: 10/11/23 Time: 09:32
Sample: 1990 2021
Exogenous variables: Individual effects
User-specified lags: 1
Newey-West automatic bandwidth selection and Bartlett kernel

Total (balanced) observations: 290
Cross-sections included: 10

Method	Statistic	Prob.**
Levin, Lin & Chu t*	-9.38028	0.0000

** Probabilities are computed assuming asympotic normality

Null Hypothesis: Unit root (individual unit root process)
Series: LNGSE
Date: 10/11/23 Time: 09:32
Sample: 1990 2021
Exogenous variables: Individual effects
User-specified lags: 1
Total (balanced) observations: 300
Cross-sections included: 10

Method	Statistic	Prob.**
Im, Pesaran and Shin W-stat	-0.71596	0.2370

** Probabilities are computed assuming asympotic normality

Null Hypothesis: Unit root (individual unit root process)
Series: D(LNGSE)
Date: 10/11/23 Time: 09:32
Sample: 1990 2021
Exogenous variables: Individual effects
User-specified lags: 1
Total (balanced) observations: 290
Cross-sections included: 10

Method	Statistic	Prob.**
Im, Pesaran and Shin W-stat	-9.52961	0.0000

** Probabilities are computed assuming asympotic normality

LNICT

Null Hypothesis: Unit root (common unit root process)
Series: LNICT
Date: 10/11/23 Time: 09:34
Sample: 1990 2021
Exogenous variables: Individual effects
Automatic selection of maximum lags
Automatic lag length selection based on SIC: 0 to 6
Newey-West automatic bandwidth selection and Bartlett kernel
Total number of observations: 290 Cross-
sections included: 10

Method	Statistic	Prob.**
Levin, Lin & Chu t*	2.05889	0.9802

** Probabilities are computed assuming asympotic normality

Null Hypothesis: Unit root (common unit root process)
Series: D(LNICT)
Date: 10/11/23 Time: 09:34
Sample: 1990 2021
Exogenous variables: Individual effects
Automatic selection of maximum lags
Automatic lag length selection based on SIC: 0 to 6
NeweyWest automatic bandwidth selection and Bartlett kernel
Total number of observations: 287
Cross-sections included: 10

Method	Statistic	Prob.**
Levin, Lin & Chu t*	-5.05972	0.0000

** Probabilities are computed assuming asympotic normality

Null Hypothesis: Unit root (individual unit root process)
Series: LNICT
Date: 10/11/23 Time: 09:34
Sample: 1990 2021
Exogenous variables: Individual effects
Automatic selection of maximum lags
Automatic lag length selection based on SIC: 0 to 6
Total number of observations: 290
Cross-sections included: 10

Method	Statistic	Prob.**
Im, Pesaran and Shin W-stat	0.43086	0.6667

** Probabilities are computed assuming asympotic normality

Null Hypothesis: Unit root (individual unit root process)
Series: D(LNICT)
Date: 10/11/23 Time: 09:35
Sample: 1990 2021
Exogenous variables: Individual effects
Automatic selection of maximum lags
Automatic lag length selection based on SIC: 0 to 6
Total number of observations: 287
Cross-sections included: 10

Method	Statistic	Prob.**
Im, Pesaran and Shin W-stat	-5.62968	0.0000

** Probabilities are computed assuming asympotic normality

LNGFCF

Exogenous variables: Individual effects
User-specified lags: 1
Newey-West automatic bandwidth selection and Bartlett kernel
Total (balanced) observations: 300
Cross-sections included: 10

Method	Statistic	Prob.**

Levin, Lin & Chu t*	1.6531 6	0.9509

Null Hypothesis: Unit root (common unit root process)
Series: D(LNGFCF)
Date: 10/30/23 Time: 07:22 Sample: 1990 2021
Exogenous variables: Individual effects
User-specified lags: 1
Newey-West automatic bandwidth selection and Bartlett kernel
Total (balanced) observations: 290
Cross-sections included: 10

Method	Statisti c	Prob.**
Levin, Lin & Chu t*	- 6.0861 8	0.0000

** Probabilities are computed assuming asympotic normality

Null Hypothesis: Unit root (individual unit root process)
Series: LNGFCF
Date: 10/30/23 Time: 07:22
Sample: 1990 2021
Exogenous variables: Individual effects
User-specified lags: 1
Total (balanced) observations: 300
Cross-sections included: 10

Method	Statisti c		Prob.**
Im, Pesaran and Shin W-stat	3	3.0456	0.9988

** Probabilities are computed assuming asympotic normality

Null Hypothesis: Unit root (individual unit root process)
Series: D(LNGFCF)
Date: 10/30/23 Time: 07:23
Sample: 1990 2021
Exogenous variables: Individual effects
User-specified lags: 1
Total (balanced) observations: 290
Cross-sections included: 10

Method	Statistic	Prob.**
Im, Pesaran and Shin W-stat	-8.10548	0.0000

** Probabilities are computed assuming asympotic normality

COINTEGRATION TEST

Pedroni Residual Cointegration Test
Series: LNPGDP LNELS LNED LNEG LNGSH LNGSE LNICT LNGFCF LNEI LNFDI
Date: 10/11/23 Time: 09:49
Sample: 1990 2021
Included observations: 320
Cross-sections included: 10
Null Hypothesis: No cointegration
Trend mption: No deterministic trend
Automatic lag length selection based on SIC with lags from 5 to 6
Newey-West automatic bandwidth selection and Bartlett kernel

Alternative hypoth esis: common AR coefs. (within - dimension)

	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	-0.239190	0.5945	-0.185575	0.5736
Panel rho-Statistic	1.233587	0.8913	1.072762	0.8583
Panel PP-Statistic	-2.050862	0.0201	-1.924452	0.0271
Panel ADF-Statistic	-2.376269	0.0087	-2.076647	0.0189

Alternative hypothesis: individual AR coefs. (between-dimension)

	Statistic	Prob.
Group rho-Statistic	2.202236	0.9862
Group PP-Statistic	-2.135016	0.0164
Group ADF-Statistic	-2.144145	0.0160

Cross section specific results

PANEL ARDL ESTIMATES

Model 1

Dependent Variable: D(LNPGDP)
Method: ARDL
Date: 10/30/23 Time: 07:32
Sample: 1992 2021
Included observations: 300
Maximum dependent lags: 2 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (2 lags, automatic): LNELS LNEI FDI LNED LNEG
Fixed regressors: C
Number of models evalulated: 4
Selected Model: ARDL(2, 2, 2, 2, 2, 2)
Note: final equation sample is larger than selection sample

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
	Long Run Equation			
LNELS	-0.539739	0.291319	-1.852743	0.0655
LNEI	4.856427	0.465329	10.43655	0.0000
FDI	0.190787	0.013239	14.41051	0.0000
LNED	-0.844724	0.230622	-3.662805	0.0003
LNEG	-0.054118	0.087227	-0.620420	0.5357
	Short Run Equation			
COINTEQ01	-0.290609	0.093371	-3.112416	0.0022
D(LNPGDP(-1))	-0.039045	0.071742	-0.544245	0.5869
D(LNELS)	1.451405	1.405615	1.032577	0.3031
D(LNELS(-1))	-0.357719	0.507412	-0.704987	0.4817
D(LNEI)	3.056525	0.972668	3.142415	0.0020
D(LNEI(-1))	-3.510395	2.275118	-1.542951	0.1246
D(FDI)	0.247587	0.296015	0.836400	0.4040
D(FDI(-1))	0.039572	0.090280	0.438322	0.6617
D(LNED)	0.343954	0.167688	2.051152	0.0417

D(LNED(-1))	0.282851	0.217634	1.299665	0.1953
D(LNEG)	0.029965	0.334205	0.089662	0.9287
D(LNEG(-1))	0.006428	0.196061	0.032788	0.9739
C	4.442410	1.400740	3.171474	0.0018

Mean dependent var	0.022228	S.D. dependent var	0.228543
S.E. of regression	0.164550	Akaike info criterion	-0.709545
Sum squared resid	5.009219	Schwarz criterion	0.880215
Log likelihood	248.5273	Hannan-Quinn criter.	-0.074724

*Note: p-values and any subsequent tests do not account for model selection.

Model 2

Dependent Variable: D(LNPGDP)
Method: ARDL
Date: 10/30/23 Time: 07:33
Sample: 1992 2021
Included observations: 300
Maximum dependent lags: 2 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (2 lags, automatic): LNGSH LNEI FDI LNED LNEG
Fixed regressors: C
Number of models evalulated: 4
Selected Model: ARDL(1, 2, 2, 2, 2, 2)
Note: final equation sample is larger than selection sample

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
		Long Run Equation		
LNGSH	-0.232583	0.089855	- 2.588428	0.0104
LNEI	1.431458	0.270044	5.300829	0.0000
FDI	1.032126	0.097692	10.56513	0.0000
LNED	-0.617961	0.142712	-4.330137	0.0000
LNEG	0.030472	0.031072	0.980663	0.3280
		Short Run Equation		
COINTEQ01	-0.255007	0.100057	-2.548614	0.0116
D(LNGSH)	-0.074305	0.105366	-0.705206	0.4815
D(LNGSH(-1))	-0.067239	0.117933	-0.570148	0.5692
D(LNEI)	0.152247	1.452230	0.104837	0.9166
D(LNEI(-1))	-4.075701	1.628869	-2.502167	0.0132
D(FDI)	0.179400	0.326387	0.549655	0.5832
D(FDI(-1))	-0.005483	0.128146	-0.042784	0.9659
D(LNED)	0.223514	0.268431	0.832668	0.4061
D(LNED(-1))	0.036243	0.163787	0.221282	0.8251
D(LNEG)	0.130209	0.187229	0.695453	0.4876

D(LNEG(-1))	0.150089	0.185420	0.809454	0.4192
C	2.786519	1.028148	2.710230	0.0073

Mean dependent var	0.022228	S.D. dependent var	0.228543
S.E. of regression	0.168463	Akaike info criterion	-0.708636
Sum squared resid	5.534029	Schwarz criterion	0.763364
Log likelihood	238.3817	Hannan-Quinn criter.	-0.120838

*Note: p-values and any subsequent tests do not account for model selection.

Model 3

Dependent Variable: D(LNPGDP)
Method: ARDL
Date: 10/30/23 Time: 07:35
Sample: 1992 2021
Included observations: 300
Maximum dependent lags: 2 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (2 lags, automatic): LNGSE LNEI FDI LNED LNEG
Fixed regressors: C
Number of models evaluated: 4
Selected Model: ARDL(2, 2, 2, 2, 2, 2)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
	Long Run Equation			
LNGSE	-0.083352	0.030686	-2.716291	0.0072
LNEI	1.597263	0.138597	11.52448	0.0000
COINTEQ01	-0.370652	0.155202	-2.388191	0.0179
FDI	0.042100	0.010637	3.957782	0.0001
LNED	-0.179880	0.031673	-5.679270	0.0000
LNEG	-0.037663	0.004656	-8.089119	0.0000
D(LNPGDP(-1))	0.038745	0.109639	0.353388	0.7242
D(LNGSE)	-0.030015	0.109352	-0.274483	0.7840
	Short Run Equation			

D(LNGSE(-1))	0.066485	0.146594	0.453529	0.6507	Note: final equation sample is larger than
D(LNEI)	0.626331	1.687098	0.371247	0.7109	selection sample

D(LNEI(-1))	-3.807336	1.816777	-2.095654	0.0375
D(FDI)	0.367323	0.295075	1.244847	0.2148
D(FDI(-1))	0.126280	0.080601	1.566733	0.1189
D(LNED)	0.276041	0.290990	0.948627	0.3440
D(LNED(-1))	0.193865	0.180933	1.071474	0.2854
D(LNEG)	0.051948	0.166537	0.311929	0.7554
D(LNEG(-1))	0.132330	0.184637	0.716704	0.4745
C	3.409278	1.321836	2.579199	0.0107

Mean dependent var 0.022228 S.D. dependent var 0.228543
S.E. of regression 0.192497 Akaike info criterion -0.732618
Sum squared resid 6.855160 Schwarz criterion 0.857142
Log likelihood 252.2189 Hannan-Quinn criter. -0.097797

*Note: p-values and any subsequent tests do not account for model selection.

Model 4

Dependent Variable: D(LNPGDP)
Method: ARDL
Date: 10/30/23 Time: 07:36
Sample: 1992 2021
Included observations: 300
Maximum dependent lags: 2 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (2 lags, automatic): LNICT LNEI FDI LNED LNEG
Fixed regressors: C
Number of models evaluated: 4
Selected Model: ARDL(2, 2, 2, 2, 2, 2)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
	Long Run Equation			
LNICT	-0.123545	0.027119	-4.555748	0.0000

Note: final equation sample is larger than selection sample

LNEI	2.951900	0.589312	5.009057	0.0000
FDI	0.548196	0.115468	4.747586	0.0000
LNED	-0.878006	0.240146	-3.656130	0.0003
LNEG	-0.067726	0.047854	-1.415249	0.1587

Short Run E quation

COINTEQ01	-0.254482	0.084125	-3.025029	0.0028	
D(LNPGDP(-1))	-0.106484	0.058473	-1.821096	0.0702	C
D(LNICT)	0.025032	0.037628	0.665261	0.5067	
D(LNICT(-1))	0.010541	0.047868	0.220209	0.8260	
D(LNEI)	0.774039	1.479815	0.523064	0.6016	3
D(LNEI(-1))	-3.708835	1.991131	-1.862678	0.0641	.
D(FDI)	0.269035	0.320019	0.840685	0.4016	7
D(FDI(-1))	0.102213	0.162504	0.628991	0.5301	4
D(LNED)	0.261357	0.275099	0.950046	0.3433	3
D(LNED(-1))	0.010765	0.158088	0.068095	0.9458	3
D(LNEG)	0.031487	0.223729	0.140735	0.8882	7
					1
		1.226327	3.052508	0.0026	

D(LNEG(-1)) 0.133229
0.180230 0.739218
0.4607

Mean dependent var	0.022228	S.D. dependent var	0.228543
S.E. of regression	0.166900	Akaike info criterion	-0.709196
Sum squared resid	5.153312	Schwarz criterion	0.880564
Log likelihood	248.4714	Hannan-Quinn criter.	-0.074375

*Note: p-values and any subsequent tests do not account for model selection.

CAUSALITY TESTS

Pairwise Dumitrescu Hurlin Panel Causality Tests
Date: 10/30/23 Time: 07:46
Sample: 1990 2021
Lags: 2

Null Hypothesis:	W-Stat.	Zbar- Stat.	Prob.
PGDP does not homogeneously cause ICT	9.46822	9.72482	0.0000

ICT does not homogeneously cause PGDP	2.73185	0.74385	0.4570

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Date: 10/30/23 Time: 07:46
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Null Hypothesis: W-Stat.		Zbar- Stat.	Prob.
PGDP does not homogeneously cause ICT	9.46822	9.72482	0.0000
ICT does not homogeneously cause PGDP	2.73185	0.74385	0.4570

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Date: 10/30/23 Time: 07:46
Sample: 1990 2021
Lags: 2

Null Hypothesis: W-Stat.		Zbar- Stat.	Prob.
PGDP does not homogeneously cause ICT	9.46822	9.72482	0.0000
ICT does not homogeneously cause PGDP	2.73185	0.74385	0.4570

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Te
Date: 10/30/23 Time: 07:46
Sample: 1990 2021
Lags: 2

Null Hypothesis:	W-Stat.	Zbar- Stat.	Prob.
PGDP does not homogeneously cause ICT	9.46822	9.72482	0.0000
ICT does not homogeneously cause PGDP	2.73185	0.74385	0.4570

APPENDIX C

Publications from Thesis;

i. Macaver, O.J,[1] IDOKO SUZAN A[2]. , Ojo, F.A[3] (2020) Economics of Electricity Consumption, Billing and Payment Systems in Igbesa-Agbara Development Area of Ogun

State,Nigeria. Confluence Journal of Economics and Allied Sciences (CJEAS) Kogi State University. Vol. 3 Number3, December 2020, Pg46-61

ii. Awe, Emanuel O[1], Ugbaka Malachy A[2]., Abudukadirr, Y.Y[3]. And IDOKO SUZAN A[4] (2020) Electricity Infrastructure and Economic Growth in Nigeria: Analysis. Confluence Journal of

Economics and Allied Sciences, (CJEAS) Kogi State University. Vol.3 Number2, August 2020 Pg 115-130

iii. **Idoko Suzan A**[1] and Olufemi, M. Saibu[2] and Oyede. A.A[3] July Edition (2024) (Acceptance letter) . Information and Communication Technology Infrastructure and Economic Growth in Sub-Saharan Africa Countries

iv. **Idoko Suzan A**[1] and Olufemi, M. Saibu[2] and Oyede. A.A[3]

Infrastructural Development and Economic Growth in Sub-Saharan Africa May 2024 Crawford Book of Reading 2